UNIVERSITY OF MANITOBA

EXPERIMENTAL INVESTIGATION OF LOW REYNOLDS NUMBER TURBULENT FLOW AND HEAT TRANSFER IN THE THERMAL ENTRANCE REGION OF INTERNALLY FINNED TUBES

by

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ABSTRACT

The heat transfer and pressure drop characteristics were determined for a horizontal smooth tube and five integral inner finned tubes of various designs for heating water in low Reynolds number turbulent flow. The flows were fully developed hydrodynamically prior to the start of the heated sections. The tubes were uniformly heated by resistance wires wrapped uniformly around them. Heat transfer data are presented for both the thermal entrance region and the fully developed region. Friction factors were determined for both isothermal and diabatic conditions. Data were also obtained on both critical Reynolds numbers and on thermal entry lengths.

For the smooth tube, the experimental results were consistent with the findings of previous studies. Axial distributions of wall temperatures and local Nusselt numbers revealed the presence of secondary flow and showed their developing pattern.

For the internally finned tubes, novel data were obtained for the thermal entry regions, which showed a weak influence of buoyancy effect. The results for fully developed Nusselt numbers and friction factors were generally in good agreement with the results of previous investigators. A correlation for fully developed Nusselt numbers was developed to describe all of the heat transfer data to within 6.5 percent.

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NOMENCLATURE

ENGLISH SYMBOLS

A_a	=	Actual surface area per unit length [m^2/m]
A_{fa}	=	Actual flow area [m^2]
A_{fc}	=	Core flow area [m^2]
A_{fn}	=	Nominal flow area = $\pi D_i^2/4$ [m^2]
A_n	=	Nominal inside surface area = $\pi D_i L$[m^2]
A_w	=	Wall cross-sectional area [m^2]
b	=	Average distance between fins (taken as the average of the arc lengths at the root and tip of adjacent fins) [m]
c_p	=	Specific heat of the fluid [J/Kg.K]
D_{ft}	=	Fin tip diameter [m]
D_h	=	Hydraulic diameter = 4 A_{fa}/A_a [m]
D_i	=	Inside diameter [m]
D_{os}	=	Outside diameter [m]
f	=	Friction factor defined by equation (3.4)
g	=	Gravitational acceleration [m/s^2]
H	=	Relative fin height = ℓ/R_i
h	=	Convective heat transfer coefficient
k_c	=	Copper thermal conductivity [W/m.k]
k_f	=	Fluid thermal conductivity [W/m.k]
L	=	Heated length [m]
L_p	=	Distance between pressure taps [m]
ℓ	=	Fin height [m]
M	=	Number of fins
$\dot{m}$	=	Mass flow rate of fluid [Kg/s]

P	=	Pressure [Pa]
p	=	Pitch of fins (length per turn)
Q_e	=	Rate of electrical heat input [W]
Q_f	=	Rate of heat gained by the fluid [W]
R_i	=	Inside radius = Di/2 [m]
T_b	=	Local bulk temperature [°C]
T_m	=	Mean bulk temperature [°C]
T_w	=	Wall temperature [°C]
$\overline{T}_w$	=	Average of top and bottom wall temperature [°C]
x	=	Axial distance from the beginning of heating [m]
X^+	=	Reduced length = $x/(\frac{1}{2} D_h Re_h Pr)$

DIMENSIONLESS QUANTITIES

G_r	=	Grashof number = $g \beta \rho^2 D_h^3 (T_w - T_b)/\mu^2$
G_{r^*}	=	Modified Grashof number = Gr Nu
Nu	=	Nusselt number = $Q_f D_h/[A_a L(\overline{T}_w - T_b) k_f]$
P_r	=	Prandtl number = $\mu c_p/k_f$
R	=	Rayleigh number = Gr.Pr
Ra*	=	Modified Rayleigh number = Ra.Nu
Re_h	=	Reynolds number = $(\dot{m} D_h/\mu A_{fa})$
Re_i	=	Reynolds number = $(\dot{m} Di/(\mu A_{fa})$

GREEK SYMBOLS

α	=	Helix angle
β	=	Fluid thermal expansion coefficient [1/K]
γ	=	Half-fin angle
μ	=	Fluid viscosity [$N.s/m^2$]
ρ	=	Fluid density [kg/m^3]
ϕ	=	Temperature-difference ratio in equation (2.2)

SUBSCRIPTS

cr	=	Critical (at laminar - turbulent transition)
dia	=	Diabatic
fd	=	Fully developed
f	=	Fluid
h	=	Based on hydraulic diameter
i	=	Based on inside diameter
iso	=	Isothermal
m	=	Mean (evaluated at mean bulk temperature)
w	=	Wall
x	=	Local value

CHAPTER I

INTRODUCTION

Energy is no longer cheap and plentiful, and must be used wisely and managed effectively. The latter has led to demands for more efficient heat exchange equipment that provide increased heat fluxes for the same temperature differences and pumping power, or reduced size/weight (especially for mobile applications) for the same heat duty and pumping power. This need for high performance compact heat exchangers has, in turn, generated considerable research interest in augmenting or intensifying heat transfer.

Many augmentative techniques have been developed and tested in recent years. Among them are [1]; augmentative stimulators (fluid additives, electrostatic fields, and surface or fluid vibrations), turbulence promoters (coiled wires, inlet vortex generators, twisted tapes, displaced promoters, and spirally grooved tubes), extended heat transfer surfaces (mainly finned surfaces) and enhanced heat transfer surfaces (involving permanent surface treatments to enhance condensing and boiling). Some of these techniques, such as surface or fluid vibrations and electrostatic fields, have found little application due to their requirement of an external source of power which is often costly. Others, such as finned tubes, have gained wide popularity due to their relative simplicity and suitability to a wide range of engineering applications. Externally finned tubes have been commonly used for many years, however, new manufacturing techniques have recently made it possible to produce a wide variety of tubing with integral internal fins which longitudinally may be either straight or spiralled. Internally finned tubes provide heat transfer enhancement by the additional surface area and, in the case of spiral fins, by the vortex motion produced. This thesis deals with a variety of internally finned tubes. These tubes are now available commercially in various diameters with different fin heights and fin types (straight and spiral). A typical cross-section of an internally finned tube with fins equi-spaced about the inner perimeter, is shown in Figure 1.1.

Numerous experimental and analytical results are now available in the literature regarding heat transfer and pressure drop characteristics of internally finned tubes for both laminar and turbulent flows. These data, together with performance analyses, have clearly shown the effectiveness of internal fins. However, all of these results have dealt basically only with the fully developed region. A few heat transfer results have provided overall-average Nusselt numbers for heated sections which included an entrance length. In addition, for fully developed laminar flow, analytical treatments (until recently [2]) have considered only pure forced convection, whereas it is known that free convection effects can be significant. It is necessary for designers to gain some knowledge of friction factor and heat transfer characteristics in the entrance regions of internally finned tubes. This is essential particularly when dealing with the short tubes frequently encountered in compact heat exchangers.

The object of this work was to investigate experimentally the heat transfer characteristics in the thermal entrance region and the fully developed region for horizontal internally finned tubes. Five commercial copper tubes (one spiral) of various diameters, fin numbers and fin heights were tested (together with a smooth tube) under uniform heat flux conditions with distilled water as the working fluid. For each test, the flow was

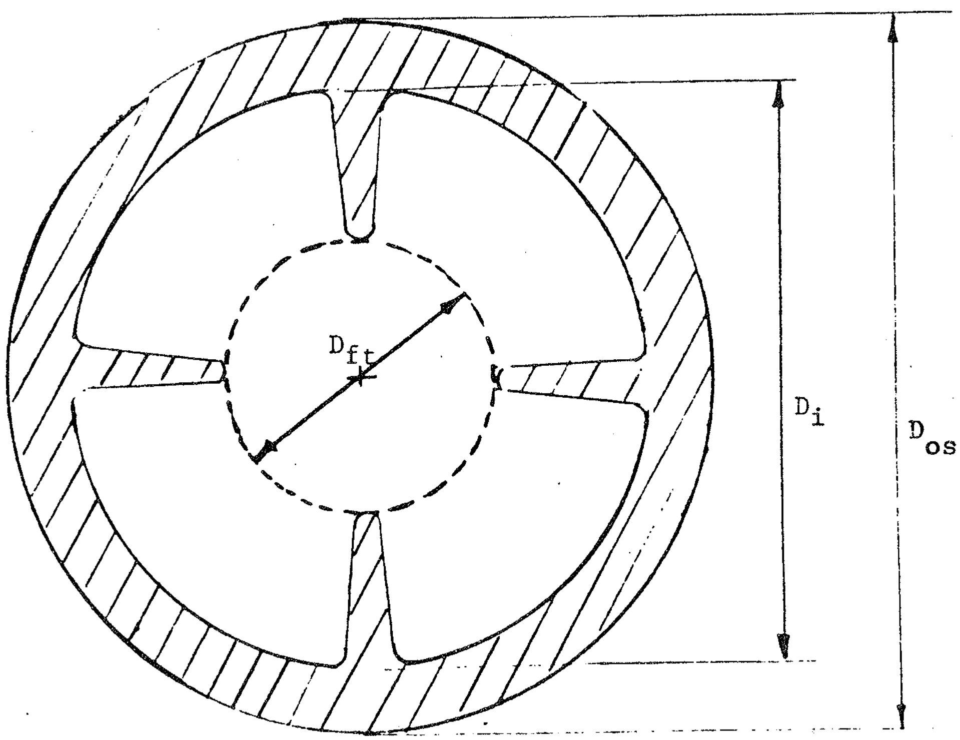


Figure 1.1 Schematic diagram of an internally finned tube

fully developed hydrodynamically at the entrance to the heated section. The experimental program was conducted by I.M. Rustum and the present author and encompassed laminar flow, transition, and the bottom end of the turbulent flow regime. In addition to the heat transfer results, data were also obtained on both isothermal and diabatic friction factors. The laminar flow results for combined free and forced convection have already been reported by Rustum [3]. The present author was primarily responsible for the low-Reynolds number turbulent experiments. These experimental results and the associated study are reported herein. Some laminar flow data are also presented here (where appropriate) in order to show continuity and/or to reinforce a point of discussion. As shown later, the fully developed turbulent results were found to compare favourably with the results of previous investigators. For the thermal entrance region, there are no other results available in the open literature, hence the present results are novel and should be of direct interest and value to designers.

CHAPTER II

LITERATURE REVIEW

2.1 PREAMBLE

Tubes with extended surfaces, or fins, have long been under investigation by various researchers. However, until recently, most work has been devoted to tubes with external fins. It is only after overcoming difficulties in manufacturing that internal fins have finally found practical use as surface promoters. In parallel with this, relatively recent published data on the performance characteristics of internally finned tubes, have indeed brought into attention the importance of this configuration as a means of substantially increasing heat transfer rates over smooth tubes.

In the following sections, a review of the work related to this area is presented. Most of the review is devoted to literature concerned with turbulent flow in internally finned tubes, for it is of direct relevance to the present investigation. However, a brief review is also included on laminar flow in internally finned tubes and on turbulent flow in smooth tubes.

2.2 SMOOTH TUBES

The extreme abundance of literature regarding turbulent convection in smooth tubes make it impractical for an extensive review. Thus only results of importance to the present work are reported.

Ede [4] reported data on the fully developed heat transfer coefficient in straight pipes of various diameter and compared his data to that predicted from two widely accepted equations for turbulent flow in smooth tubes:

Dittus-Boelter: $$\overline{Nu} = 0.023(Re)^{0.8}(Pr)^{0.4} \tag{2.1}$$

Martinelli: $$\frac{\overline{Nu}}{Re\ Pr} = \frac{(f/2)^{0.5}}{5\phi\{Pr + \ln(1+5Pr) + 0.5\ Pr\ \ln[(Re/60)(f/2)^{0.5}]\}} \ . \tag{2.2}$$

Both air and water were used as the working fluids and a constant heat flux boundary was imposed. The range of Reynolds number explored extended from 100,000 down to 300 and therefore made it convenient for direct comparison with the present results. For the tests with water, values of Pr ranged from 4 to 12 and their effect on heat transfer was represented using the Nusselt-Prandtl modulus $\overline{Nu}/(Pr)^{0.4}$. Ede found his data for water ($Re > 9000$) to be well correlated by equation (2.2). Equation (2.1) had a somewhat lower slope and did not precisely represent neither data for water nor for air, but served as a compromise between the two sets. The discrepancy, however, was not serious. For Reynolds number below about 5000, uncertainty of the results increased due to instability of flow in the neighbourhood of the critical Reynolds number. Most of the data for $5000 < Re < 9000$ fell below that predicted by both equations (2.1) and (2.2). At Reynolds numbers below 2300 the Nusselt numbers obtained were stable, but were very scattered when plotted against Re . This was attributed to the effect of natural convection. The variation of Nusselt number with Re ($Re < 2300$) was not apparent but the effect of Grashof number was very strong. The results were approximately represented by the equation:

$$\overline{Nu} = 4.36[1 + 0.06(Gr)^{0.3}] \ . \tag{2.3}$$

Allen and Eckert [5] reported friction and heat transfer results for water flowing in a uniformly heated tube. The effect of heating (variable fluid properties) on both friction and heat transfer coefficients was the main objective of the investigation. Reynolds numbers ranged from 13,000 to 111,000 and two values of Prandtl number (7 and 8) were used. In reducing the data, all fluid properties were taken at the bulk temperature at a fixed axial position (called the control point) located 22 diameters from the start of the heated section. For all runs the bulk temperature at the control point was kept at, or close to 17.8°C (64°F).

A linear relationship of the Nusselt number and the friction factor versus wall-to-fluid temperature difference was reported. This allowed for an extrapolation to evaluate those factors at zero heat rate or constant properties. Values of fully developed Nusselt numbers (constant properties) proved to be 10 to 20 percent higher than those predicted by the Dittus-Boelter equation (2.1). The exponent of the Reynolds number ranged from 0.84 to 0.87 for $Pr = 8$. However, these exponents were in rather good agreement with the analytical results of both Deissler [6] and Sparrow et al, [7], both of whom used the uniform wall heat flux boundary condition. Other notable findings were:

a) At the lowest Reynolds number, the control point Nusselt number was found to be little affected by heating rate. At higher Reynolds numbers the effect was approximated by the viscosity ratio rule of Sieder and Tate [8].

b) The effect of heating rate on the friction factor (at constant fluid flow rate) was more marked than that on Nusselt number, but little dependence on Reynolds number level was noted for $13{,}000 < Re < 111{,}000$.

c) A free convection effect characterized by the difference between Nusselt numbers at top and bottom of the tube, was of the order of 1 percent for $10^5 < Gr < 10^6$ and $13{,}000 < Re < 20{,}500$. At higher values of Re, the difference was undetectable.

Mori et al, [9] studied the effect of buoyancy on the velocity and temperature fields in forced convective heat transfer for air in a horizontal straight tube. Constant heat flux was applied at the boundary and both laminar and turbulent regimes were investigated. The radial temperature and velocity distributions were obtained and used to evaluate the Nusselt number. It was found that secondary flow strength becomes well established when the product of the Reynolds number and the Rayleigh number exceeds about 10^4. For laminar flow, when the product Re Ra is large, the velocity distributions deviate considerably from the velocity distribution of Poiseuille flow, with the temperature distribution having a similar profile. The effect of buoyancy on the local Nusselt number for laminar flow appears at about Re Ra $= 10^3$ and increases with increasing Re Ra product. The following correlation formula was developed:

$$\overline{Nu} = 0.61(\mathrm{Re\ Ra})^{0.2}\left\{1 + \frac{1.8}{(\mathrm{Re\ Ra})^{0.2}}\right\} \qquad (2.4)$$

For turbulent flow, the effect of the secondary flow on the temperature and velocity distributions was very small and no effect on Nusselt number was observed. The effect of secondary flow on the critical Reynolds number was also studied. It was found that with a low turbulence level at the entrance of the tube, the critical Reynolds number decreases with increasing Rayleigh number, while with a high turbulence level the critical Reynolds number increases with the Rayleigh number.

El-Hawary [10] investigated the effect of combined free and forced convection on the stability of flow in a horizontal tube. Water was uniformly heated in a horizontal tube with length to diameter ratio of 300, at various combinations of flow rate and wall heat flux. Stability was detected by examining signals from a thermocouple probe and a hot film anemometer probe placed in the tube at the test section outlet. Also the sharp increase in the pressure drop across the test section marked the onset of a turbulent flow. Stability maps were presented showing regions of different flows under different forced and natural convection effect. These maps (plots of Ra^* vs Re) displayed five different regions described as: laminar, hydraulic transition, disturbed, thermal transition and turbulent. The disturbed regime referred to the region where fluctuations of velocity and/or temperature occurred. The label "thermal transition" was given to the region where the effect of free convection was predominant. One important feature of these maps was the value of the critical Reynolds at which turbulence was achieved. It was shown that turbulent flows could be obtained in tubes with heated walls at values of Reynolds number much smaller than isothermal critical values.

Another interesting finding was that a plot of the wall temperature and bulk temperature distributions versus axial distance, displayed an over-shoot in the fluid-wall temperature difference at a certain distance downstream. The wall-fluid temperature difference increased with axial distance to a peak value, then gradually decreased to reach a value that remained constant for further downstream locations. The reduced downstream temperature difference was attributed to buoyancy forces. A certain length of the heated section was required for the secondary flow patterns to become fully developed and to have a steady influence on the flow. This phenomenon was also observed earlier by Shannon and Depew [11].

Other important studies conducted between 1966 [9] and 1980 [10] on the stability and structure of flow in horizontal tubes are those by

Nagendra [12] and by Petukhov et al, [13,14]. The latter authors have also very recently reviewed [15] the entire field of buoyancy effect on heat transfer in forced channel flows for both laminar and turbulent conditions.

2.3 INTERNALLY FINNED TUBES

2.3.1 Experimental Studies

2.3.1.1 Turbulent Flow

One of the earliest works regarding internal fin tubes was reported by Brouillette et al, [16] in 1957. They noted previous work by other researchers apparently dating as far back as 1923. Brouillette et al, [16] investigated tubes with V-shaped type of spiral fins (notches). Their configurations of various triangular fin height and pitch, differ somewhat from that used in the present and most other recent experiments, viz trapezoidal profiles; longitudinal or shallow spiral. Heat transfer coefficients were reported to be 30 to 100 percent greater than those for a smooth tube (of same I.D.), whereas friction factors increased by 15 to 400 percent. Also, the results showed the interesting fact that the fin height had a greater effect than the number of fins in increasing the heat transfer coefficient.

Hilding and Coogan [17] reported results of experimental measurement of heat transfer (heating air) and pressure loss for air flows in small tubes (copper) with ten different arrangements of internal fins (brass). The range of Reynolds number covered (1000 to about 20,000) allowed for the study of performance characteristics at different flow patterns (laminar - transition - turbulent). For Re $\geq$ 5000 (based on hydraulic diameter), the Colburn j-factor (Nu/(Re $Pr^{1/3}$) was lower than that for a smooth tube. However, in some cases the reverse was true at lower Re. Reasons for this effect were mentioned, but no definite conclusions were drawn. Friction factors (diabatic) were noted to be higher than those for a smooth tube, particularly at Re > $\sim$ 5000.

In 1971, Bergles et al, [18] presented data on heat transfer (heating water) and fluid friction for tubes with straight and spiral fins ($M = 10$-30, $H = 0.1 - 0.48$, $p/D_i = 11.4 - 246$) at Re_h from about 1000 to 40,000. The use of hydraulic diameter and effective area, as correlating parameters for heat transfer, was found effective only for straight fins of moderate height ($H \approx 0.22$). This approach seemed to over-predict the data for tubes with large fin height ($H \approx 0.5$) and the reason was attributed to flow stagnation in the troughs between fins. Results, based on nominal heat transfer area and inside diameter, were also presented and were useful in providing a direct indication of the improvement to be expected if a smooth tube were to be replaced by an internal fin tube of the same inside diameter. The Nusselt number for these tubes was found to have improved 50 to 200 percent over the smooth tube, with tubes having short spiralled fins displaying the greatest improvement. The adiabatic friction factor data (for $Re \geq 10{,}000$) were fairly well correlated by the hydraulic diameter and therefore showed reasonable closeness to the generally accepted Moody chart results for smooth tubes. The diabatic pressure drop results proved slightly lower than the adiabatic results, especially at lower Reynolds numbers where laminar - turbulent transition and free convection would be particularly pronounced. Finally, it was observed that the critical Re_h (value at which transition takes place) was relatively low (especially for spiral tubes), as compared to the critical value for smooth tubes.

In two separate papers, Watkinson et al, [19,20] reported the performance characteristics of a large variety of tubes with straight or spiral internal fins ($M = 6\text{-}50$, $H = 0.05\text{-}0.32$, $p/D_i = 6\text{-}33$). Water and air were used as the working fluids, and steam (in a steam jacket) served as the heating medium, thus providing an isothermal boundary.

For water flows, the isothermal friction factor ratios, $f_i/f_{i,0}$ (based on inside diameter, where f_i is the friction factor for finned tube and $f_{i,0}$ the corresponding value for a smooth tube), ranged from 1.75 to 2.25 , being lowest for straight fin tubes and highest for high spiral fin tubes. Friction factors based on hydraulic diameter deviated significantly (-20% to +10% for straight fins, -40% to +60% for spiral fins) from the Blasius equation, $f = 0.0791(R_e)^{0.25}$, especially at lower Reynolds number ($Re < 10{,}000$) where a considerable increase in friction factor was noticed. The straight fin tube friction factors were correlated within ± 10.8 percent (standard deviation) by the following equation, valid over the range $5000 \le Re_h \le 75{,}000$ and $0.21 \le b/D_h \le 0.49$:

$$f_h = 0.406(b/D_h)^{0.16}/(Re_h)^{0.39} \quad . \qquad (2.5)$$

For spiral fin tubes, the friction factors were found to increase with tighter spiraling (lower p/D_h), and were correlated within ± 12.3 percent by the equation:

$$f_h = 0.64/[(Re_h)^{0.39}(p/D_h)^{0.2}] \ , \qquad (2.6)$$

for $5000 \le Re_h \le 75{,}000$ and $9.2 \le p/D_h \le 79.2$.

On the nominal area and inside diameter basis, the greatest enhancement of heat transfer was achieved with the largest diameter spiral fin tubes (improvements of up to 170 percent). The enhancements for straight fin tubes were much lower but still significant at low Reynolds number (90% at

$Re_i = 10^4$, 45% at $Re_i = 10^5$). For all tubes, performance over smooth tubes decreased at higher Reynolds numbers, and indeed appear to approach that of a small tube at very high Reynolds number.

Heat transfer data, based on effective area and equivalent diameter were correlated as follow for $5000 \le Re_h \le 100{,}000$:

$$\overline{Nu} = 0.212(Re_h)^{0.6}(b/D_h)^{0.34}(Pr)^{1/3}(\mu/\mu_w)^{0.14}, \quad (2.7)$$

for straight fin tubes with $0.21 \le (b/D_h) \le 0.49$; and

$$\overline{Nu} = 0.369(Re_h)^{0.63}(p/D_h)^{-0.27}(b/D_h)^{0.21}(Pr)^{1/3}(\mu/\mu_w)^{0.14}, \quad (2.8)$$

for spiral fin tubes ($0.12 \le (b/D_h) \le 0.52$; $9.2 \le p/D_h \le 79.2$). Concerning the effect of finning configuration, it was observed that fewer fins gave better performance at a given Reynolds number, but no significant effect of fin height was noticed.

The same experiment was run with air as the working fluid [20]. The basic performance characteristics were not much different from those with water. However, different correlations were developed. One major difference was the fact that the Nusselt - Prandtl modulus increased with (b/D_h) for water at $Re_h \le 25{,}000$, which a decrease was noted for air. No explanation was given.

Russell and Carnavos [21] conducted a study on forge-fin tubes with integral internal fins manufactured by the Forge-Fin Division of Noranda Metal Industries, Inc. Six straight fin tubes ($M = 10$, I.D. = 7.04 - 13.9 mm, A_a/A_n = 1.54 - 1.84) in turbulent air flow ($Re_i \approx 10{,}000$ to 500,000) were tested. Heat transfer enhancement was found to be roughly equal to the heat transfer area increase. Friction factors ranged from 80 to 100 percent over the square of the heat transfer area increase. Tubes with smaller diameters showed a greater enhancement in heat transfer at the expense of increased pressure drop. However, the constant pumping power performance was good enough to lead the authors to recommend the tubes for some applications.

In a later paper, Carnavos [22] led a similar experiment with a broader variety of finned tubes (straight and spiral with $M = 5-41$, $H = 0.05 - 0.58$, $\alpha = 2.5° - 20°$). All the heat transfer data (based on hydraulic diameter and effective area) were correlated within ± 6 percent by a single equation:

$$\overline{Nu}/(Pr)^{0.4} = 0.023(Re_h)^{0.80}(A_{fa}/A_{fc})^{0.10}(A_n/A_a)^{0.50}(\sec\alpha)^3 . \quad (2.9)$$

Diabatic pressure drops for most tubes were correlated within ± 7 percent by:

$$f_h = [0.046/(Re_h)^{0.2}](A_{fa}/A_{fn})^{0.5}(\cos\alpha)^{0.5} . \quad (2.10)$$

A constant pumping power analysis (using the same criterion as in [20]) demonstrated the potential of these tubes to reduce the total footage of tubes by 17 percent to 100 percent, together with the potential of increasing the capacity of an existing heat exchanger by 12 percent to 66 percent.

Carnavos continued his work [23] by heating more or less the same tubes, with water and glycol/water as working fluids. The same correlations of Nusselt number and friction factors were developed (within ± 10%) except for the exponent on the cos α factor (changed from 0.5 to 0.75). A deviation from the slope of 0.8 was noted for the spiral fin tubes, particularly at higher helix angles and lower Reynolds numbers. The use of three different fluids permitted a study of the effect of Prandtl number on the heat transfer performance of these finned tubes. They were found to be no more Prandtl sensitive than a smooth tube.

Vasilchenko and Barbaritskaya presented results of an experimental study of flow resistance [24] and heat transfer [25] of tubes with internal longitudinal fins ($M = 0\text{-}8$, $H = 0\text{-}0.6$). Transformer oil was being cooled under laminar and turbulent conditions ($Re_h \approx 100$ to 12,000) at two different mean temperatures ($\sim 40°C$, $Pr \approx 140$ and $\sim 70°C$, $Pr \approx 70$). The resistance of all tubes with cooling the oil,was found to be considerably higher than that with isothermal flow; the difference being much more pronounced within the laminar flow regime. Correlations were developed for both the laminar and turbulent regimes for isothermal flow and were corrected for diabatic flow by the complex, $(Pr_w/Pr_f)^m$, where m is a geometry dependent parameter. The influence of Prandtl number on the heat transfer coefficient was similar for laminar and turbulent flows. Compared with a round tube of the same diameter, the heat transfer coefficient showed an increase of 200 to 300 percent in laminar flow while in turbulent flow it was only about 30 to 70 percent.

2.3.1.2 Laminar Flow

In contrast to turbulent flow, studies in laminar flow on internally finned tubes were mostly analytical. Some of the few experimental works are reviewed here.

Watkinson et al, [26] reported pressure drop and heat transfer data for various tubes with straight and spiral fins for laminar oil flow (heating) with constant wall temperature. Reynolds number and Prandtl number ranged from 50 to 3000 and 180 to 250 respectively. At a Reynolds number of 500 (based on inside diameter), the enhancement of Nusselt number varied from 8 to 224 percent, depending on tube geometry. For the case of straight fins, the enhancement decreased with increasing fin numbers, but increased with increasing relative fin height. The friction factor at a given value of Reynolds number increased strongly with the ratio of hydraulic diameter to inside diameter. The critical Reynolds numbers (where transition to turbulent flow starts) were higher at lower ℓ/D_i and approached the smooth tube value (2100) as ℓ/D_i approached zero.

Marner and Bergles [27] conducted experiments on internally finned tubes (with straight or spiral fins) using water and ethylene glycol as working fluids. Isothermal and diabatic pressure drops and heat transfer coefficients were measured for both constant heat flux ($M = 10$, $H = 0.22$, $\alpha = 0$) and constant wall temperature ($M = 16$, $H = 0.17$, $\alpha = 0.52°$) conditions. Tests for the latter condition entered the turbulent flow regime. Mean Nusselt number data were plotted against Reynolds number and a change in slope was noted at $Re_i \approx 1400$. This was attributed to the secondary flow and turbulence induced by the spiral fins.

2.3.2 Analytical Studies

2.3.2.1 Turbulent Flow

Until recently, according to Said [28], theoretical work on turbulent flow for internally finned tubes had been limited to a single study [29,30]. Ivanovic [29] developed numerical predictions for the local characteristics of flow and heat transfer for straight finned tubes in the combined range $6 \leq M \leq 18$ and $0.2 \leq H \leq 0.45$. Fin thickness and secondary flows were neglected.

Said [28] and Said and Trupp [31] extended the work using a two-equation turbulence model that included secondary flow and took into account the finning configuration (trapezoidal profile). Uniform heat input per unit axial length with constant peripheral (including fin surfaces) temperature were imposed as boundary conditions. Although this analysis was aimed mainly at revealing details of the flow structure and local heat transfer characteristics, results for friction factors and average Nusselt numbers were also reported for a large variety of fin configurations. The following correlations were developed and showed to be compatible with those of previous investigators:

$$\overline{Nu}/Pr)^{0.4} = 0.027(Re_h)^{0.774}(b/D_h)^{0.397}(A_n/A_a)^{-0.168}, \qquad (2.11)$$

$$f_h = 0.210(Re_h)^{-0.216}(b/D_h)^{0.351}(A_n/A_a)^{-0.148}, \qquad (2.12)$$

for $0.2 \leq H \leq 0.8$, $6 \leq M \leq 14$, $(0.31 \leq b/D_i \leq 0.77)$, and $25{,}000 \leq Re_h \leq 150{,}000$.

It is appropriate at this point to comment briefly on an interesting aspect of heat transfer in internally finned tubes under low turbulent Reynolds number flow conditions. An internally finned tube is a non-circular duct and hence, under turbulent (but not laminar) flow conditions, is subject to "secondary flows of the second kind" as dealt with in detail by Said [28]. The absolute strengths of these secondary flows increase with both Reynolds number and fin height [28]. In general, for the low Re involved in the present study, they would be expected to be relatively weak and also perhaps somewhat distorted, due to geometric imperfections in manufacturing the present finned tubes. Otherwise, they should be fairly independent of the presence of heat transfer, except for some influence due to fluid property variations with temperature. On the other hand, under diabatic conditions, thermally-induced secondary currents will arise in horizontal finned tubes under both laminar and turbulent flow conditions.

These will be influenced by the presence and orientation of the fins. Overall, they are expected to influence $\overline{Nu}$ significantly for laminar flow, but this influence is normally expected to diminish for turbulent flow and to become insignificant at high Re. Under diabatic, low turbulent Re flow conditions in horizontal internally finned tubes (as encountered in the present study), the question emerges as to the type of interaction between thermally-induced and turbulence-induced secondary flows. Using the results of [28] and the experimental evidence for circular tubes [14] as guides, it appears that both are of comparable magnitude. The answer to the question is of course well beyond the scope of the present investigation, nonetheless the phenomenon and its potential is hereby recognized.

2.3.2.2 Laminar Flow

As mentioned before, analytical work on internally finned tubes has mostly been directed to laminar flow. Some of the most recent investigations were reported by Soliman et al, [32-34]. Infinite series were used to develop solutions for fluid flow [32] and heat transfer (uniform heat flux axially) [33]. Later, heat transfer solutions were provided [34] for the case of uniform wall temperature using a finite difference approach.

It is to be noted here that these laminar flow analyses in internally finned tubes were conducted under the condition of forced convection only. However, it has been known from previous investigations on horizontal smooth tubes that free convection has a major effect on heat transfer coefficients and therefore a study of mixed - forced - free convection would be of importance. Work of this kind had been reported by many researchers for smooth tubes, but none prior to Mirza [2] had been reported for internally finned tubes. Mirza [2] recently completed an analysis (using the finite difference method) that provided some insight regarding mixed convection. An experimental investigation aimed towards the same goal was undertaken in parallel [3] and some of the findings are presented here as a contribution to this thesis.

CHAPTER III

EXPERIMENTAL INVESTIGATION

The object of the present study was to experimentally investigate the low Reynolds number turbulent heat transfer and pressure drop characteristics of internally finned tubes. Both the thermal entry regions and fully developed regions were considered and studied extensively. In all cases, the flow was hydrodynamically fully developed at the entrance to the heated section.

Five copper internally finned tubes with various geometries were tested along with a smooth copper tube. The tubes were uniformly heated and distilled water was selected as the working fluid. Data were carefully gathered for each tube and reduced to study the following features:

1. The isothermal and diabatic, fully developed, friction factors and the critical Reynolds number at which transition to turbulent flow occurs.
2. The axial variation of the local average Nusselt number at different Reynolds and Rayleigh numbers.
3. The axial variation of top and bottom wall temperatures.
4. Variation of the fully developed Nusselt number with Reynolds number.

Each of these items was studied thoroughly and conclusions were derived with the main concern being the effect of geometry and free convection on the heat transfer and flow characteristics of these tubes. Comparison with other investigators was made wherever possible.

The finned tubes were supplied by Noranda Metal Industries, French Tube Division, Newton, Connecticut. Each tube had a number assigned to it by the manufacturer and the same numbers are used here. All dimensions of the tubes were also supplied by the manufacturer and are listed in Table 1.

The smooth tube, referred to as tube No. 1, was tested to provide a base for comparison with the internally finned tubes. Also, due to the abundant literature on smooth tubes available for comparison, it has been common practice with experiments on finned tubes to first test a smooth tube as a means of verifying the techniques used in the various measurements.

3.1 GENERAL DESCRIPTION OF THE EXPERIMENTAL APPARATUS

A schematic diagram of the experimental apparatus is shown in Figure 3.1. Distilled water was pumped from an insulated (with 25 mm layer of fiber glass), 200 liter storage tank and circulated through the loop using a 3/4 horsepower centrifugal pump. A by-pass line controlled by two valves was installed to regulate the pressure level in the system and prevent any accidental overload of the pump.

The water was passed through a filter before going to the heated section (see details in Section 3.2.1), which was preceded by a long calming section. The total length of all finned tube test sections was 3.20 m of which 2.2 m served as a hydrodynamic entry length. For the present smooth tube test section, the total length was 5.65 m and 3.40 m served as a hydrodynamic entry length.

After passing through the test section, the water was allowed to mix in a mixing chamber (described in Section 3.2.2) before being cooled in two heat exchangers (described in Section 3.2.3) placed in series. After cooling, water passed through two variable area rotameters and flowed back

TABLE 1

DETAILED DIMENSIONS OF TEST TUBES

Tube Number	1	9	10	13	14	20
Tube outside diameter D_{os} - mm	21.3	12.7	9.53	9.53	15.9	12.7
Tube inside diameter D_i - mm	15.9	10.3	8.00	7.04	13.9	10.4
Fin - tip diameter, D_{ft} - mm	-	7.75	5.46	4.75	10.9	7.47
Number of fins, M	-	10	16	10	10	16
Relative Fin Height, H	-	0.248	0.318	0.325	0.216	0.282
Helix angle, α - degrees	-	0	0	0	0	2.50
Actual Plow Area, A_{fa} - mm^2	198.6	73.6	40.6	29.9	137	68.5
Actual Surface Area, A_a - mm^2/mm	50.0	54.0	60.0	35.2	67.3	65.0
Hydraulic Diameter, D_h - mm	15.9	5.45	2.71	3.39	8.15	4.21

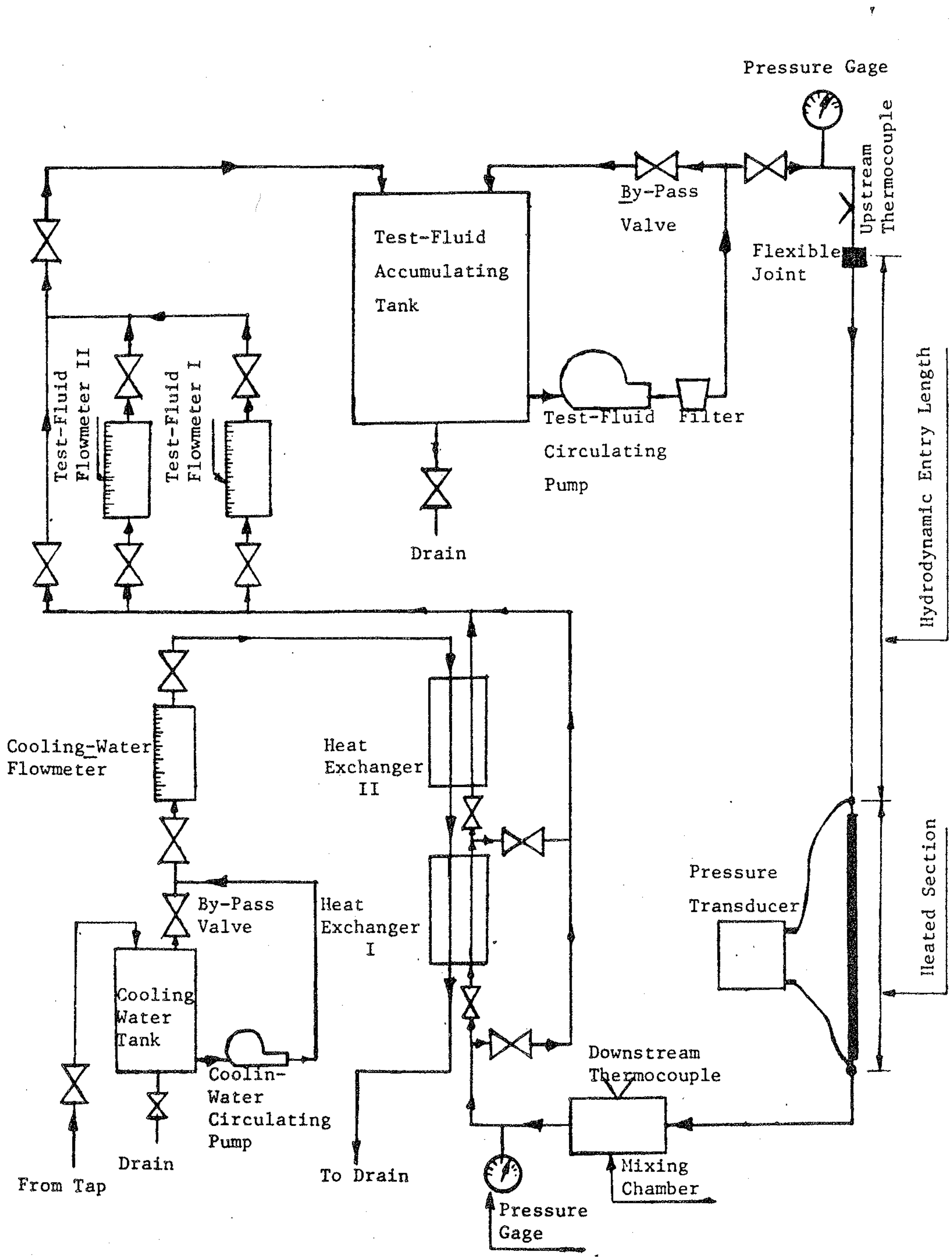


Figure 3.1 Schematic diagram of the experimental set-up

to the storage tank. The flowmeters, made by Fisher and Porter, were connected in parallel so that one, or both, could be used, depending on the flow rate. The two flowmeters were of different maximum capacity; one of 18 cm^3/s, the other of 70 cm^3/s. Both flowmeters were calibrated before the beginning of the experiment, using a one gram precision scale and a stop watch. Both flowmeters could be by-passed when flow rate measurements were not required.

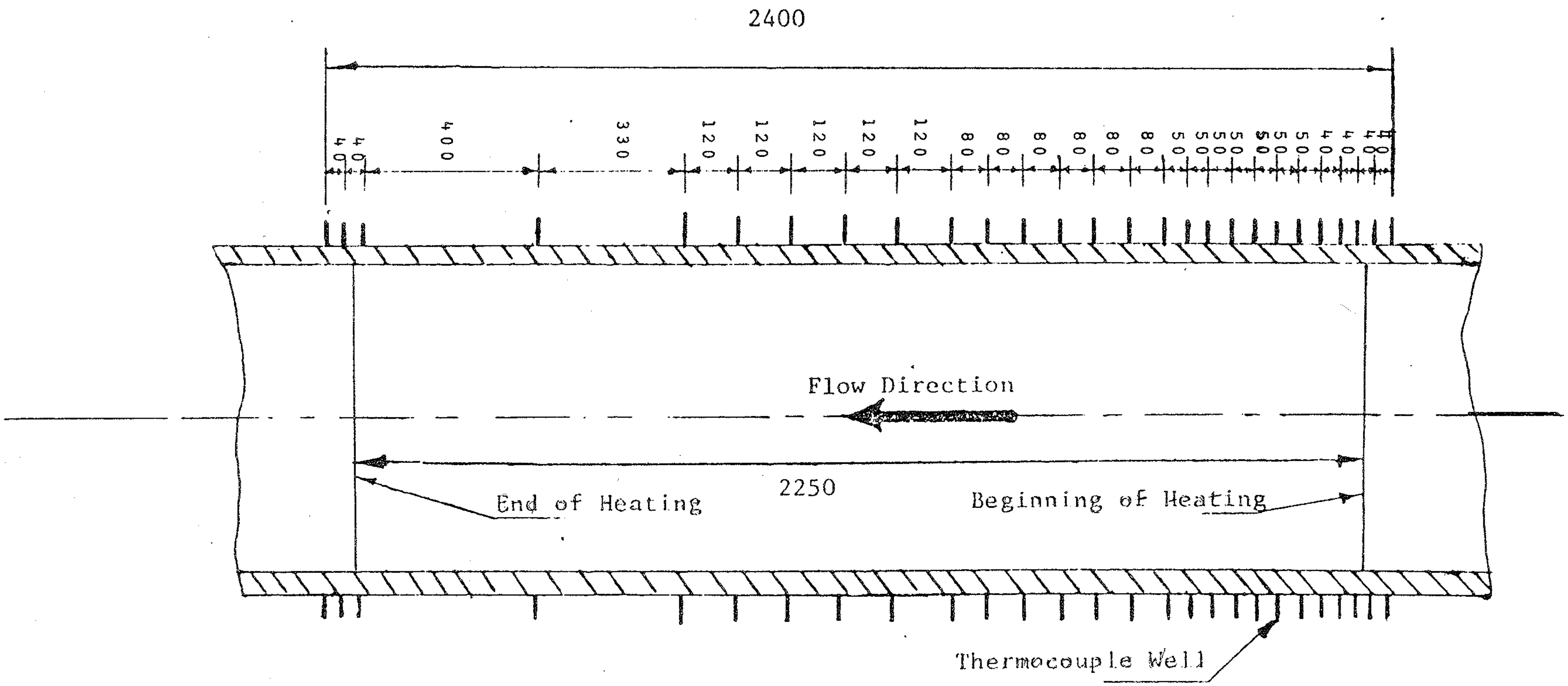
The test fluid (distilled water) was cooled in the heat exchangers by means of an open-loop system. Tap water was accumulated in a 100 liter tank to ensure a steady flow rate and, by means of a 1/4 horsepower centrifugal pump, was circulated through the heat exchangers, a flowmeter and down to the drain. The flowmeter was a variable area type made by Fisher and Porter with a maximum capacity of 300 cm^3/s.

The upstream bulk temperature was measured immediately before the test section with a precalibrated copper-constantan thermocouple inserted to be in direct contact with the test fluid. The downstream bulk temperature was measured at the mixing chamber as described in Section 3.2.2.

3.2 DETAILED DESCRIPTION OF THE MAIN COMPONENTS

3.2.1 Heated Section

Detailed dimensions of the present smooth tube and finned tubes heated sections are shown in Figures 3.2(a) and 3.2(b) respectively. The pressure taps were located 1 m apart (one just before the start of heating, the other just after the end of heating). Each consisted of two holes, one at the top, the other at the bottom, connected to a common manifold. Lead lines from each manifold were connected to either of two precalibrated



All dimensions in mm

Figure 3.2(a) Details of the heated section for the smooth tube

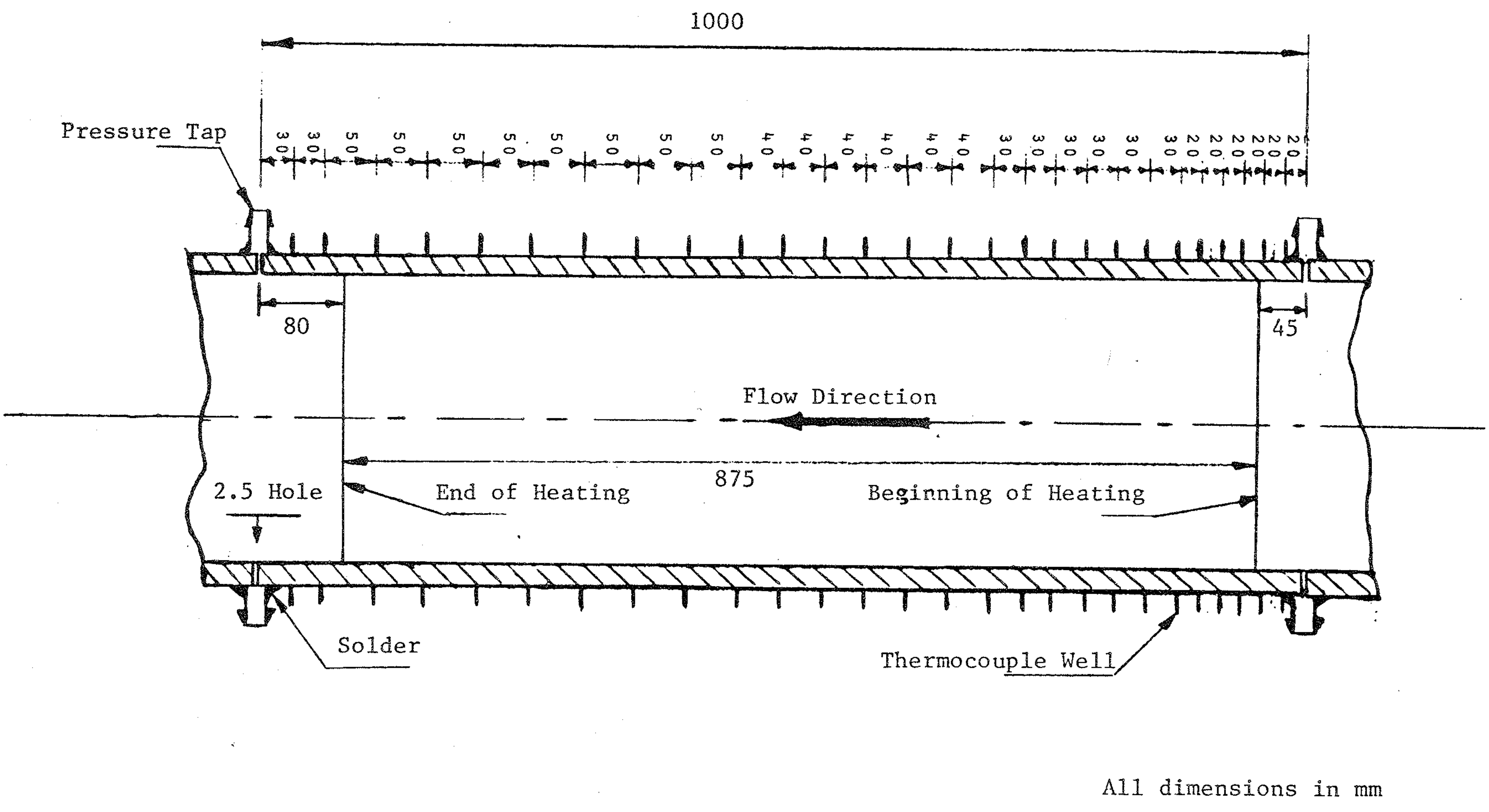


Figure 3.2(b) Details of the heated section for finned tubes

pressure transducers with ranges of 0 to 152.4 and 0 to 762 mm of water. The transducers (Model No. 1151DR), manufactured by Rosemount Inc., were powered by a D.C. power supply device with a 0 - 100 mA and 0 - 120 volts ranges. The pressure drop across the heated section was recorded via the transducer output in mA by a digital multimeter.

The top and bottom wall temperatures at the heated section were measured at 27 axial stations by means of 24 gauge copper-constantan thermocouples. Due to the relatively small wall thickness of the tubes and their small outside diameter, a special technique was adopted here to insure proper attachment of the thermocouples. At each station, the thermocouples were inserted in a small copper well, 2.5 mm in diameter, soldered to the tube wall. The wall was then filled with a high thermally conductive paste (k = 125 W/m-K) made by Omega Engineering, Inc., and then sealed with solid epoxy to insure permanent contact of the paste with the tube wall (see Fig. 3.3). Due to the very high thermal conductivity of the copper and the paste, the error introduced by taking the thermocouple readings as the actual wall temperature was trusted to be negligible. The same technique was used on the present smooth tube and proved to be effective.

The wall temperature measurement stations were added at each end of the heated section (immediately before and after). This was to determine the temperature gradient due to the axial heat conduction in the tube wall; thus allowing for correction of inlet and outlet temperatures, as will be explained later in Section 3.3.4.

At the beginning of the heated section, the thermocouples were placed close to each other, in order to detect the expected rapid rise in wall temperature. They were more distant from each other towards the end,

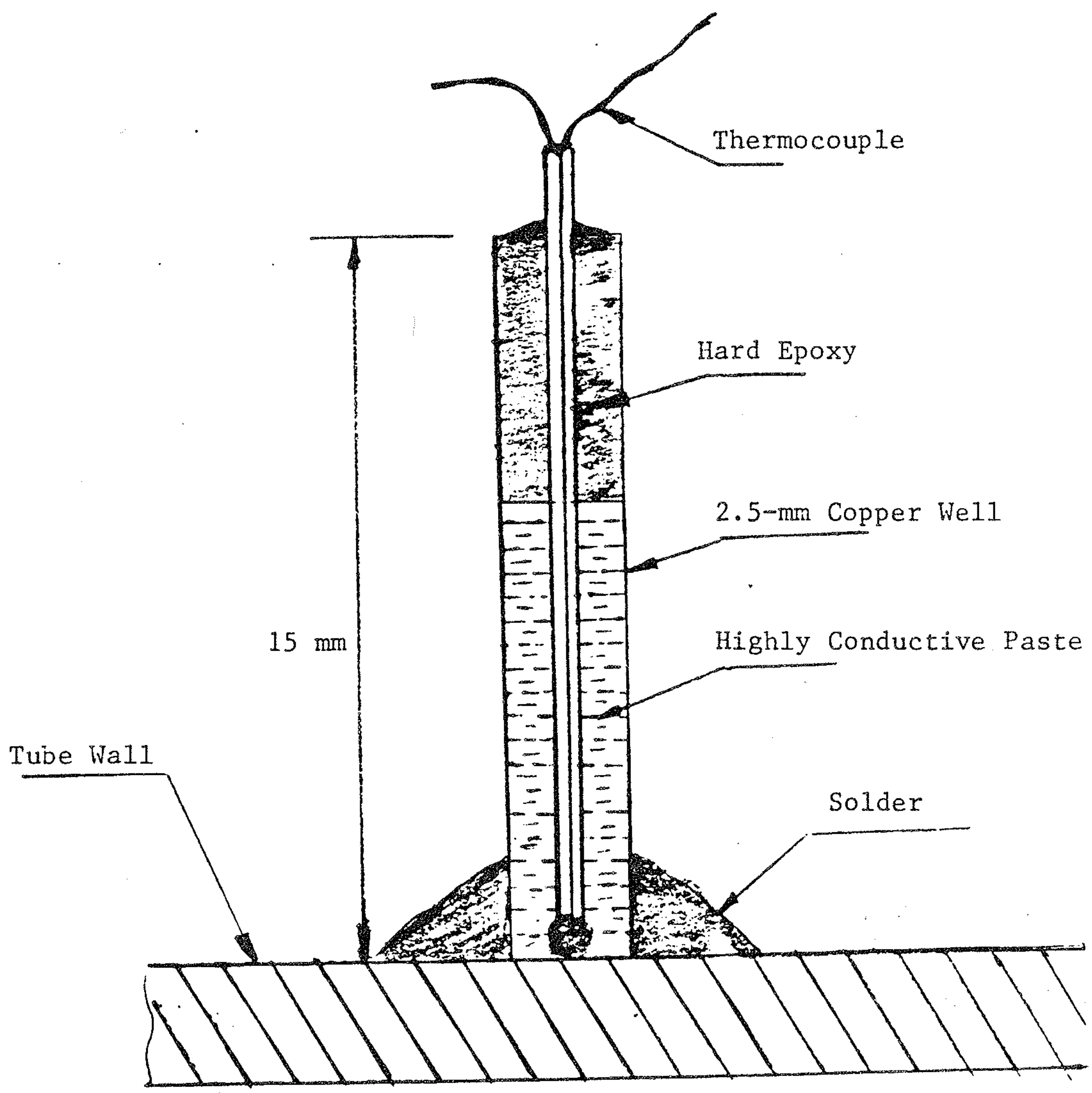


Figure 3.3 The arrangement used for attaching wall thermocouples

as the wall temperature variation was expected to be linear. Details of the dimensions and distances between stations are shown in Figure 3.2. All the thermocouple outputs were measured in °C or °F by a digital potentiometer (Leads and Northrup, Model 938, Numatron).

The tubes were heated with two insulated electrical heating wires of 0.81 mm diameter and 2.08 ohms/m, tightly wrapped around the tubes. The wires were wrapped in parallel, in order to minimize the overall resistance and therefore maximize the power input. The tubes were completely covered by the wires (except around the thermocouple wells), in order to ensure a uniform wall heat flux. The power supply to the heating wire was controlled by a 2,000 VA isolation transformer (Hammond, model EQSP) and a power variac. This impact power was measured by a digital watt-meter (Electro Industries, Model W100) with a range of 0 to 2.0 kW. Figure 3.4 shows a schematic diagram of the power circuit.

In order to minimise heat losses, the tubes (including the thermocouple wells) were covered with a 25 mm layer of fiberglas insulation. The entire test section was supported by a specially designed bed made adjustable in order to insure horizontality of the tubes (checked by a surveying level).

3.2.2 Mixing Chamber

Before measurement of the downstream temperature, the fluid was mixed thoroughly by the mixing chamber (see Fig. 3.5). The chamber was 200 mm long with a 60 mm diameter. The mixing was achieved with two grids fixed at both ends of the chamber with several inclined holes to create a vortex in the chamber. Surrounded by the mixed fluid was a well inserted

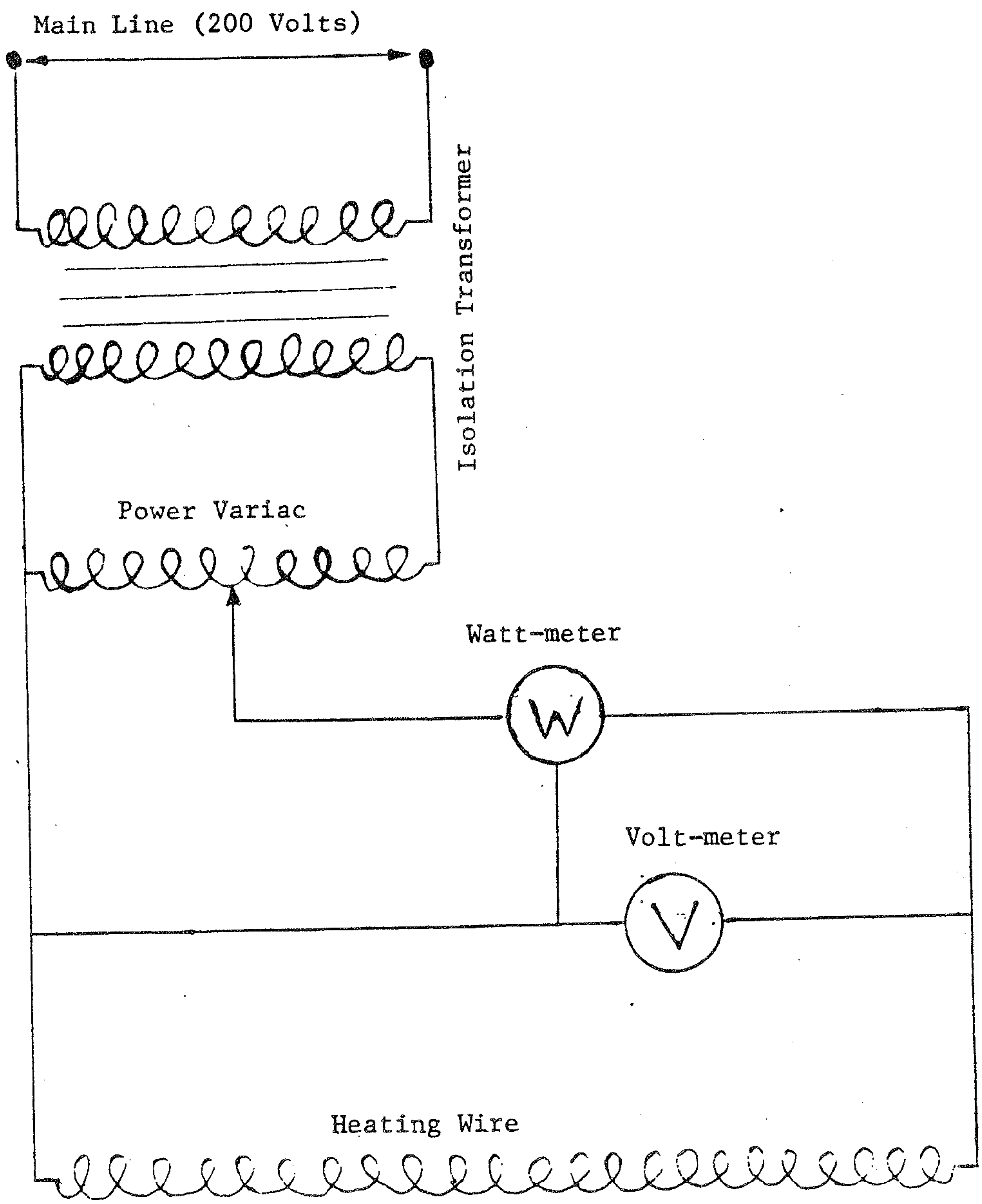
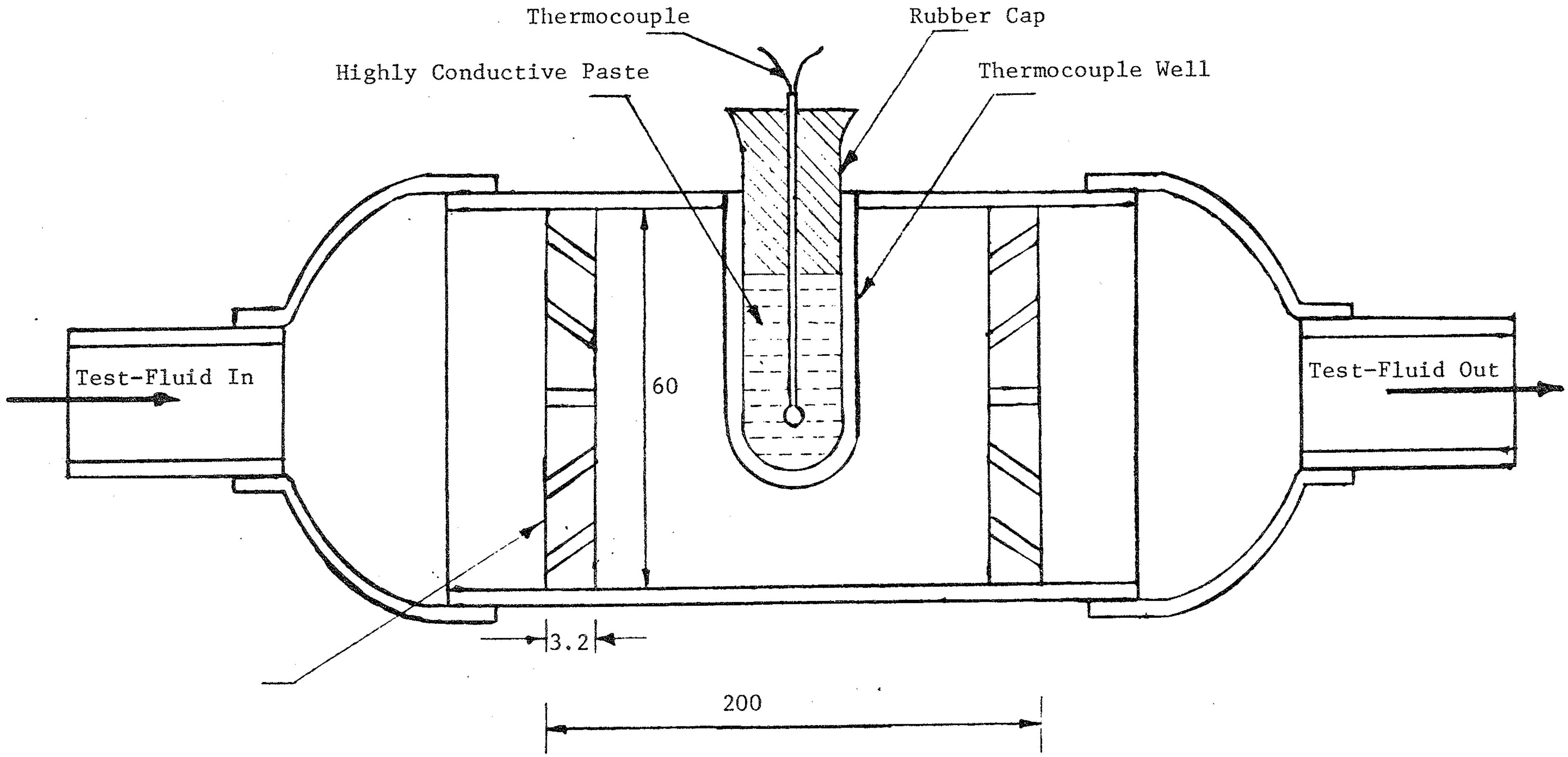


Figure 3.4 Electrical circuit used for heating



All dimensions in mm

Figure 3.5 The mixing chamber

in the chamber. The well was filled with the high thermally conductive paste (k = 125 W/m-k) whose temperature would be measured with a 24-gauge copper-constantan thermocouple. Under a steady state, with the high thermal conductivity of the paste, this temperature could be assumed to be the same as the downstream bulk temperature.

3.2.3 Heat Exchangers

The heat exchangers were essential for maintaining a steady state condition and a constant inlet temperature to the test section. The heat exchangers consisted of two, 1.5 m long concentric tubes. The inner tube was 12.7 mm inside diameter, and 15.9 mm outside diameter. The outer tube was 19.0 mm inside diameter, and 22.2 mm outside diameter. The test fluid was flowing in the annulus while the cooling fluid was counter-flowing in the inner tube. The two heat exchangers were connected in series and either one of them, or both, could be by-passed, depending on the required heat duty.

3.3 EXPERIMENTAL PROCEDURE

Before starting the experiment, water was circulated with the maximum flow rate to flush out any solid impurities collected in the tubes.

3.3.1 Measurement of Isothermal Pressure Drop and Critical Reynolds Number

For each tube, a set of runs without heating was performed at several flow rates to evaluate the isothermal friction factors in the laminar, transition and turbulent regimes. The following procedure was followed:

1. The test fluid flow rate was adjusted to its lowest detectable value of 1.3 cm^3/s.

2. Upstream temperature, downstream temperature and pressure transducer output readings were recorded when steady state conditions (noted by the constancy of these readings) were attained.

The flow rate was then increased by a precalculated amount and step 2 was repeated. This process was continued until the maximum flow-rate (corresponding to $Re_h \approx 6000$) was reached. The increased amount in the flow rate was kept small enough to detect any change in trend of the pressure drop with Reynolds number, so that in particular, an accurate estimate of the critical Reynolds number could be obtained.

The isothermal friction factor and the corresponding Reynolds number were then calculated for each run, based on both hydraulic diameter and inside diameter. Fluid properties were evaluated at the upstream temperature, which was always the same as the downstream temperature.

3.3.2 Calibration of Wall Thermocouples

The wall thermocouples (already attached to the wall) were calibrated before starting the heating runs. The following procedure was followed for each of the test sections:

1. Water was circulated in the loop at maximum flow rate. The flowmeters and the heat exchangers were by-passed, for they had no use in the calibration process (except for step 5).
2. The water was heated in the storage tank with a 1500 W capacity external heater controlled by a power variac until the water temperature reached 82°C, as determined by a thermocouple calibrated against a precision thermometer. No heat was added to the test section.
3. When steady state conditions were reached, the upstream and downstream bulk temperatures, along with all wall thermocouple readings, were recorded.

4. The heat supply was readjusted to bring the water temperature down to 60°C and step 3 was repeated.
5. Step 4 was repeated for water temperatures of 38° and 16°C, thereby covering all the range expected during testing. During these runs, the maximum difference between the upstream and downstream temperatures was of the order of 0.1°C, therefore confirming the negligible heat losses through the insulation. The average bulk temperature was taken as the reference temperature against which the wall thermocouples should be calibrated. The nominal wall thermocouples readings deviated slightly from the bulk temperature. At the bulk temperature of 82°C, the wall thermocouple readings were within the range of 80 - 82°C, while at the bulk temperature of 16°C, the wall thermocouple readings were within ± 0.2°C of the bulk temperature. The four sets of readings were judged sufficient to generate a calibration formula that would correct the readings of each thermocouple with reasonable accuracy.

3.3.3 Heat Transfer Tests

After the calibration process, both heat exchangers and the power to the heated section were turned on, thus starting the heat transfer experiment. For each tube, several sets of runs were conducted varying the flow rate and keeping a constant heat flux, or vice versa. The ranges and limits of flow rates and heat inputs depended on the tubes being tested. All runs were performed in the turbulent regime (whose start was estimated from pressure drop results). The power input was kept high enough to allow for a reasonable bulk temperature increase, and low enough to avoid some difficulties that arose due to the method used in attaching the thermocouples. This difficulty was noted in the first two tubes tested

(Nos. 10 and 13) and reasons were judged as follow: As the power was increased beyond a certain limit, the heating wire got hot enough to affect the thermocouple reading. This happened because the thermocouple junction was most likely touching the sidewall of the small well, which was in contact with the heating wire. This problem was solved by drilling a little notch on the tube wall inside each thermocouple well (see Fig. 3.6) and inserting the thermocouple all the way down before filling the well. This insured definite contact of the thermocouple junction with the tube wall. Tubes 10 and 13 were then retested.

For each run, corresponding to a certain flow rate and a certain power input, the following data were recorded under steady state conditions which were indicated by the constancy of all thermocouples, flow rates and pressure transducer readings:

1) Upstream and downstream bulk temperature.
2) All wall thermocouples readings.
3) Electrical input power in watts.
4) Pressure transducer reading.
5) Test-fluid flow rate.
6) Cooling water flow rate.

3.3.4 Data Reduction

A Fortran IV computer program was prepared and used to facilitate the reduction of the recorded data. The listing of the program is provided in Appendix A. Some of the main steps performed by the program are briefly outlined below. For details of the calculations, a sample run is presented in Appendix B.

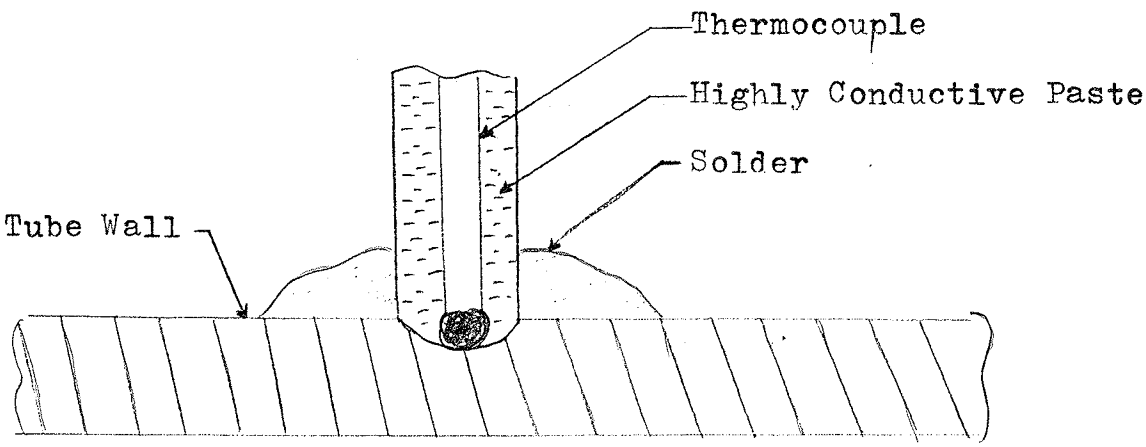


Figure 3.6 Attachment of the thermocouple with notch on the tube wall

1) Using the four sets of calibration readings and the corresponding average upstream - downstream bulk temperature, the calibration formula was generated and used to correct the wall thermocouple readings.

2) The increase in bulk temperature at the beginning of heating due to axial wall conduction was calculated and this was added to the upstream bulk temperature to evaluate the inlet bulk temperature (T_{bi}). Similarly, the increase in bulk temperature at the end of heating was calculated and subtracted from the downstream bulk temperature to evaluate the outlet bulk temperature (T_{bo}).

3) The rate of heat gained by the fluid was evaluated:

$$Q_f = \dot{m} c_p (T_{bo} - T_{bin}) \ . \tag{3.1}$$

4) The heat balance percentage error for the heated section was calculated as:

$$E = [(Q_e - Q_f)/Q_e] \ 100 \ . \tag{3.2}$$

Runs with more than 8 percent heat balance error were rejected. In fact, 90 percent of the recorded runs had heat balance error within ± 5 percent.

5) The local bulk temperature at each wall -thermocouple station was evaluated by a linear interpolation of the inlet and outlet bulk temperatures.

6) The local Nusselt number was evaluated at each station from its usual definition:

$$Nu_x = \frac{h_x \ D_h}{k} = Q_f \ D_h / [A_a \ L (\overline{T}_w - \overline{T}_b) k_f] \ , \tag{3.3}$$

which is based on the hydraulic diameter. To evaluate Nu_x based on the inside diameter, D_h and A_a were replaced by D_i and πD_i respectively.

7) Local Reynolds, Rayleigh, and Prandtl numbers were evaluated at each station, based on the local bulk temperature.

8) The reduced length, X^+ was evaluated at each station.

9) Mean values of Reynolds, Rayleigh and Prandtl numbers were evaluated at the average bulk temperature.

10) The average friction factor was evaluated as:

$$f_h = [\Delta p \; D_h \rho (A_{fa})^2]/[2L_p(\dot{m})^2] \; , \qquad (3.4)$$

which is based on the hydraulic diameter. Comparison of the present results to accepted smooth tube results were based on either the Blasius equation,

$$f = 0.0791(Re)^{-0.25} \; , \sim 10^4 < Re < \sim 10^5 \; , \qquad (3.5)$$

or the commonly employed empirical equation,

$$f = 0.046(Re)^{-0.20} \; , \qquad (3.6)$$

which closely fits the Karman - Nikuradse equation over the range $3 \times 10^4 < Re < 10^6$[35].

All the results obtained from this program for all the test runs are tabulated in Appendix C. Included in the program is a sub-routine to evaluate the Nusselt number taking into consideration the axial conduction of the tube wall. The effect proved to be negligible and therefore the results are not discussed, but are included in Appendix C.

CHAPTER IV

RESULTS AND DISCUSSION

Results of pressure drop with and without heating and local and fully developed Nusselt number are presented and discussed in this chapter. Correlations were developed where practical. Comparison with other investigators were made wherever possible. All results for the smooth tube are discussed separately in the first section. The ranges of operating conditions for each of the tested tubes are listed in Table 2.

4.1 SMOOTH TUBE

4.1.1 Friction Factor Results

The axial pressure drop across the test section (2.25 m) was measured as described in the previous chapter. The diabatic friction factors were calculated using equation (3.4). All properties were evaluated at the average inlet - outlet temperature. Data without heating (isothermal) were not obtained, due to technical difficulties in the initial equipment set-up. Therefore, only diabatic results are presented.

Figure 4.1 shows the diabatic friction factor distribution versus Reynolds number. Attention is immediately directed to the apparent change of slope at $Re_i \approx 6000$. Note that this change of slope is not the usual one encountered at the laminar - turbulent transition where the change is accompanied by a sharp increase in the friction factor value. This transition was estimated to have occurred earlier. At values of Reynolds number lower than 6000 the slope was of the order of 0.5, and at higher

TABLE 2

RANGES OF OPERATING CONDITIONS

Tube Number	Mass Flowrate, $\dot{m}$(Kg/Hr)	Input Power, Qe, Watts	Mean Reynolds Number, Re_h	Mean Modified Rayleigh Number, $Ra^* \times 10^{-6}$	Mean Prandtl Number, Pr	Number of Test Runs
1	125.1-943.2	485-3000	3050-23,700*	7.96-75.9	5.1-6.6	28
9	47.3-290.3	740-1470	1640-8900	0.55-1.83	3.7-5.3	18
10	21.7-235.9	240-1725	610-8280	0.011-0.13	3.3-6.4	26
13	24.8-235.2	500-1940	1050-9640	0.093-0.54	4.0-6.5	18
14	101.5-467.5	500-1250	2310-10,800	1.72-5.44	4.3-5.1	14
20	25.1-232.3	1000-1450	740-5130	0.32-0.43	3.7-5.2	7

* Heat balance errors were excessive for all Re > ∿ 15,000.

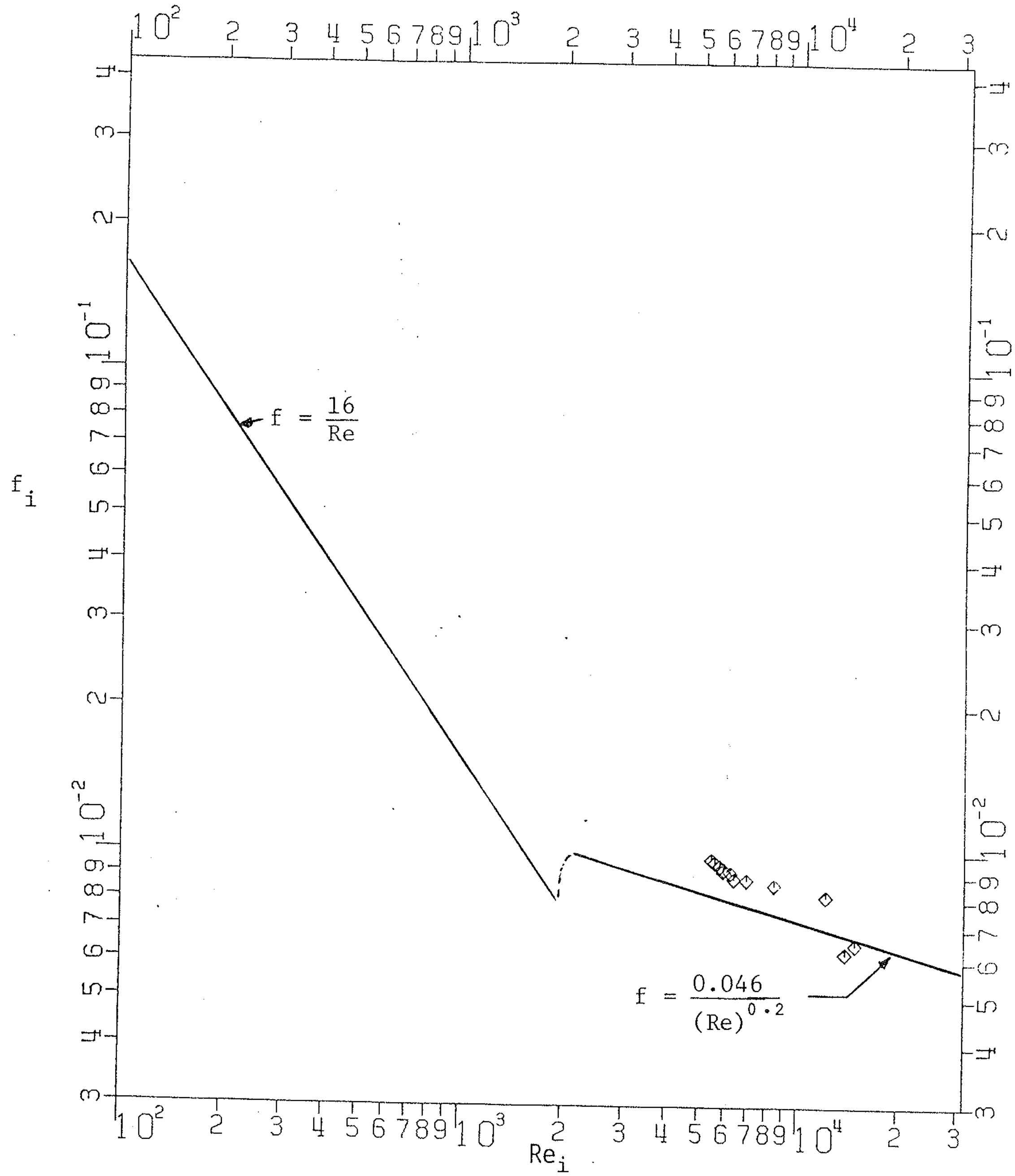


Figure 4.1 Diabatic friction factors for present smooth tube

values of Re it was of the order of 0.2, the familiar value found in equation (3.6). The actual values of the present diabatic friction factors averaged about 11 percent higher than those predicted by equation (3.6) and about 3 percent higher than the Blasius equation (3.5). According to Kays and Crawford [35] (for heating water), based on viscosities at typical wall and bulk temperatures, one would have expected diabatic friction factors to be slightly lower (about 3%) than isothermal friction factors. The discrepancy may be due to a small roughness factor. Alternatively, the small increase in friction factor and the change in Reynolds exponent may be due to buoyancy effects. El-Hawary [10], in a similar experiment (horizontal tube, heating water, uniform heat flux), reported diabatic friction factors to be somewhat higher than the isothermal values, at least for laminar flow. The presence of secondary flows/free convection is discussed further in connection with the heat transfer results.

4.1.2 Heat Transfer Results

Results for axial wall temperature distribution, local Nusselt number, and fully developed Nusselt number are presented and discussed in this section. The testing procedure was described in detail in the previous chapter. The local Nusselt number, average Nusselt number and dimensionless axial distance were calculated as follows:

$$Nu_x = Q_f \, D_i / A_a \, L(\overline{T}_w - T_b) k_f \;, \qquad (4.1)$$

$$\overline{Nu} = \sum_{10}^{23} Nu_x]/14 \;, \qquad (4.2)$$

where 10 to 23 represent the axial locations, and

$$X^+ = [x/R_i]/[Re_x \; Pr_x] \quad . \qquad (4.3)$$

4.1.2.1 Wall Temperatures

Two samples of axial wall temperature distribution are presented in Figures 4.2a) and b) at Re_i = 3640 and Re_i = 6240, respectively. Both runs had the same modified Rayleigh numbers of about 0.5 x 10^8. Both top and bottom temperatures are shown in the figures.

According to Metais and Eckert [36], under these conditions these runs (especially Fig. 4.2a)) were near the boundary between the forced convection turbulent regime and the mixed convection turbulent regime. In fact, the following observations suggest the mixed convection regime, since there is evidence of the presence of secondary flows.

As can be seen in the figures, the wall-fluid temperature difference increases with the axial distance to a peak value, then gradually decreases to reach some value that remained approximately constant for further downstream locations. El-Hawary [10] reported a similar phenomenon and attributed it to the effect of buoyancy forces. A certain length of the heated tube is required for the secondary flow patterns to become fully developed and hence to have a steady influence on the heat transfer characteristics. To support this hypothesis, attention is directed to the difference between top and bottom temperatures in Figure 4.2a). At the early stage of heating ($x/D_i < 24$), the difference is negligible, suggesting that secondary flows have not taken place yet. However, further downstream ($24 < x/D_i < 48$), the difference becomes noticeable with the top temperatures being higher than the bottom temperatures. This marks the onset of secondary flow which increases the local heat transfer coefficient, thereby allowing a reduction in the wall-fluid temperature difference. Farther downstream ($x/D_i > 48$), the difference between top and bottom temperatures

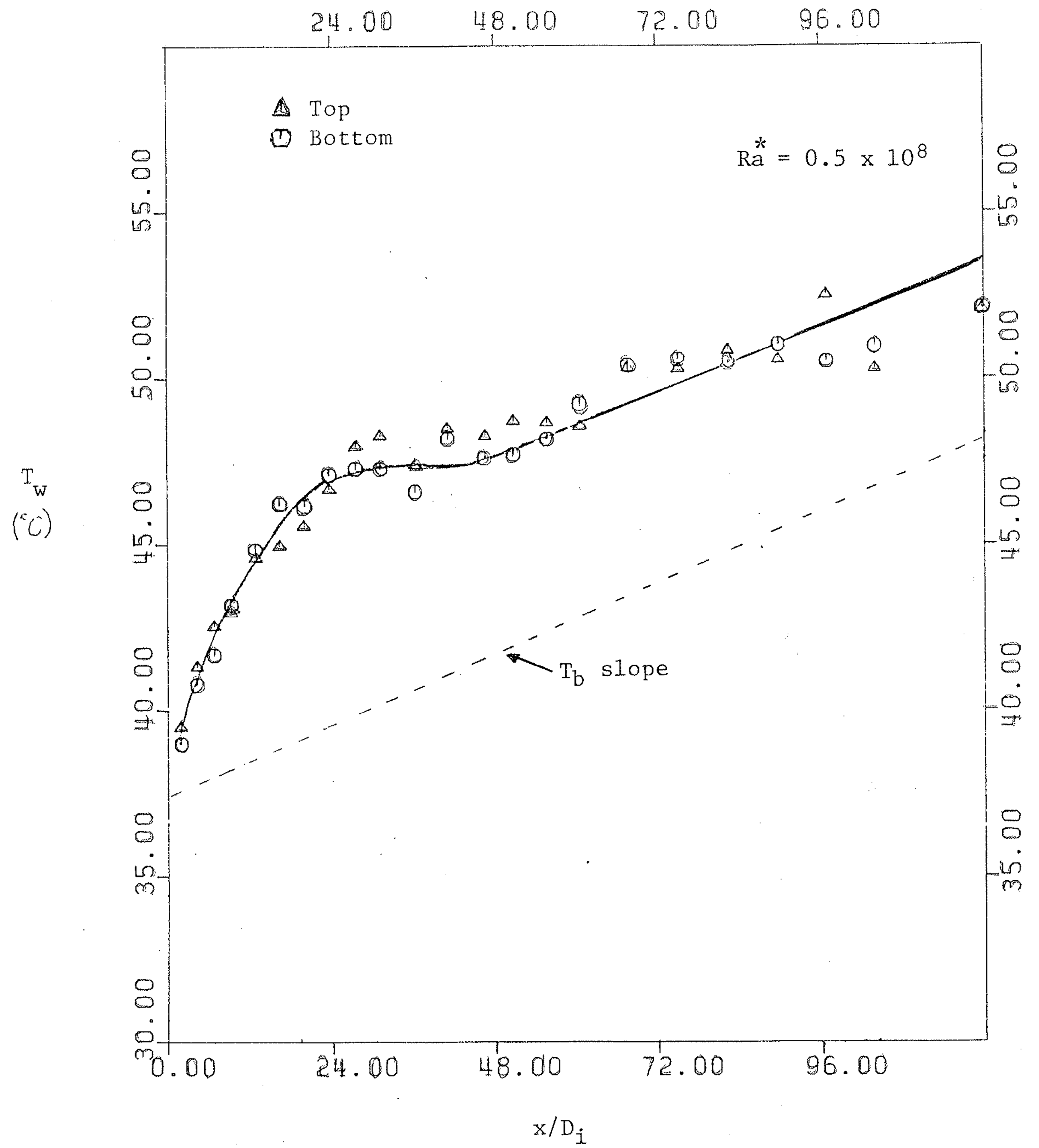


Figure 4.2(a) Axial wall temperature distribution for present smooth tube. Re_i = 3640.

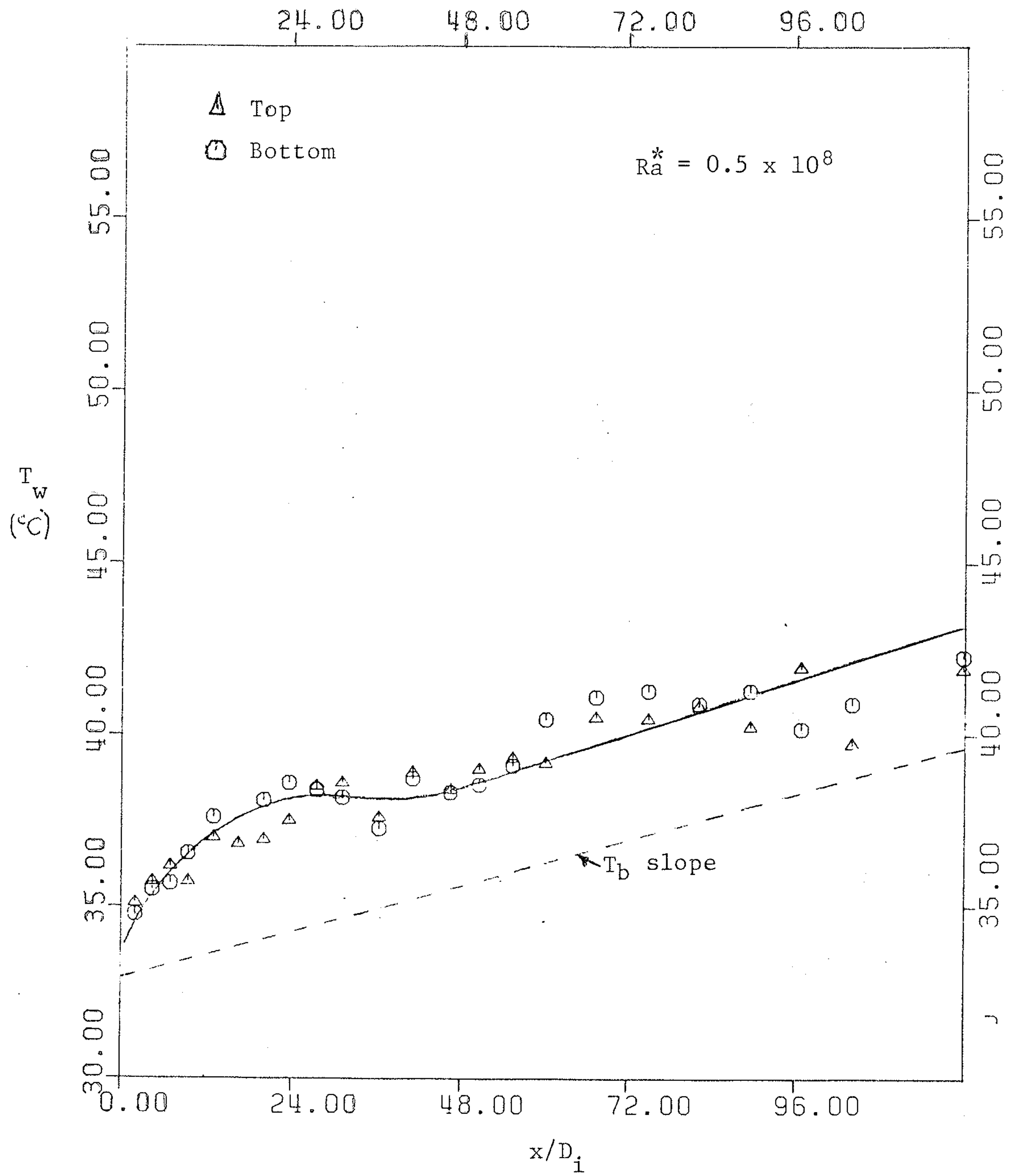


Figure 4.2(b) Axial temperature distribution for present smooth tube. $Re_i = 6240$

became negligible again. The secondary flows circulate fastest upon reaching a fully developed state, hence allowing for a more uniform temperature distribution over the tube perimeter. Figure 4.2b) shows a similar wall temperature over-shoot behavior at a higher Reynolds number, however, the data is more scattered and makes it difficult to suggest any effect of the Reynolds number on the secondary flow patterns.

4.1.2.2 Local Nusselt Numbers

Figure 4.3 shows the axial distribution of local Nusselt numbers at $Re_i \approx 3200$. In an attempt to support the argument in the above section, two plots at two different Rayleigh numbers are included. The graph clearly* shows higher Nusselt number values corresponding to the higher Ra^*. Note that the temperature difference reduction discussed earlier is displayed here by an increase in the Nusselt number at that particular axial distance. Also note that the difference between the two sets of data is minimal at the start of heating, but increases to reach a fairly uniform difference for all locations downstream of the $(\bar{T}_w - T_b)$ peak.

In order to determine the thermal entry length for the present smooth tube, Figure 4.4 is introduced. Two runs at two different Reynolds numbers (similar Ra^*) are shown. The effect of Reynolds number is evident as can be expected for water ($Pr = 5$-10). The thermal entry length values are approximated as $x/D_i \approx 12$ for $Re = 3640$ and $x/D_i \approx 9$ for $Re = 6240$. These values seem to be within expectations [35] and extrapolate favour-

* Strictly speaking, the present $\bar{N}u$ results for 15 tests having Re between 3000 and 7000 can be correlated to within about 2 percent by the equation $\bar{N}u/Pr)^{0.4} = 0.0054\ (Re_i)^{0.95}$. For the two cases shown in Figure 4.3, this equation predicts $\bar{N}u$ values of 22.95 and 24.20 compared to the experimental values 22.9 and 24.2, respectively. However, although this correlation does not contain an explicit Ra^* effect, because of the relatively narrow Ra^* range involved, free convection (or Ra^* effect) may well be imbedded in the coefficient 0.0054.

	Ra^*	Re	Pr	$\bar{Nu}$
⊙	0.796×10^7	3046	6.27	22.9
△	0.310×10^8	3388	5.56	24.2

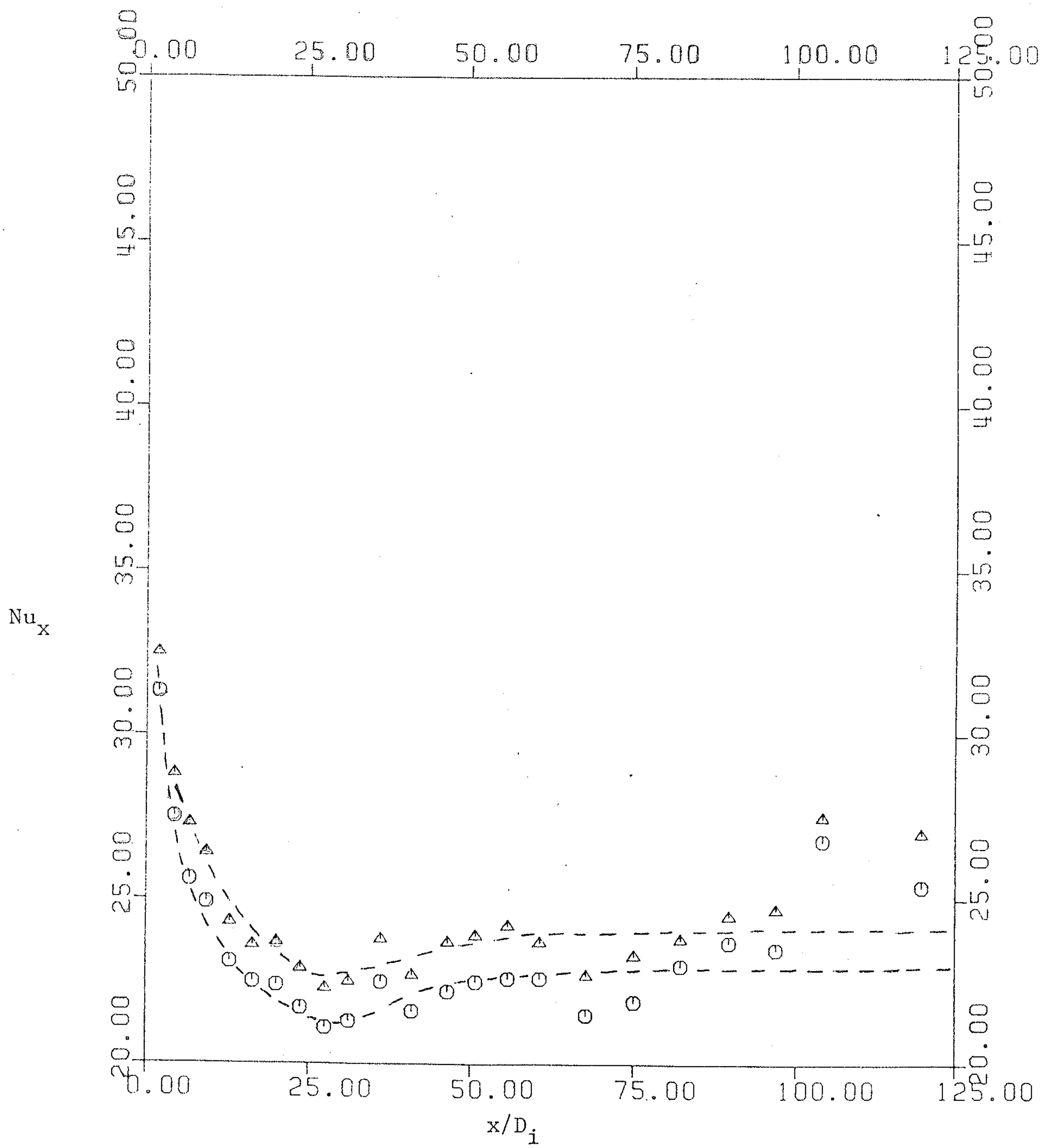


Figure 4.3 Effect of modified Rayleigh number on local Nusselt number for present smooth tube $Re_i \approx 3200$

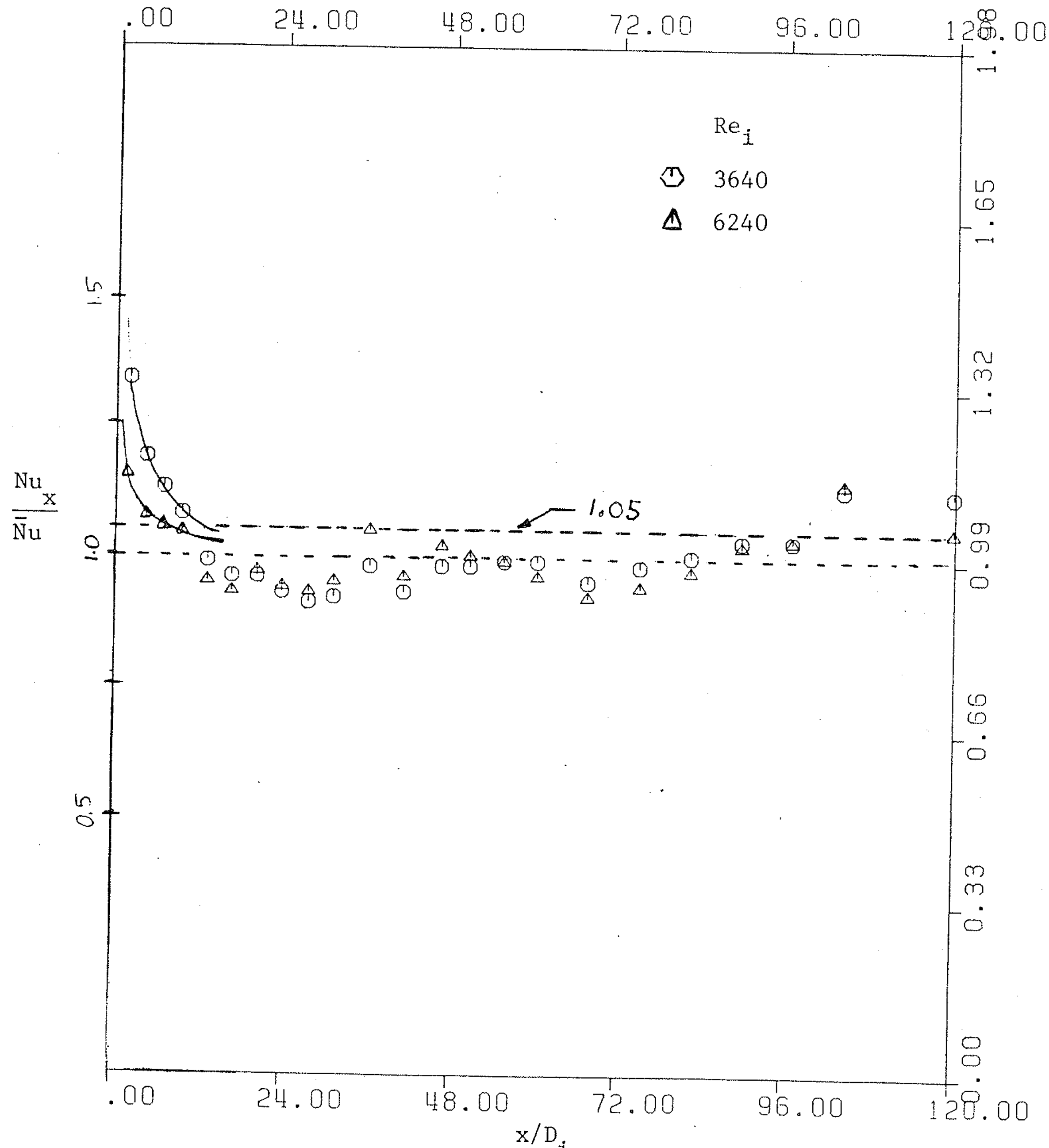


Figure 4.4 Thermal entry length for present smooth tube ($Ra^* \approx 0.49 \times 10^8$)

ably to the values reported in [37], viz. $x/D_i = 8$ for $Re_i = 10^4$ and $x/D_i = 5$ for $Re_i = 3 \times 10^4$. The same criteria used in both references was used here; i.e.: the thermal entrance length was evaluated as the distance required for the local Nusselt number to become no more than 5 percent higher than the fully developed Nusselt number.

4.1.2.3 Fully Developed Nusselt Numbers

Each fully developed Nusselt number was obtained by arithmetically averaging the last fourteen local Nusselt numbers, as per equation (4.2). These correspond to the values obtained after an axial distance of approximately $x/D_i = 30$. As can be seen from Figure 4.4, beyond this distance the local Nusselt numbers are more or less constant, characterizing a fully developed thermal region.

Figure 4.5 shows the results of the fully developed Nusselt number in the form of a graph of $Nu/(Pr)^{0.4}$ against Re_i. Reynolds number ranged from approximately 300 to 15,000. The term $(Pr)^{0.4}$ has been suggested by many researchers as a means of representing the effect of the variation of Prandtl number on the Nusselt number. The procedure has been adopted here for purpose of direct comparison with other investigators. Also shown in Figure 4.5 is some of the data obtained by Ede [4], together with the correlation lines of Dittus-Boelter (2.1) and Martinelli (2.2).

All of the present data in the range of Re_i=3000 to 15,000, fall below that predicted by both correlations, however, a better agreement with Martinelli's line is noted. At low Reynolds numbers ($Re_i \approx 3000$), the present results are about 20 percent lower than those predicted by Dittus-Boelter; however, the level of agreement improves at higher Reynolds number with differences of about 13 percent at $Re_i \approx 9000$. Data for higher Reynolds number could not be obtained, due to pump limitations.

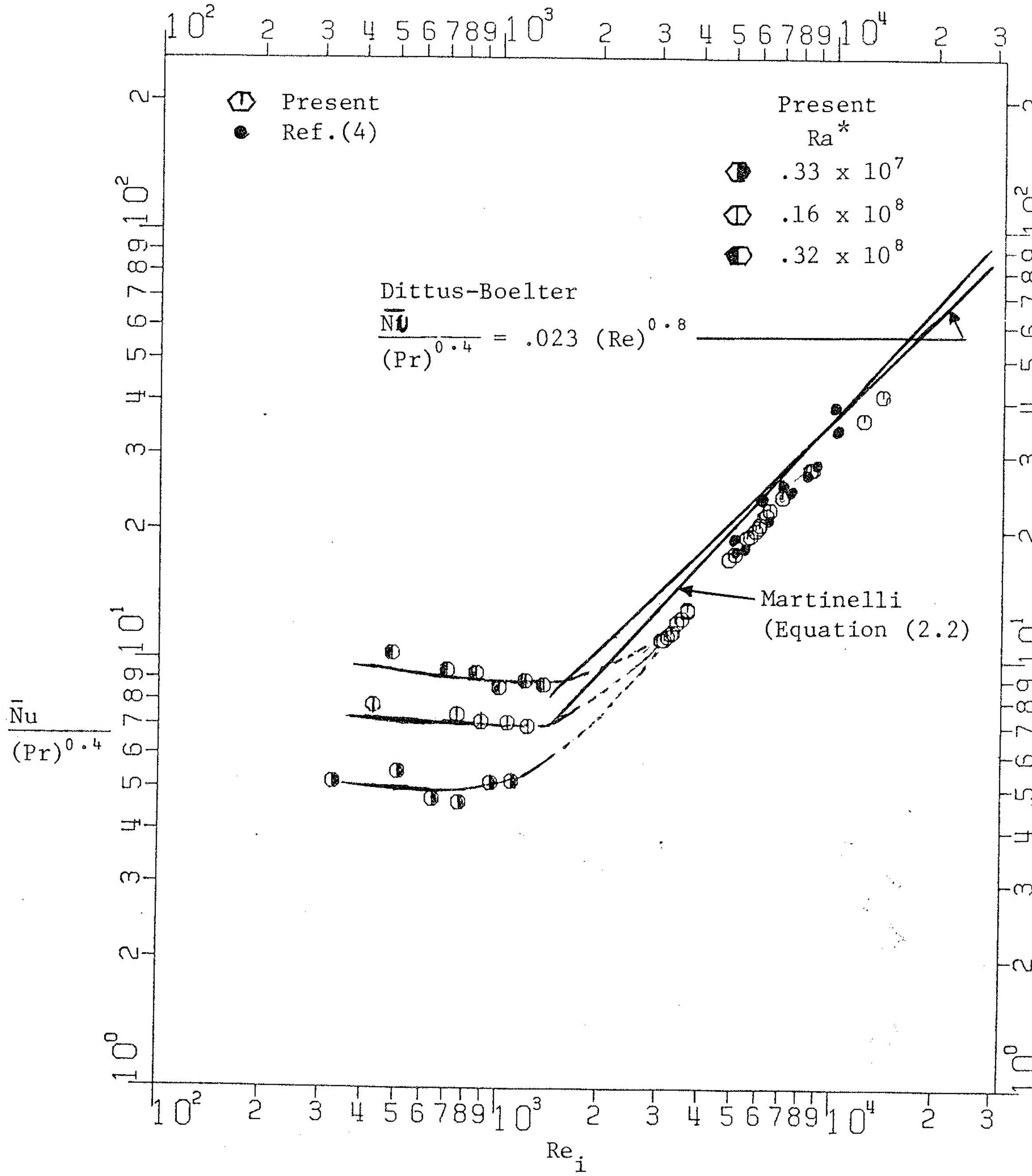


Figure 4.5 Fully developed Nusselt number for smooth tube

Therefore, comparison of the present data with that predicted by Dittus-Boelter equation (which was derived for Re > 10,000) is only tentative. It is common knowledge that in smooth tubes the flow is not considered fully turbulent until Re > 10,000. In some reports, e.g. [37], turbulence is considered to be effective for Reynolds number as low as 4000; however, no specific studies were conducted to determine the exact behavior of Nusselt number at such low Reynolds numbers.

Ede [4] collected data in a wide range of Reynolds number (500 - 100,000) and some of his results (for $5000 < Re_i < 10,000$) are included in Figure 4.5. Ede pointed out that results at such low Reynolds numbers were unstable (effect of which caused a more pronounced scatter of the data); however, most of his results at low Re are in good agreement with the present data.

Some results for laminar flow (Re < 2000) are also included in Figure 4.5 in an attempt to illustrate a transition pattern between laminar and turbulent regimes. The wide scatter of the data in the laminar regime was expected and was due to the much pronounced effect of free convection as compared with turbulent flow. Note that three sets of data are clearly distinguished corresponding to three different Ra^*. For each set, the Reynolds number has negligible effect, as expected for laminar flow. Even though there is insufficient data to clearly establish a transition pattern, an interpolation was attempted and is illustrated with dotted lines. As Re increases, the effect of Ra^* decreases (illustrated by the convergence of the dotted lines) to become minimal at high Re (turbulent flow). Note that in the turbulent region, two points far apart could have the same Ra^* (see Appendix C).

Friction factor and heat transfer characteristics in the laminar flow regime were extensively studied and reported by Rustum [3]. The same apparatus was used as for the present work. His results proved consistent with those of previous investigators. This, together with the present smooth tube results, proved sufficient to use with confidence the experimental set-up for studies on internally finned tubes.

4.2 INTERNALLY FINNED TUBES

The same testing procedure and data reduction described for the smooth tube were adopted for internally finned tubes. The results are also presented in the same manner as for the smooth tube.

4.2.1 Friction Factor Results

The axial pressure drop across the test section (1 m) was measured (with and without heating) as described in the previous chapter. The friction factor was calculated using equation (3.4). For the diabatic tests, all properties were evaluated at the average inlet - outlet bulk temperature. For the isothermal cases, pressure drops were measured at a constant inlet temperature of about 27°C.

Figure 4.6 shows the isothermal pressure drop results with the friction factor and Reynolds number evaluated using the hydraulic diameter (D_h). For each tube, a sharp* change in slope occurs to indicate the transition from laminar to turbulent flow. For each tube, transition occurs at a Re_h value which is significantly lower than the commonly accepted value of 2100 to 2300 for smooth tubes. The critical Reynolds numbers (on the basis of both D_h and D_i) are listed in Table 3. Tube No. 14 (smallest H) has the highest Re_{cr}, whereas tube No. 13 (largest H) has

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* Except perhaps for Tube No. 13.

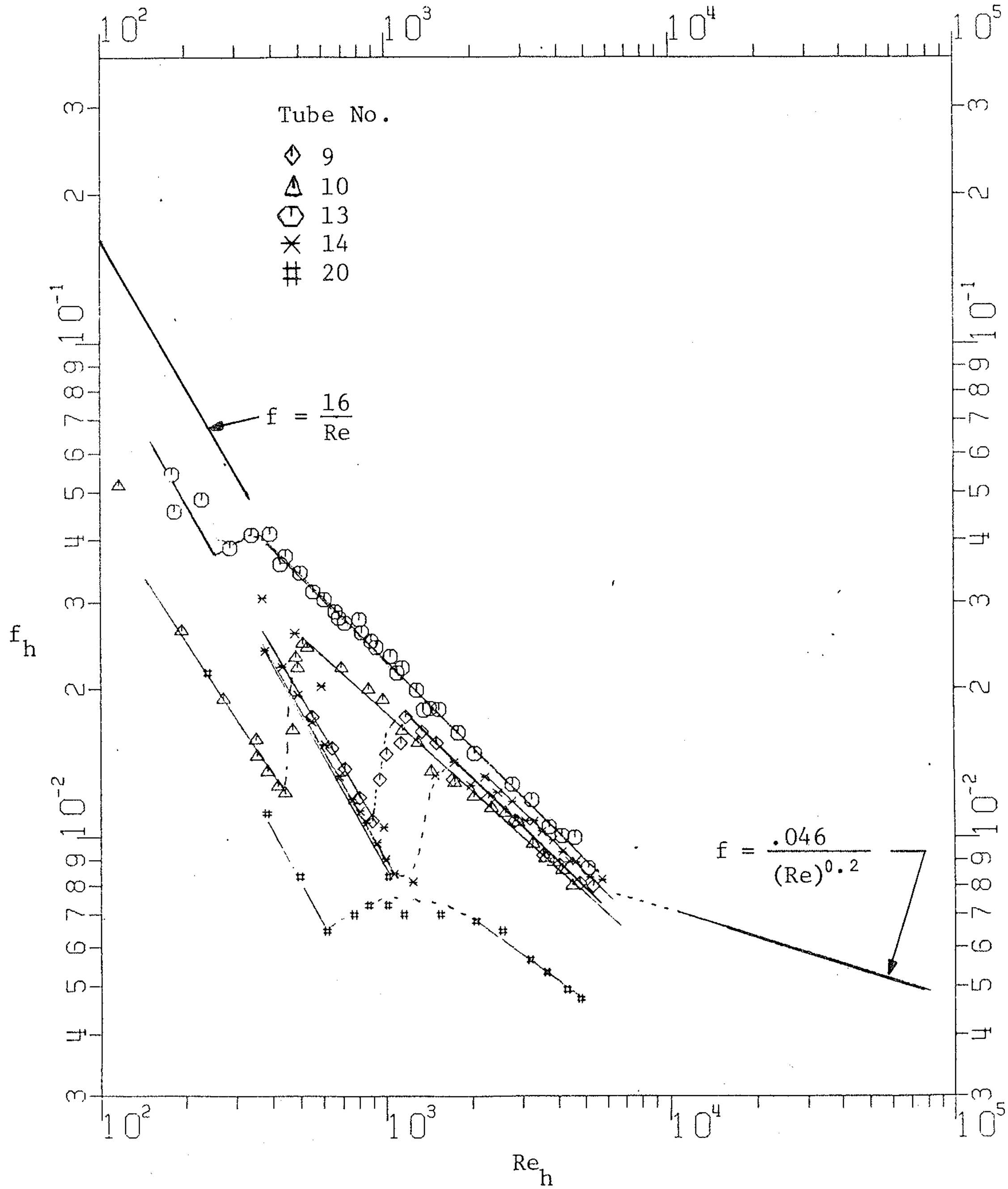

Figure 4.6 Isothermal friction factors for internally finned tubes (based on hydraulic diameter)

TABLE 3

CRITICAL REYNOLDS NUMBERS BASED ON THE INSIDE AND HYDRAULIC DIAMETERS

Tube Number	H	M	$(Re_{cr})_i$	$(Re_{cr})_h$
9	0.248	10	1530	810
10	0.318	16	1300	440
13	0.325	10	600	289
14	0.216	10	2130	1249
20	0.282	16	1465	593

the lowest Re_{cr}. Both of these tubes have 10 fins. In fact, the data presented in Table 3 shows (for fixed fin number, M) that Re_{cr} decreases substantially with increasing relative fin height, H. This same trend was noted by Watkinson et al, [26]. Regarding the effect of M on Re_{cr} (for fixed H), the limited data suggest no influence for $H \approx 0.25$, but for higher fin heights ($H \approx 0.32$), increasing M seems to cause a modest increase in Re_{cr} . The present critical Reynolds number data are plotted against $(\ell/D_h)^*$ in Figure 4.7, together with the results reported by Watkinson et al, [26]. The appropriate tube number is listed adjacent to each of the five data points in Figure 4.7 for identification purposes. The straight line from [26] represents the spiral finned tube data. This line shows Re_{cr} to decrease with increasing (ℓ/D_h); whereas for low H, Re_{cr} approaches the conventional value for smooth tubes. The data for straight fins from [26] and the present results for tubes 9, 10 and 14 (straight fins), all lie above the Watkinson spiral fin line. Tube 20 (spiral) is also above the line, but is near to some of the high spiral data of [26]. On the other hand, tube 13 (straight fins) lies slightly below the line. The reason for this is not apparent; however, it is noted that tube 13 had the largest H and thickest fins of the batch, and its laminar-turbulent transition was the least abrupt (see Fig. 4.6). Finally, the theoretical predictions of Maslijah and Nandakumar [38] for straight finned tubes for $0.065 \leq (\ell/D_h) \leq 0.22$, is also shown in Figure 4.7. Tubes 9 and 14, which fall in, or near, this (ℓ/D_h) range, show good agreement as do most of the straight fin data of [26].

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* Note that $(\ell/D_h) = H/(D_h/R_i)$ where $D_h/R_i = f(M,H)$.

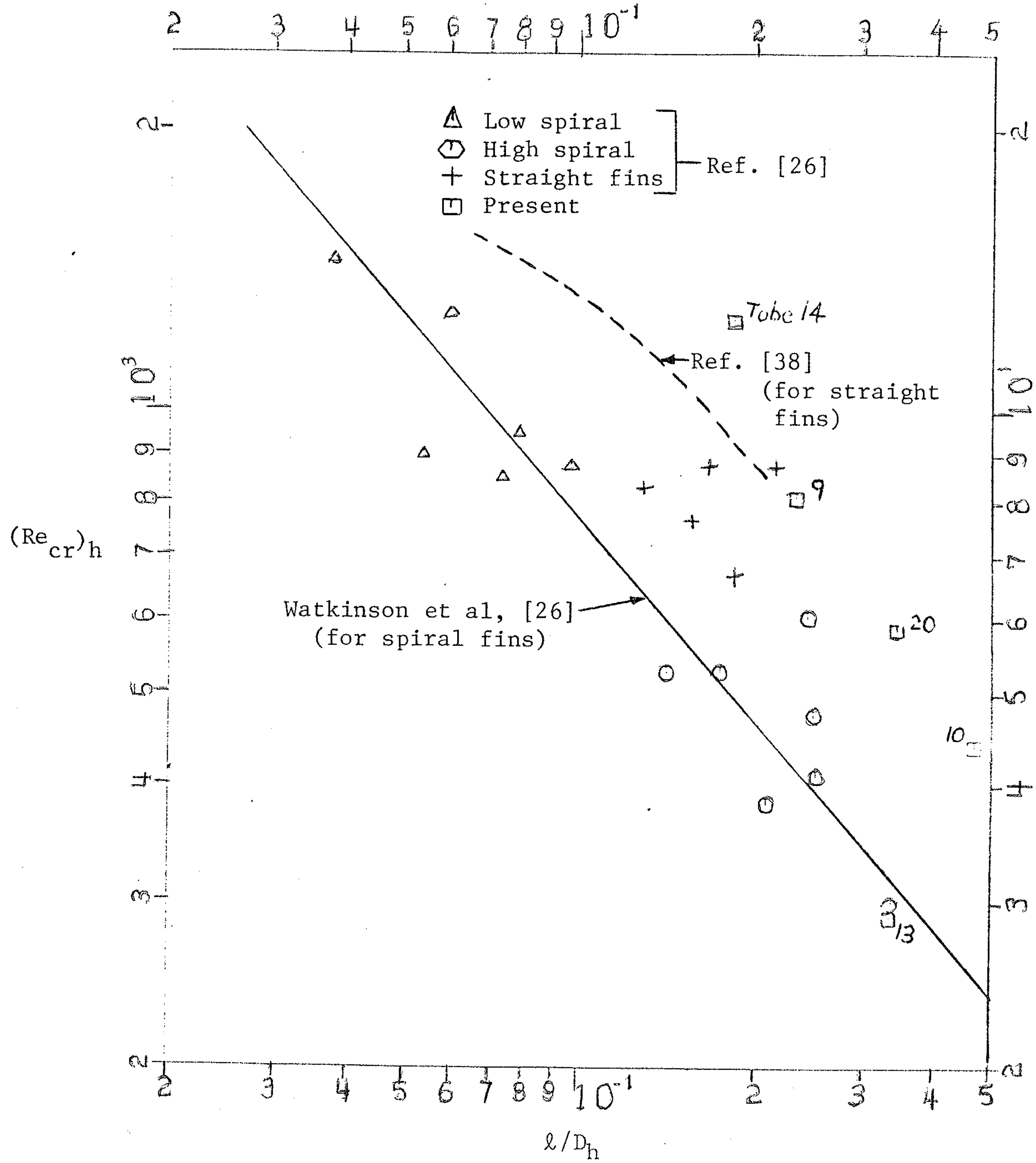

Figure 4.7 Critical Reynolds numbers for internally finned tubes

Returning to the data shown in Figure 4.6, friction factors in the laminar flow region were lower than predicted by the theoretical equation for smooth tube ($f = 16/Re$), but no particular trend was noted with respect to the fin height. The effect of the number of fins could not readily be determined for there was insufficient data, but a close examination of the data for both tubes 10 and 20 (both with 16 fins) reveals that they are by far most detached from the rest. Therefore, it might be suggested that the equivalent hydraulic diameter concept becomes less valid (in rationalizing the geometry difference between smooth tube and internally finned tubes) as the number of fins increases. At the same time, however, the fitted lines for the various tubes in the laminar region all have similar slopes, which are about the same as that for smooth tubes. Hence the customary dependence of f_h on Re_h is preserved. This fact has been reported by several previous investigators, e.g. [24,26].

For the turbulent flow region, as shown in Figure 4.6, the present low turbulent Reynolds number data deviate considerably from that predicted by equations (3.5) or (3.6), the accepted correlations for smooth tubes. Of course, these correlations are applicable for $Re > \sim 10^4$, a range that could not be attained in the present experiments due to pump limitations. The fitted curves for the various tubes show close similarity in slope. This slope suggests a Reynolds exponent of about 0.55 (versus 0.25 to 0.20). As noted in Section 4.1.1, a similar slope was obtained for the present smooth tube for $Re < 6000$. Furthermore, (and more importantly), a close examination of the friction factor results of previous investigators for $5000 < Re_h < 10^4$, readily shows that higher slopes were observed in this Re_h interval (see e.g. [17,18,19,20,24]). In particular, the f_h versus Re_h plots of Watkinson et al, [19] clearly show higher slopes in this Re_h interval and changes in slope at $Re_h \approx 10^4$ to the familiar Blasius slope. Hence it is believed for the present internally finned tubes, that the slopes would approach 0.25 to 0.20 as Re_h approaches $\sim 10^4$. Direct evidence of this is contained in Figures 4.8 and 4.11; note the Carnavos [23] slope is 0.20 (see equation (2.10)]. This matter is discussed further later in this section.

Isothermal friction factor results, based on hydraulic diameter are presented individually in Figures 4.8 to 4.12 for each tube, together with the corresponding data collected while heating. All of the friction factors with heating fell within ± 10 percent of the isothermal values, being generally slightly higher. As observed in Section 4.1.1, the diabatic friction factors were expected to be slightly lower than the isothermal ones, due to a drop in the fluid viscosity near the heated surfaces. The discrepancy is probably due to free convection effects. Most of the present data (with heating) were collected at a Ra^* of the order of 0.11×10^5 to 0.54×10^7, a fact that suggests the presence of secondary flows strong enough to overcome the viscosity effect. This argument is supported by the following observations. Data for tubes 9 and 14 correspond to the highest values of Ra^*, resulting in higher diabatic friction factors than isothermal ones, as shown in Figures 4.8 and 4.11. Data for tube 10 correspond to the lowest values of Ra^* resulting in lower diabatic friction factors, as shown in Figure 4.9. Similar effects (but much more pronounced) were observed in the laminar flow results of Rustum [3]. Bergles et al, [18] reported that their diabatic friction factors were slightly lower than the isothermal friction factors, but an attempt to determine the dependence of μ_w/μ_b on f_{dia}/f_{iso} was inconclusive. Watkinson et al, [19]

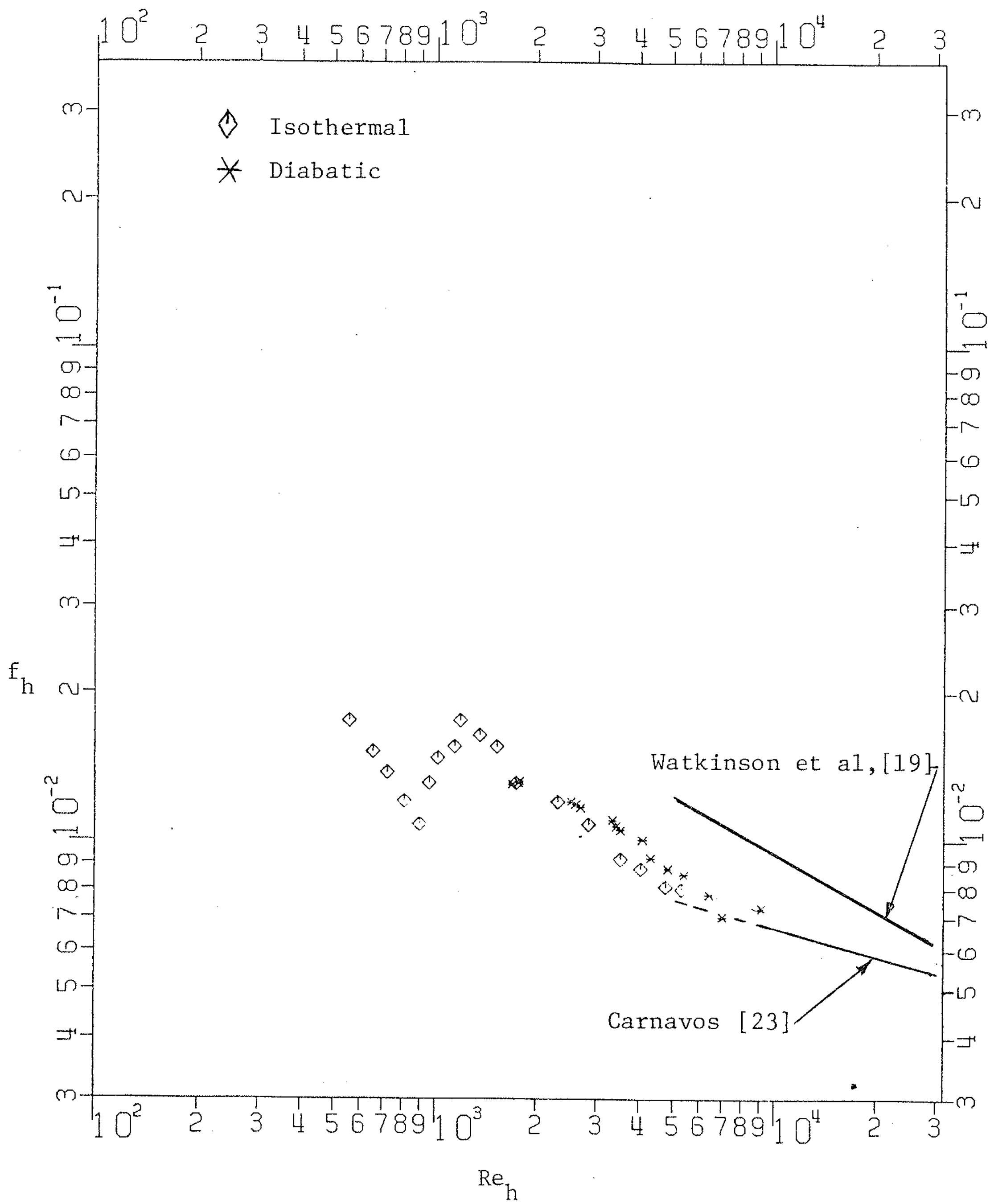

Figure 4.8 Friction factor for Tube No. 9

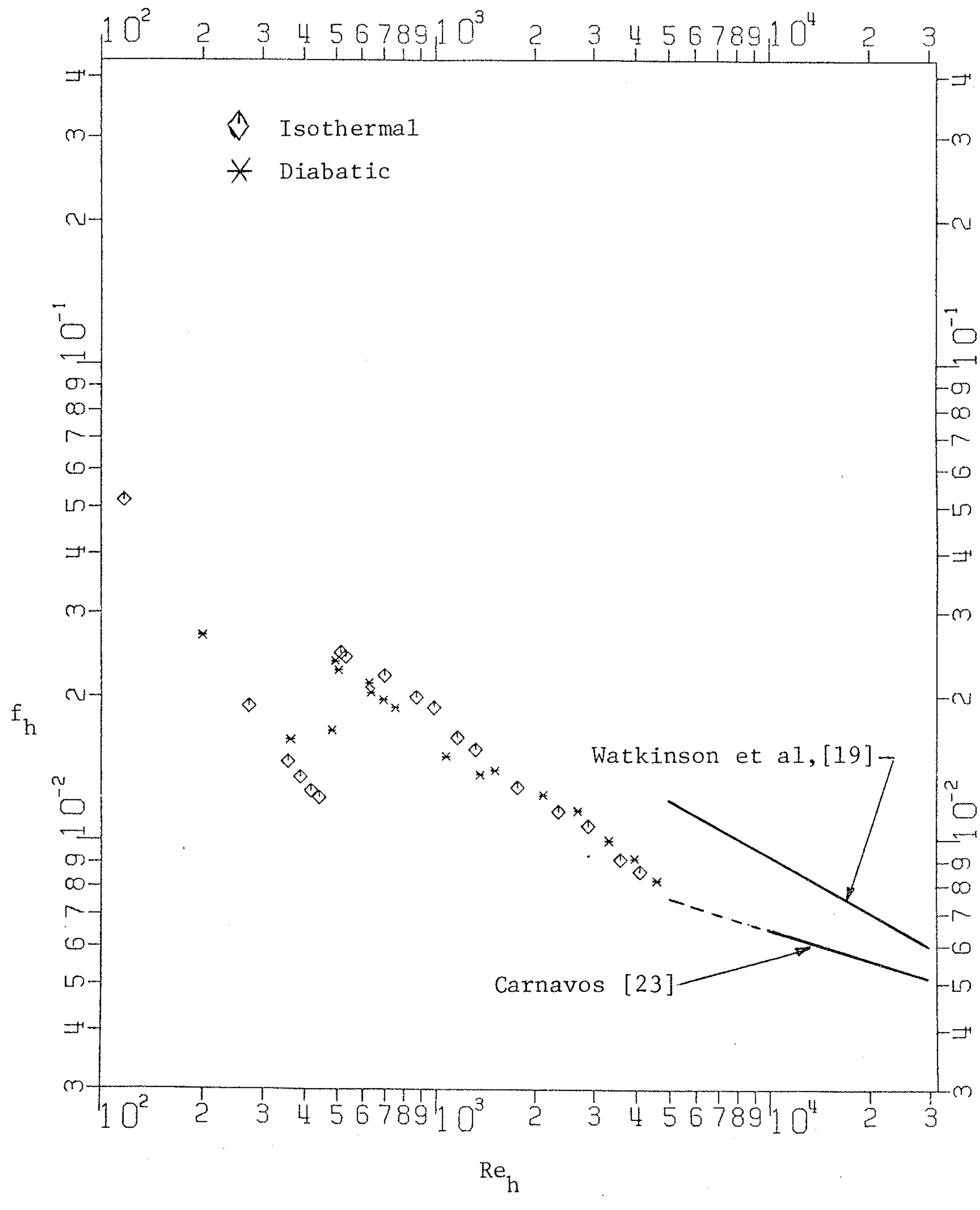

Figure 4.9 Friction factor for Tube No. 10

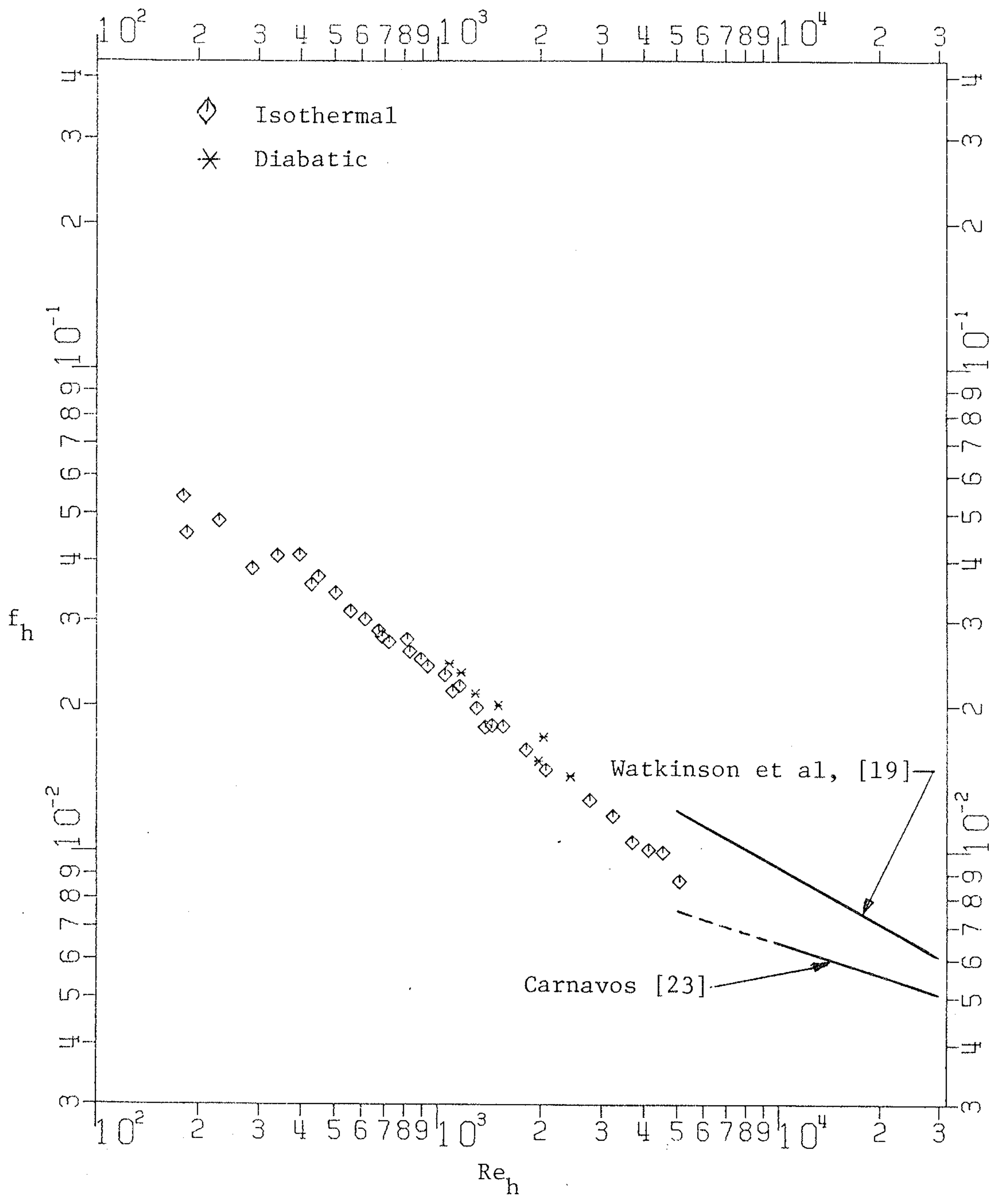

Figure 4.10 Friction factor for Tube No. 13

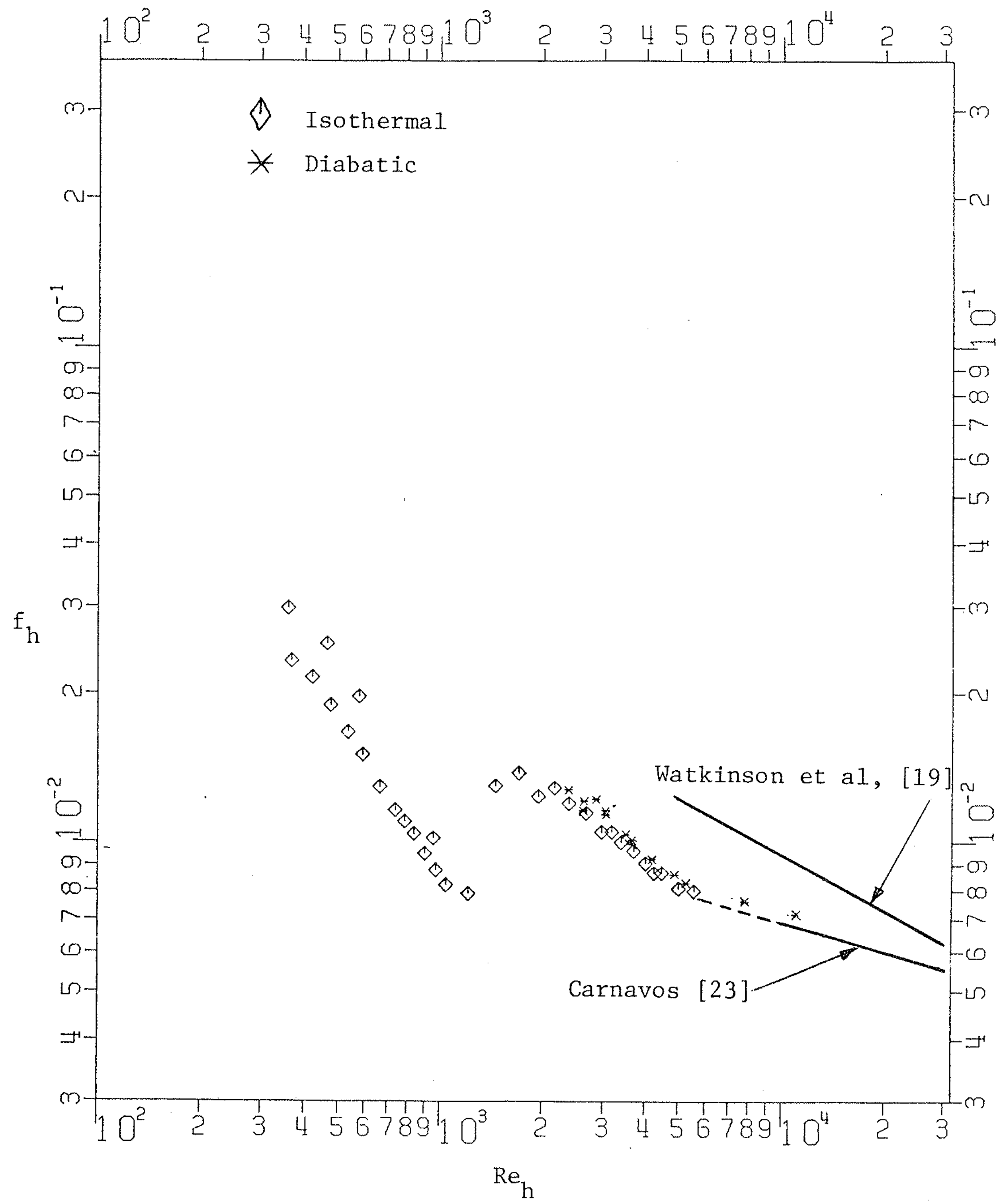

Figure 4.11 Friction factor for tube No. 14

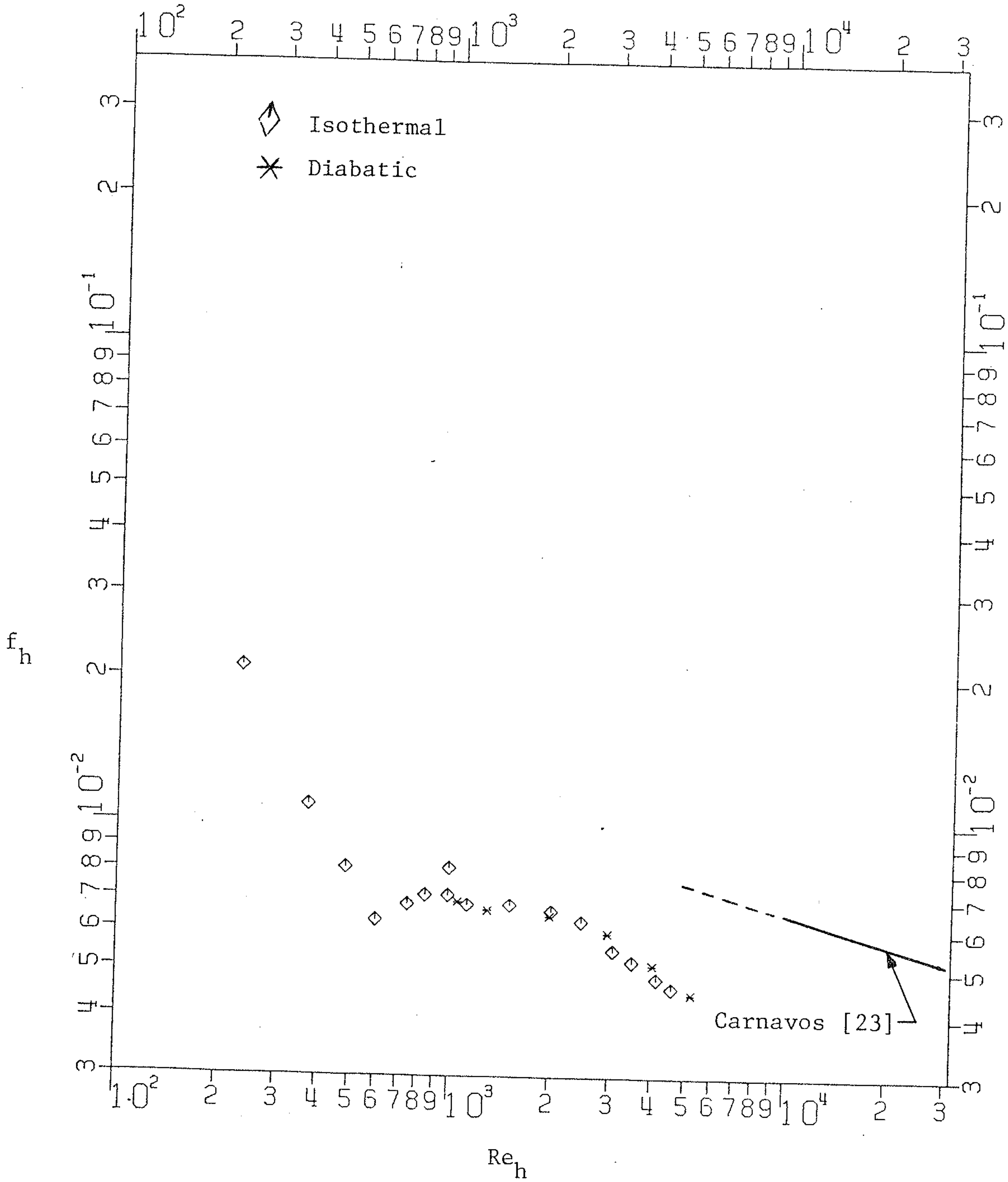

Figure 4.12 Friction factor for Tube No. 20

also found f_{dia} to be 5 percent to 10 percent lower than f_{iso}. However, both of these studies involved heating water with a constant temperature boundary condition (condensing steam), hence compared to the present uniform heat flux boundary condition, free convection effects would be both less and different.

It is noted next that due to a decrease in viscosity while heating, the range of the f_h data was extended up to a value of $Re \approx 10^4$ in some cases. This allowed for a clear observation of the eventual change of slope mentioned earlier in this section. For both tubes 9 and 14 (tubes with lowest fin heights), the variation of the diabatic friction factors with Reynolds number was of a similar nature (same slope) than that obtained with isothermal runs at $Re_h < 6000$, however, beyond that value (range for which isothermal data was not available), the diabatic friction factors flattened out to attain a slope of about 0.2 (see Figs. 4.8 and 4.11). This effect did not occur for tubes 10 and 13 (tubes with the highest fin heights)(see Figs. 4.9 and 4.10), but of course the data is confined to $Re_h < \sim 6000$.

The same general characteristics discussed above were found to apply to tube 20 (spiral tube)(Fig. 4.12). However, the actual values of friction factors were much lower than expected. Experiments on this tube were repeated several times in an attempt to detect a possible measurement error, but in vain.*

The dimensions of this tube raised suspicion as different investigators used different techniques in measuring the same tube, and came up

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* Carnavos [39], for another similar situation, has questioned whether true static pressure could be measured with wall taps in the finned section of a spiral finned tube; but it seems unlikely that peripheral variations in pressure could be that significant.

with different dimensions. Dimensions provided by the manufacturer were used here.

The present friction factor results are compared in Figures 4.8 to 4.12 to the correlations of Watkinson et al, [19] and Carnavos [23]. For the Watkinson correlation for straight fins [equation (2.5)], the present fins were modelled as trapezoidal in profile and the inter-fin spacing (b) was calculated as the average of the arc lengths at the root and tip of adjacent fins. All (b/D_h) values were within the correlation range. As can be seen in the figures, the present results fall substantially below the predictions of equation (2.5). At $Re_h = 5000$, the present isothermal friction factors are about 35 percent lower for tubes 9, 10 and 14, and about 28 percent lower for tube 13 (thickest fins). The discrepancies may be due to differences in fin thicknesses and/or surface finishes. Alternatively, it may be that equation (2.5) does not serve well at low Re_h. In any case, the agreement with Carnavos [23] is much better. The Reynolds number range for this correlation for diabatic friction factor for both straight and spiral finned tubes [equation (2.10] was $\sim 10^4$ to $\sim 10^5$, however the correlation was extrapolated down to $Re_h = 5000$ for comparison purposes. At $Re_h \approx 5000$, the present diabatic results for tubes 9, 10 and 14 are only slightly higher than [23] by about 5 percent at most, whereas the isothermal results for tube 13 is about 20 percent high. Tube 20 is about 40 percent low, however as noted earlier, the geometric specification for this tube may be in error. Rustum [3] encountered a parallel discrepancy for this tube under laminar flow conditions.

In the preceding presentation and discussion, friction factor and Reynolds number were based on equivalent hydraulic diameter, as is customary for non-circular ducts. It is also possible to recast the same experimental data in terms of finned tube inside diameter (D_i). This approach is popular (e.g. [32]) for internally finned tubes under laminar flow conditions. The concept is used to indicate directly the change in pressure drop to be expected if an existing smooth tube is replaced by an internally finned tube of the same inside diameter carrying the same mass flow rate. The present isothermal friction factor results, based on inside diameter are shown in Figure 4.13. As expected, friction factor values for all tubes tested are higher than those predicted for smooth tubes at the same Reynolds number for both laminar and turbulent flows. Close examination of the curves shows a strong dependence of f_i on relative fin height (H) for laminar flow and a similar degree of dependence for turbulent flow. However, the effect on f_i of the number of fins (M) appears much more pronounced in turbulent flow compared to laminar flow. This is evident when comparing the results for tubes 10 and 13 (similar H but M = 16 and 10 respectively), in both flow regimes. For each finned tube in laminar flow, f_i varies inversely with Re_i (like the smooth tube). As shown by Rustum [3], the present f_i Re_i values compare well (except for tube 20) with the predictions of Soliman and Feingold [32]. The increase in f_i Re_i over the smooth tube value (16) was highest for tube 13 (H = 0.325, M = 10) and lowest for tube 14 (H = 0.216, M = 10). The experimental f_i Re_i values were 47.4 and 25.3 respectively, which illustrates the strong dependence of f_i Re_i on H in laminar flow. For turbulent flow, the five f_i versus Re_i lines have similar slope indicating (as in Fig. 4.6) a Reynolds exponent of about 0.55. The results here require no further discussion, and have already been compared to existing correlations on a D_h basis.

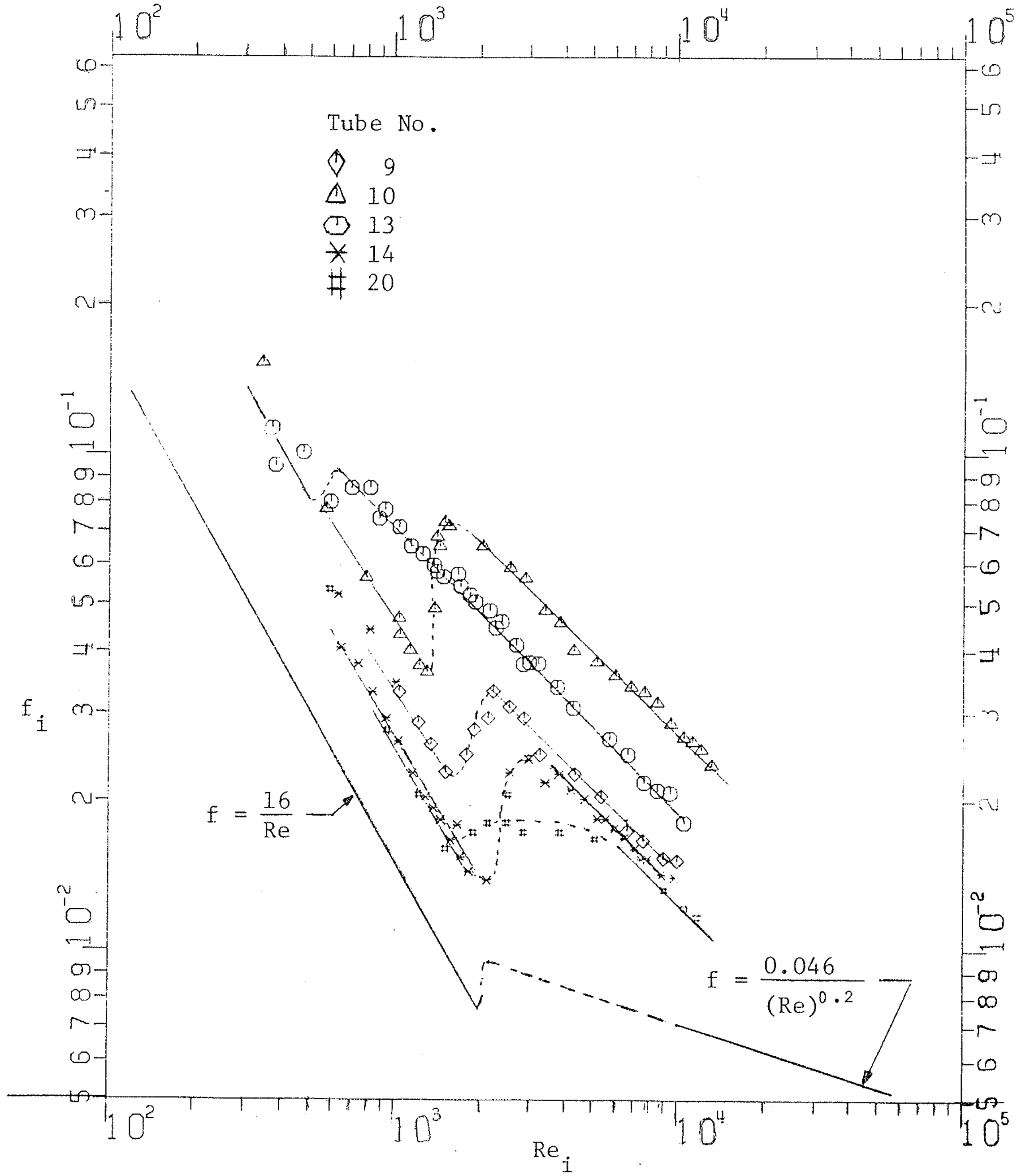

Figure 4.13 Isothermal friction factor for internally finned tubes (based on inside diameter)

4.2.2 Heat Transfer Results

4.2.2.1 Wall Temperatures

Two samples (at two different Re_h) were selected for each of tubes 9 and 14 and the results are presented in Figures 4.14 and 4.15. Data for other tubes has not been included here, since the wide scatter of the local wall temperatures made it impractical for presentation. Each plot shows top and bottom temperatures in an attempt to detect the presence of secondary flows, as was pointed out for the smooth tube.

In both Figures 4.14 and 4.15 the same qualitative behavior encountered with the smooth tube (Fig. 4.2) is observed here in that a small wall-fluid temperature depression occurs at a certain length from the start of heating. The axial position at which this phenomena occurs ($x/D_h \approx 32$) appears to be about the same as for the smooth tube, even though hydraulic diameter is used to determine the dimensionless length. Unlike the smooth tube, the wall temperature does not over-shoot, hence the subsequent temperature depression is much less pronounced than for the smooth tube. Also the difference between top and bottom temperatures is negligible. This suggests that the presence of fins tend to minimise the effect of secondary flow. It is also noted that there is no obvious effect of Reynolds number on the two patterns. Data of this nature for internally finned tubes are not available in the literature.

4.2.2.2 Local Nusselt Numbers

Local Nusselt numbers (average of top and bottom) are plotted against reduced length (X^+) for tubes 9 and 14 in Figures 4.16 and 4.17, respectively. In an attempt to determine the effect of free convection, two plots at different Ra^* but similar Re_h are included in each figure. Each tube involved

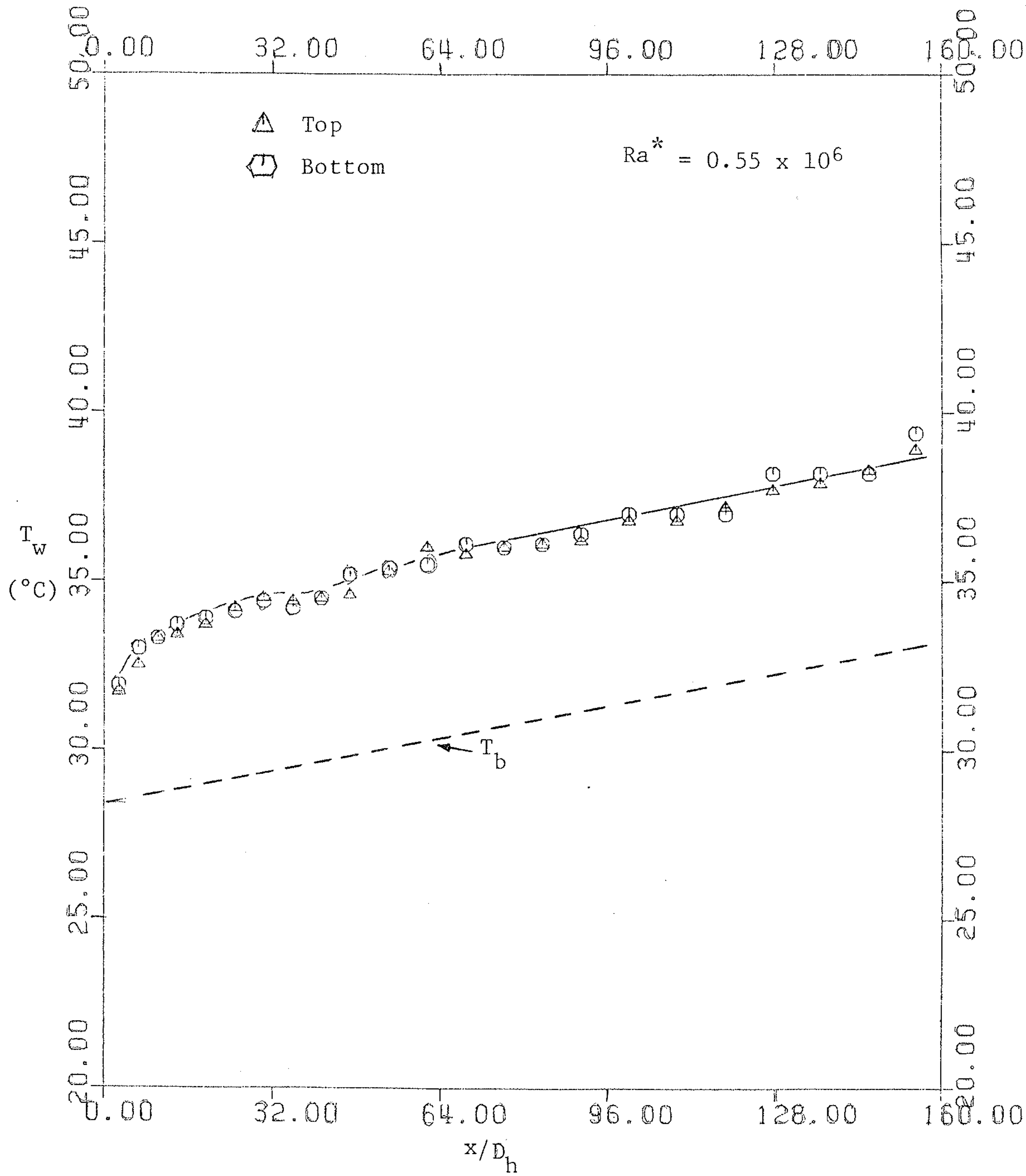

Figure 4.14(a) Axial wall temperature distribution for Tube No. 9. $Re_h = 3260$.

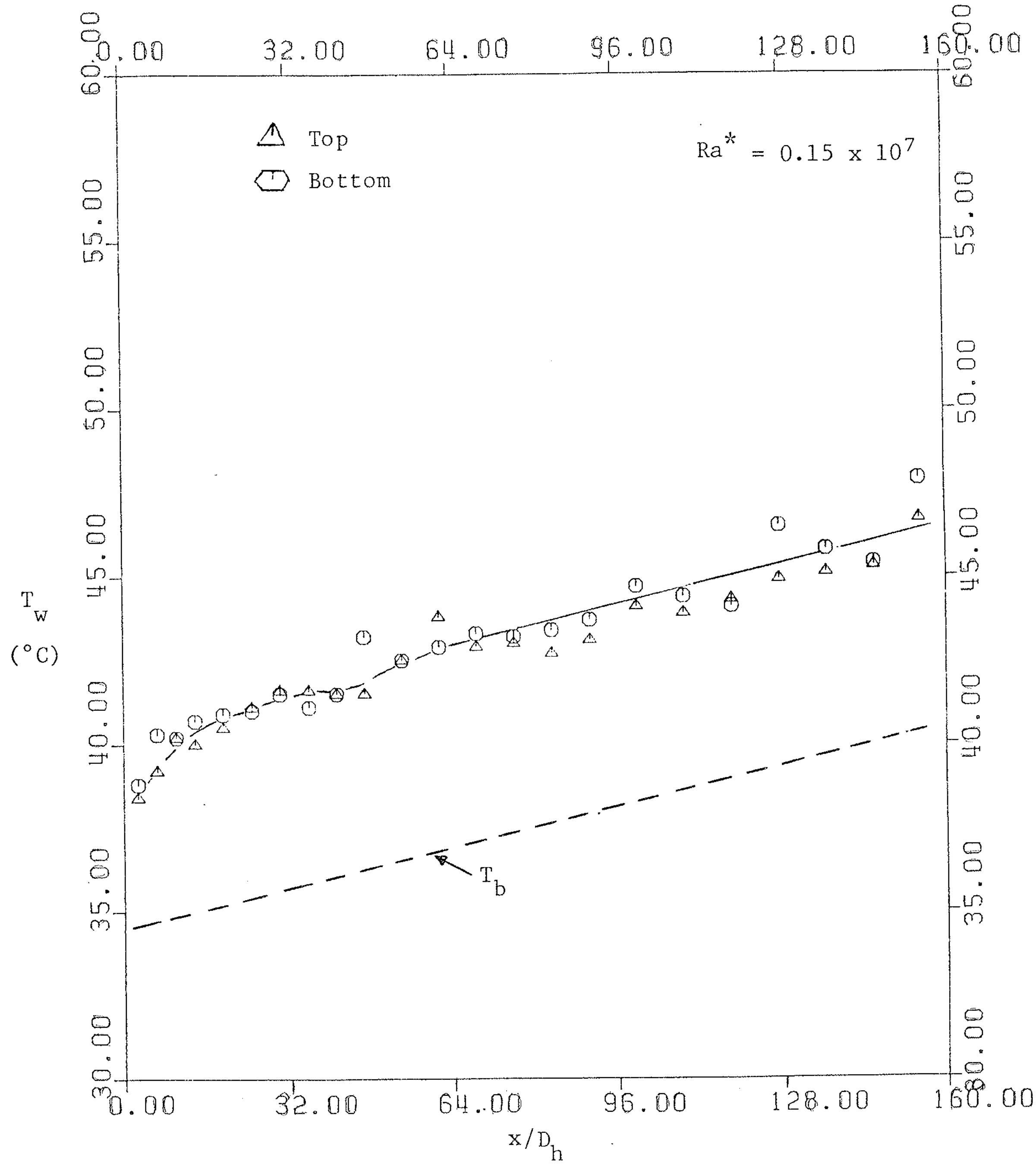

Figure 4.14(b) Axial wall temperature distribution for Tube No. 9. $Re_h = 6250$.

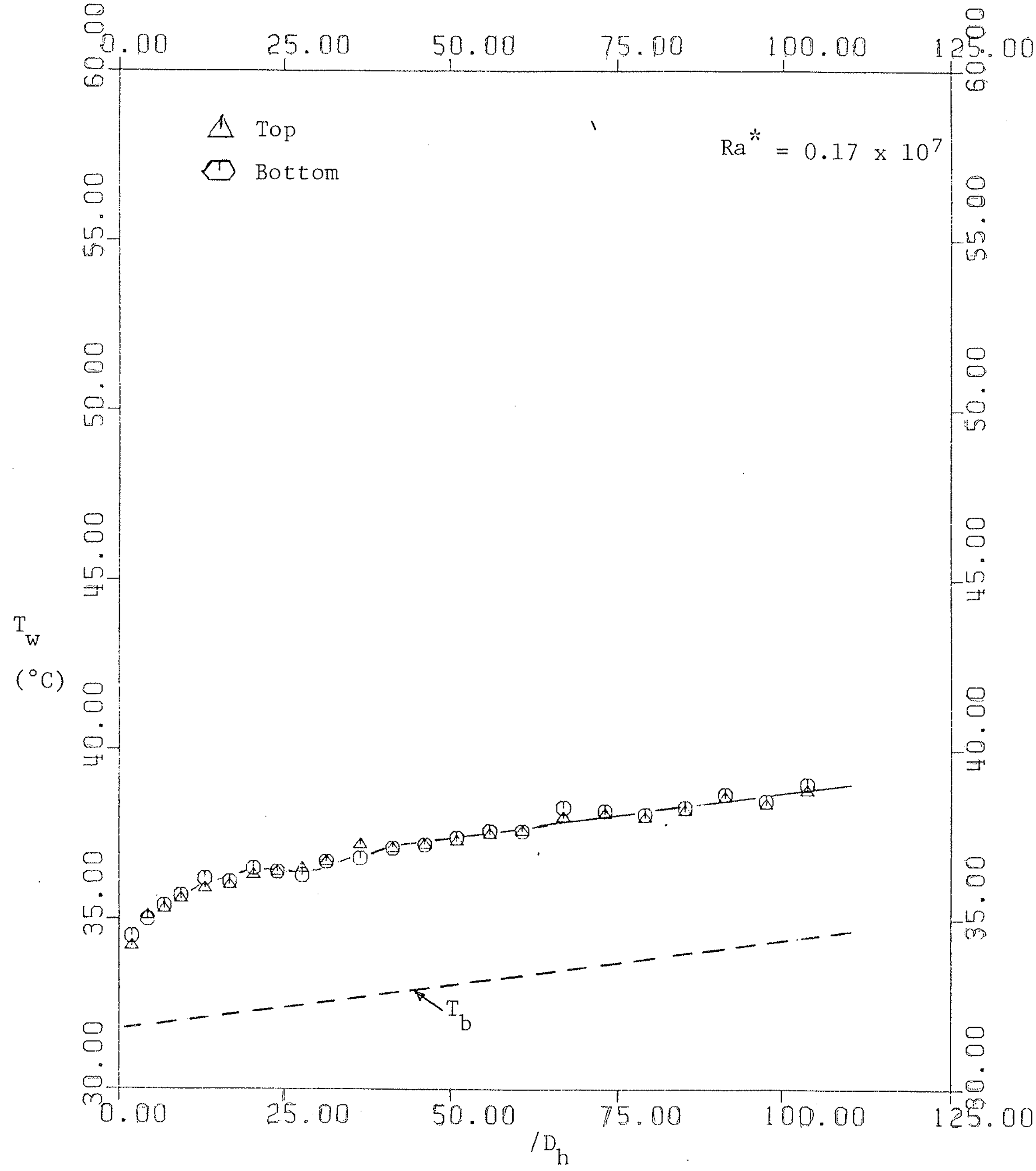

Figure 4.15(a) Axial wall temperature distribution for Tube No. 14. Re_h = 3410.

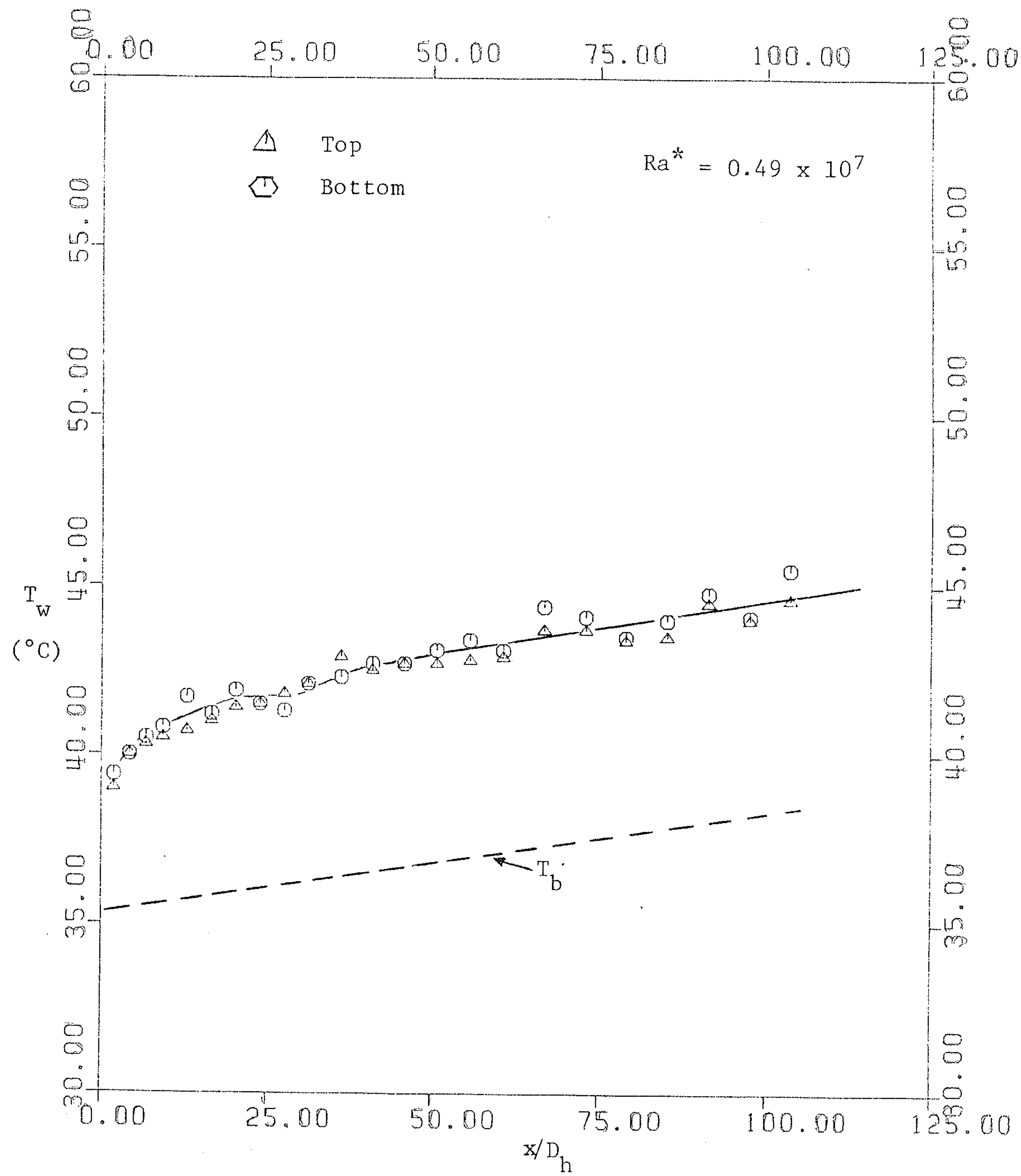

Figure 4.15(b) Axial wall temperature distribution for Tube No. 14. Re_h = 7620.

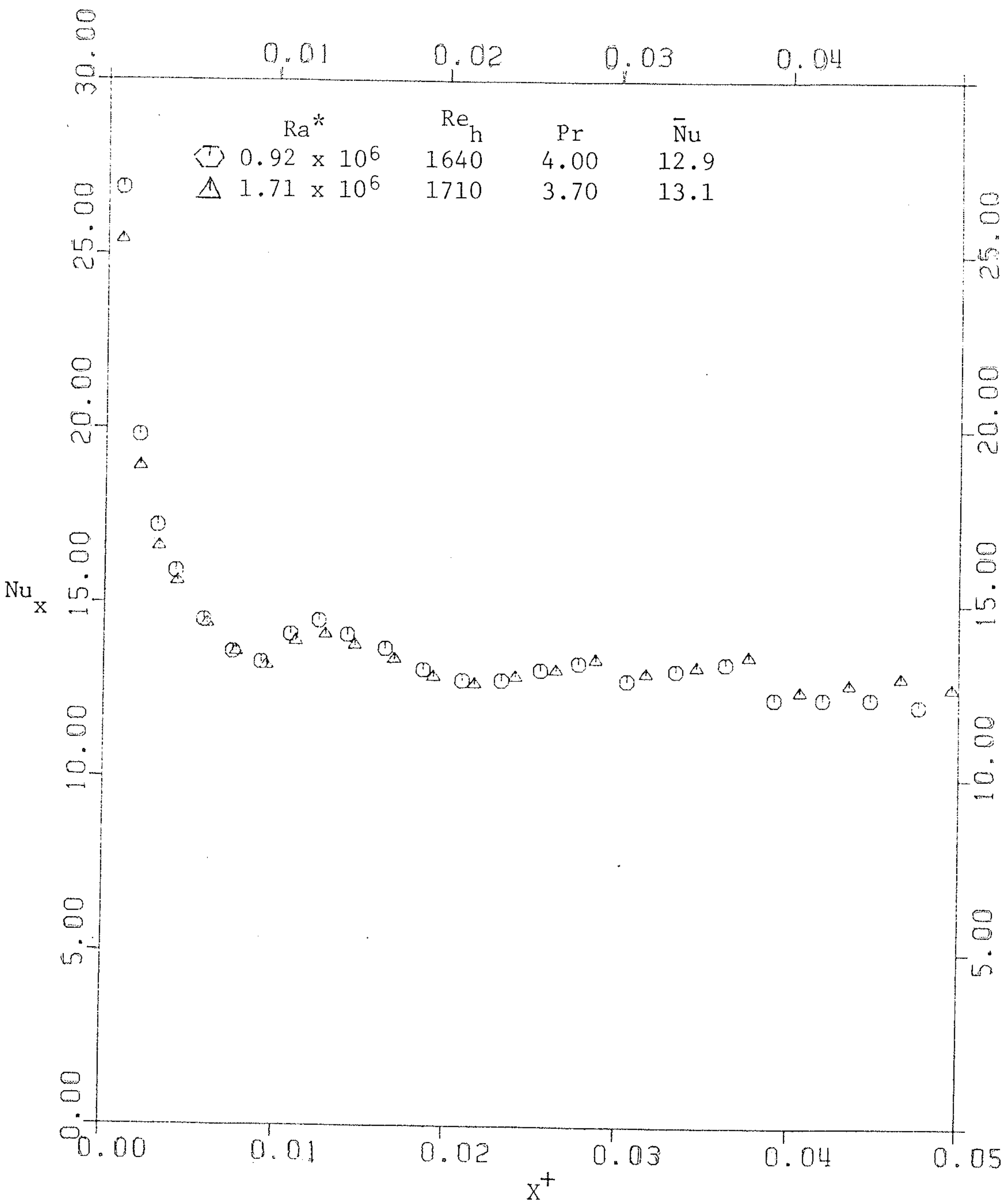

Figure 4.16 Effect of Rayleigh number on local Nusselt number for Tube No. 9. $Re_h \approx 1680$.

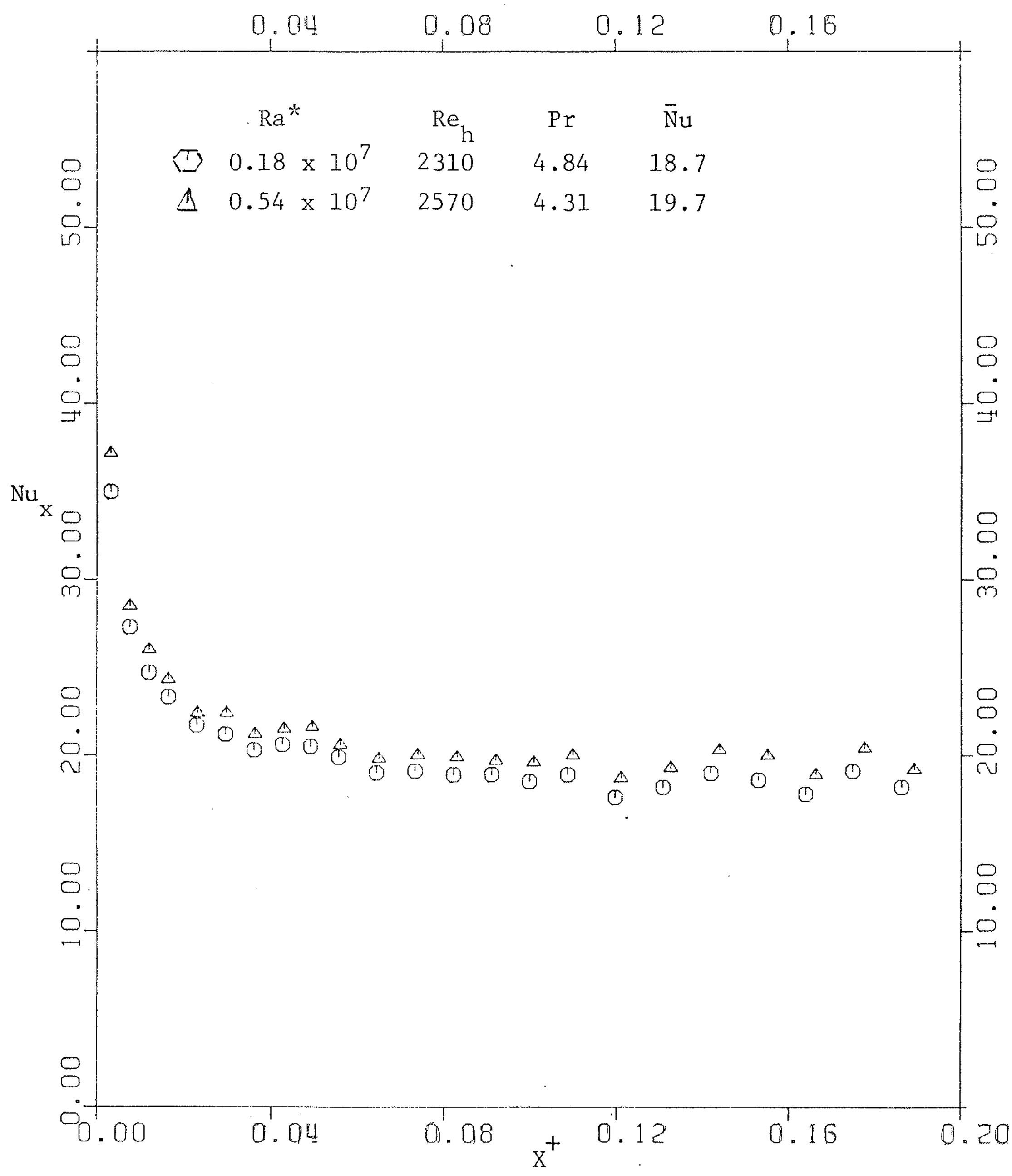

Figure 4.17 Effect of Rayleigh number on local Nusselt number for Tube No. 14. $Re_h \approx 2440$.

$M = 10$ and low H. For tube 9 (Fig. 4.16; $H = 0.248$), the Ra* differences are by a factor of about 2. For tube 14 (Fig. 4.17; $H = 0.216$), the Ra* levels are higher and differ by a factor of about 3. For tube 9 (larger H, but smaller Ra* difference), Figure 4.16 shows no significant difference between the two sets of data. For tube 14, Figure 4.17 shows higher Nu_x values at the higher Ra*, hence suggesting the presence of buoyancy effects/secondary flow. However, the differences are no greater than about 5 percent. In fact, this difference could be attributed to the small difference in Re_h and Pr for the two cases.* But at the same time, this explanation does not necessarily mean that buoyancy effects are negligible. Because of the small Ra* difference, buoyancy effect would not change much, i.e. would remain nearly constant. For both tubes, the general Nu_x versus X^+ pattern contains a small "bump" in Nu_x in the vicinity of the wall temperature depression. This alone suggests some buoyancy effect, at least for finned tubes having small fin heights. Overall, compared to the smooth tube (Fig. 4.3), buoyancy effects (for comparable Ra*) are probably considerably smaller due to interference by the fins and interactions with secondary flows of the second kind.

Thermal entry lengths are considered next, and typical data for each tube are shown in Figures 4.18 to 4.22, inclusive. Three runs at different Reynolds numbers were selected for each tube and the results are presented in the form of a graph of $Nu_x/\overline{Nu}$ versus x/D_h. The scatter of the data, together with the narrow range of Reynolds numbers (2000 - 8000), made it

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* For example, assuming pure forced convection, the local Nusselt number ratio might be estimated as $(2570/2310)^{0.8}\ (4.31/4.84)^{0.4} = 1.040$, or about a 4 percent difference. The parallel calculation for tube 9 yields a ratio of 1.002, i.e. essentially unity.

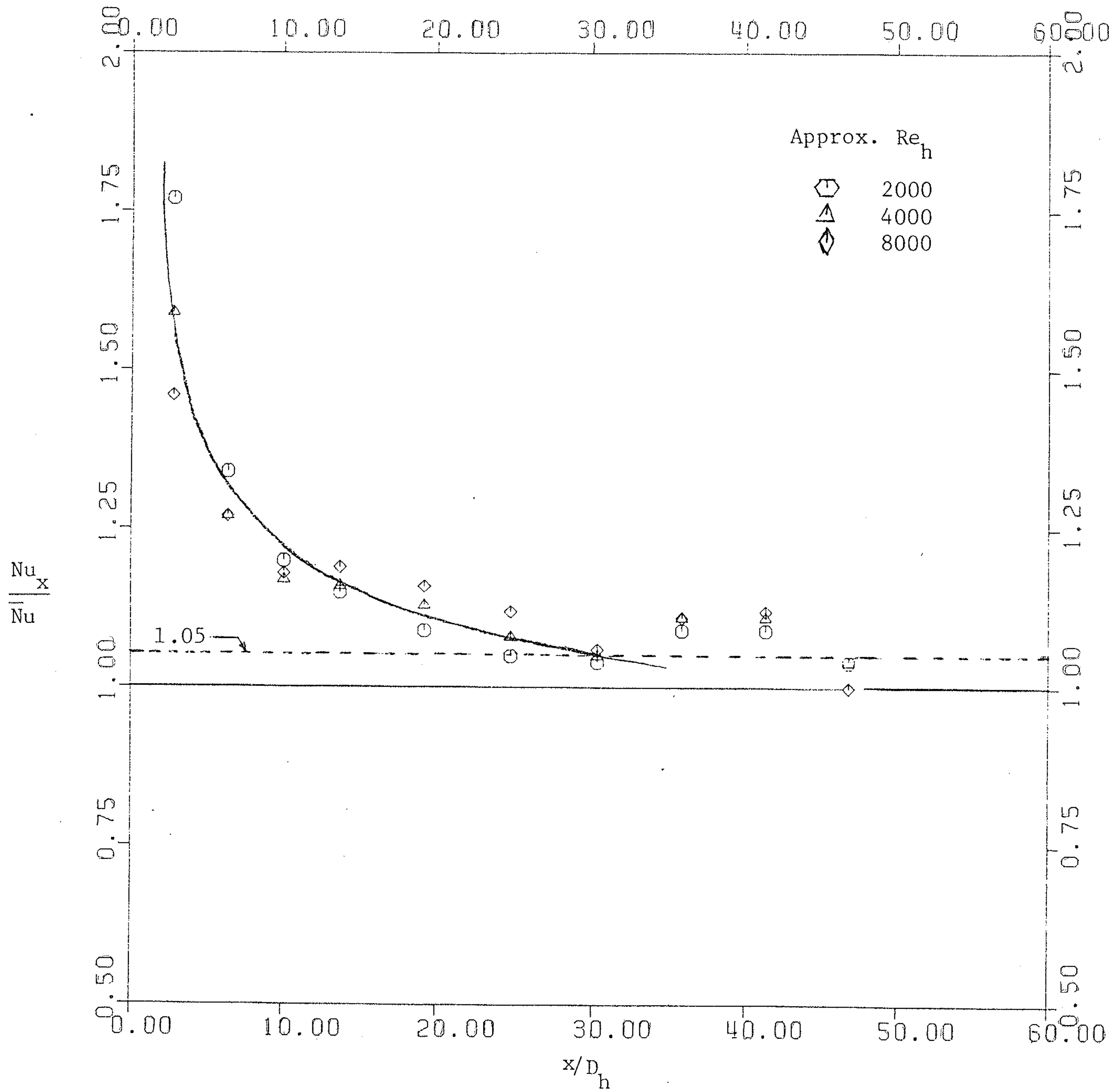

Figure 4.18 Thermal entry length for tube No. 9.

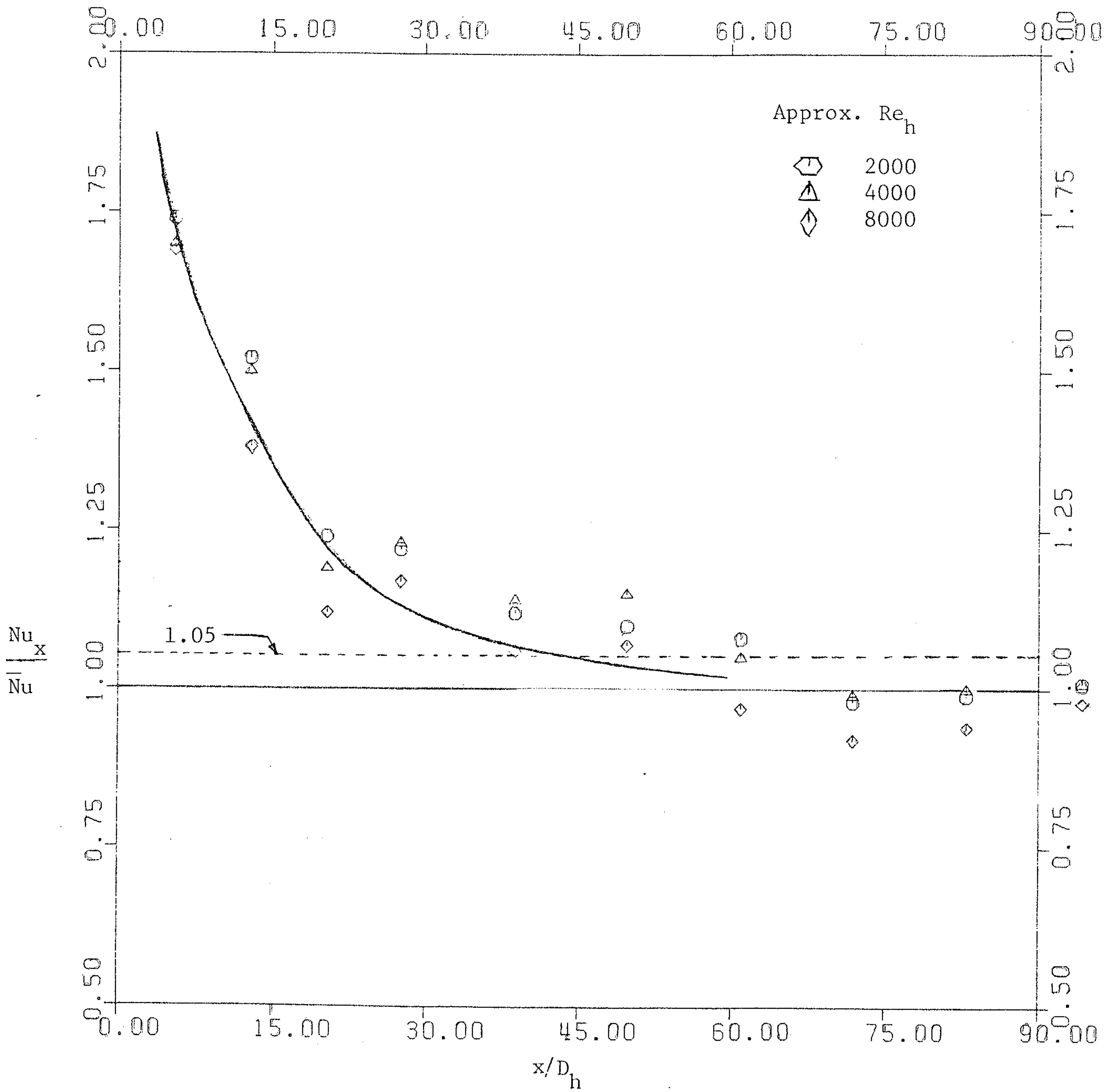

Figure 4.19 Thermal entry length for tube No. 10

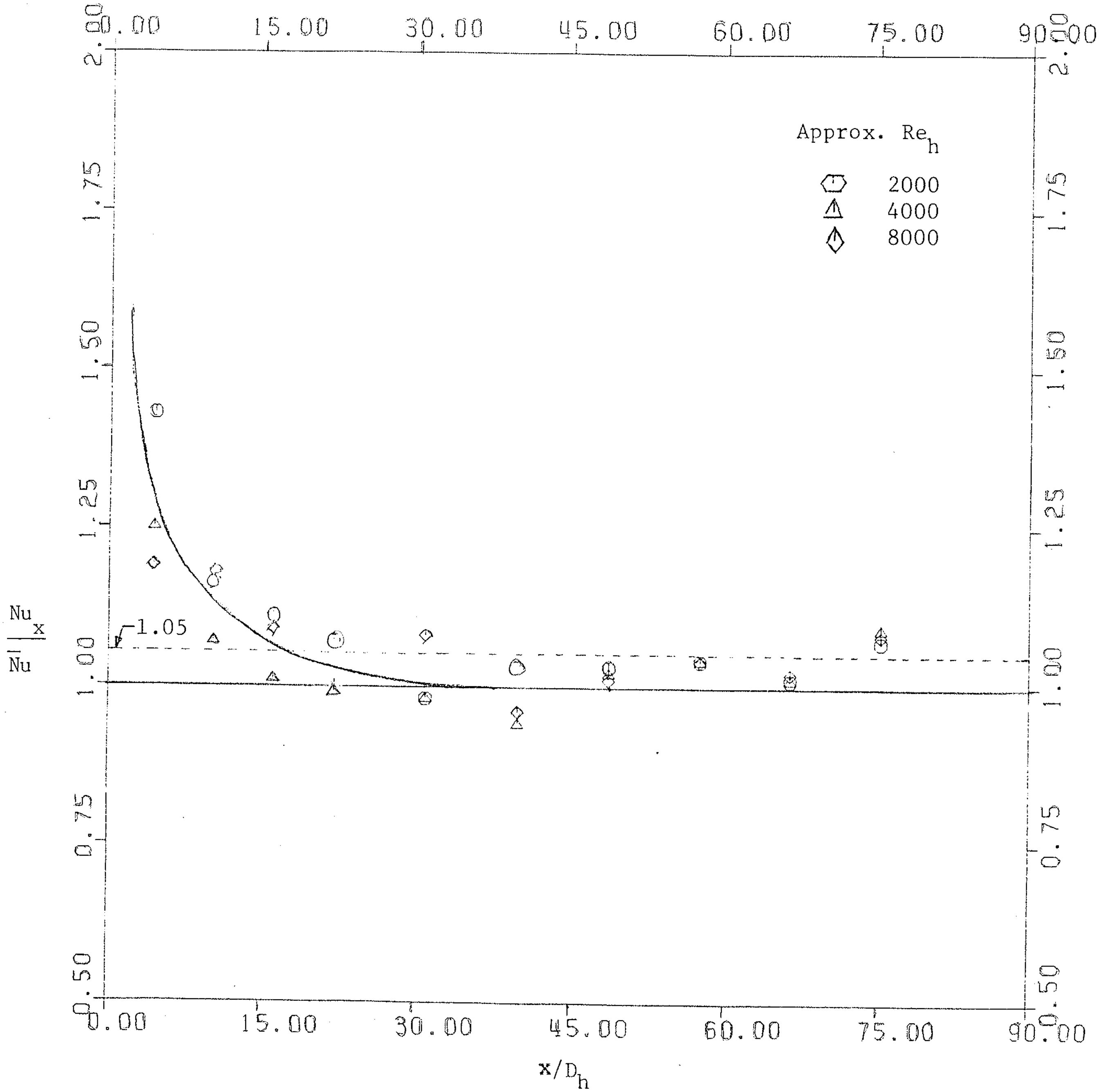

Figure 4.20 Thermal entry length for tube No. 13.

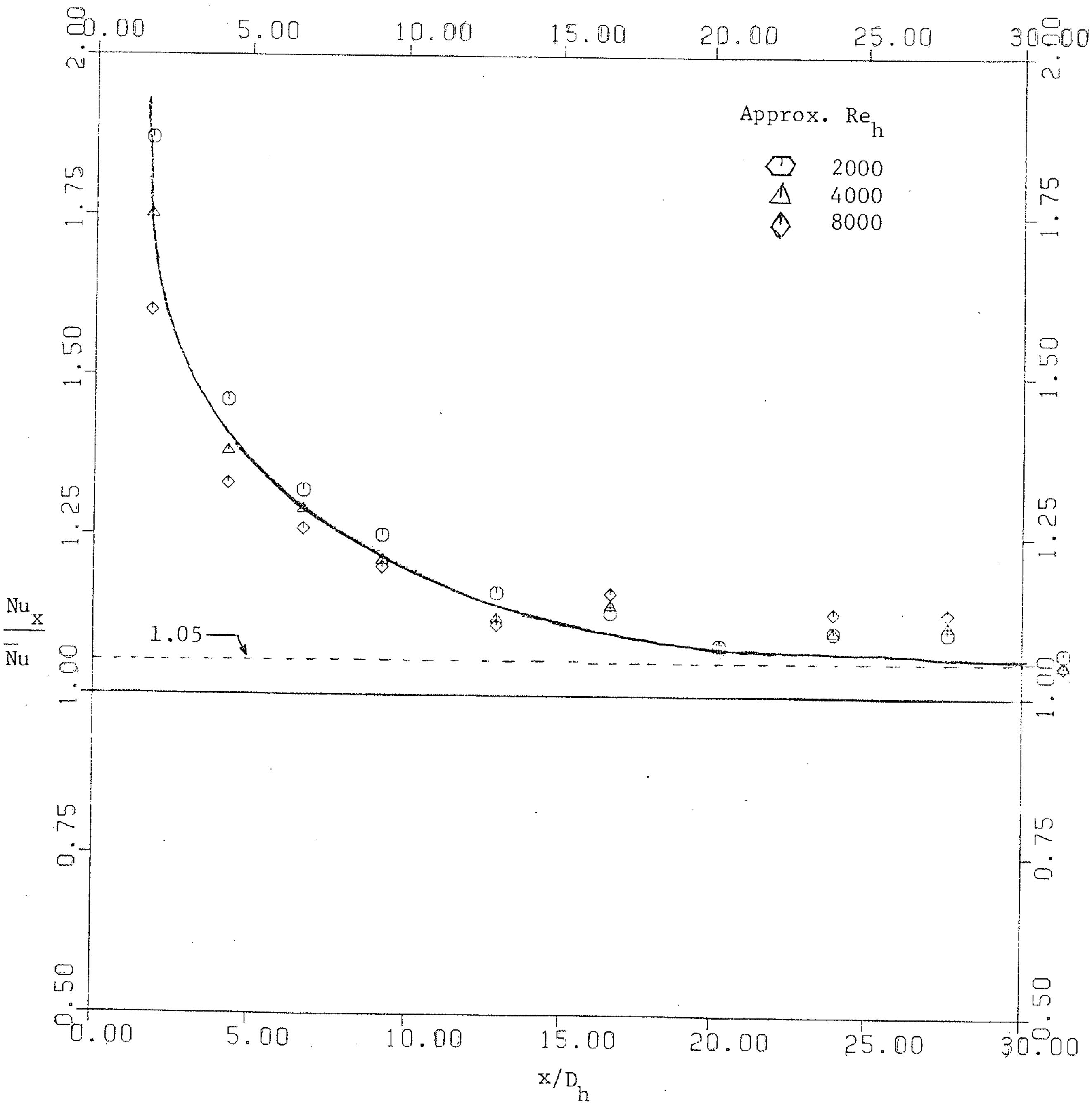

Figure 4.21 Thermal entry length for tube No. 14.

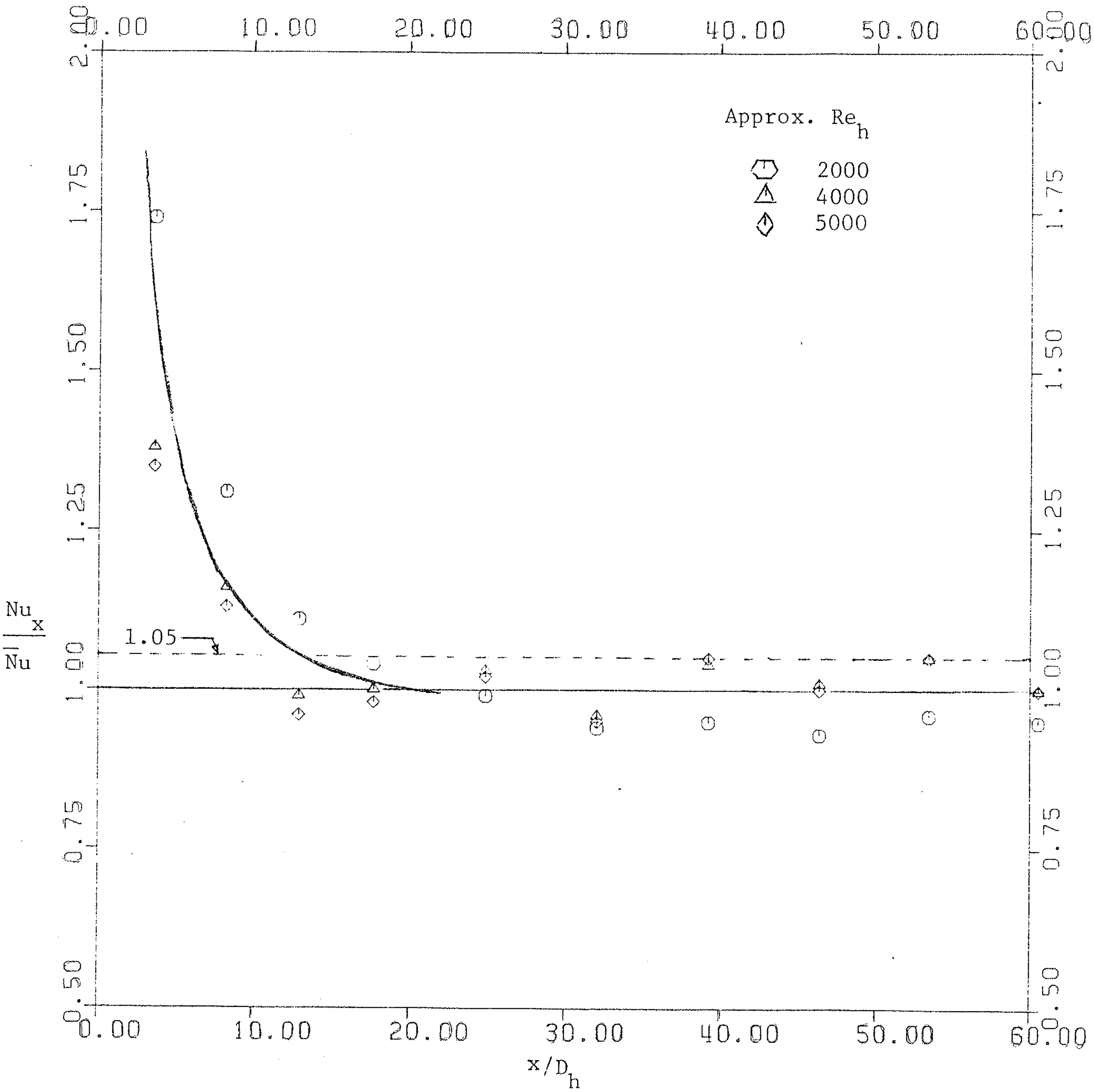

Figure 4.22 Thermal entry length for tube No. 20.

difficult to isolate the effect of Reynolds number on the thermal entrance length*. Therefore, a single curve was faired through all the data for each tube to facilitate evaluation of the thermal entrance length. The latter was based on the same criterion applied to the smooth tube (Section 4.1.2.2).

The results for thermal entry length** are listed in Table 4 in terms of both x/D_h and x/D_i. Tube 10 has the longest thermal entry length in terms of D_h, but ranks only third longest in terms of D_i. Tube 20 (spiral fins) has the shortest entrance length, which is not surprising since the induced swirl would promote rapid thermal mixing. Among the tubes with the same number of fins (tubes 9, 13 and 14 with 10 fins), tube 14 (lowest H) has the longest entrance length, and tube 13 (highest H) has the shortest entrance length. This suggests that an increase in H tends to decrease the thermal entry length (in terms of either D_h or D_i). This seems plausible since with increasing H, heat from fin tips is progressively injected further into the core flow region. Regarding the effect of M for straight fins, comparing tubes 10 and 13 ($H \approx 0.32$) indicates that increasing M increases the thermal entry length. This is not expected if the core region governs thermal development. However, if the inter-fin region governs, the explanation may reside in reductions in velocity and turbulent diffusion as the bay regions become narrower with increasing M. In any

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* The data for tubes 10,14 and 20 suggest the thermal entrance length (evaluated as x/D_h) decreases with increasing Re_h (like the smooth tube) The data for tube 9 suggests the opposite (if anything), whereas the data for tube 13 is noncommittal.

** The reader is reminded that the flow for each tube was fully developed hydrodynamically at the start of the heated section. Hydraulic entry lengths ranged from about 270 to 800 hydraulic diameters, or about 160 to 300 tube inside diameters.

TABLE 4

THERMAL ENTRY LENGTH VALUES FOR INTERNALLY FINNED TUBES

		Pr = 4 - 6		Thermal Entry Length	
Tube Number	H	M	Re_h	x/D_h	x/D_i
9	0.248	10	2000-8000	30	15.9
10	0.318	16	2000-8000	41	13.9
13	0.325	10	2000-8000	17	8.2
14	0.216	10	2000-8000	34	19.9
20	0.282	16	2000-5000	13	5.3

event, the present data is far too limited to draw any definite conclusions on either the effect of number of fins or spiralling of fins.

The present results for thermal entry lengths for internally finned tubes are novel; i.e., there are no published data available for comparison. At most, the present results can be compared to those for a smooth tube where thermal entry lengths would be expected to be about 9 to 12 diameters for the same Reynolds range. On the basis of D_i, the present values for straight fins average about 14 inside diameters, i.e., only a bit higher than for the smooth tube. But on the basis of D_h, the present entry lengths are substantially greater than for the smooth tube. It is also noted for M = 10 that in order to accommodate the trend of thermal entry lengths (on either a D_i or D_h basis) decreasing with H in the region $0.21 < H < 0.33$, it is necessary for thermal entry lengths to first increase with H leaving H = 0 (smooth tube) and to peak prior to $H \approx 0.21$, before decreasing with H in the present fin height interval. This type of pattern with increasing H (and fixed M) might perhaps be due to a transition from the core region governing to the inter-fin (bay) region governing the thermal development.

The results for the thermal entry region shown in Figures 4.18 to 4.22 show a qualitative similarity, but the details are basically unique for each finned tube.* Nonetheless, some similarities were noted. For example, for tubes 9, 13 and 14 (all with M = 10), $Nu_x/\overline{Nu}$ achieves a value of 1.25 at about $x/D_h = 8 \pm \sim 1$, whereas the average Nu_x over the thermal entry region is about 120 percent of $\overline{Nu}$. For tubes 10 and 20 (both with

* The data was also examined in the form $Nu_x/\overline{Nu}$ versus X^+ (as in laminar flow), but the scatter was substantial as expected.

$M = 16$), the average (over the entry length) Nu_x is noticeably higher, being about 130 to 135 percent of $\overline{Nu}$. Although the present results are very limited in scope, it is hoped that they will provide some guidance to designers of compact heat exchangers employing internally finned tubes. A conservative design approach (for similar finned tubes) would be to assume thermal entry lengths to be the same (on a D_i basis) as for the smooth tube with average local Nusselt numbers being about 1.20 $\overline{Nu}$. Of course this suggestion is only tentative and would have to be refined when additional data becomes available for a wider assortment of internally finned tubes.

4.2.2.3 Fully Developed Nusselt Numbers

Fully developed heat transfer data, based on hydraulic diameter and actual surface area, are presented in Figure 4.23 for the five internally finned tubes. The Nusselt-Prandtl modulus [$\overline{Nu}/Pr)^{0.4}$] is plotted against Re_h for each tube in a log-log plot to provide direct comparison to the smooth tube result, as given by the Dittus-Boelter equation (2.1). Reynolds numbers ranged from 600 to 10,000, but most of the data is for $Re_h > 1{,}200$ for which the flow is definitely turbulent (see Fig. 4.6). Almost all of the data falls below the smooth tube line as is usually the case for internally finned tubes. However, the slopes for the lines drawn through the data for each tube*, were similar, but slightly lower than that (0.8) usually encountered for smooth tubes. The data for tubes 10 and 20 (each with $M = 16$)are the most detached from the Dittus-Boelter line. The proximities of the remaining three tubes (each with $M = 10$) to the Dittus-

* For tube 10, only the low Re_h data has a slope (see line drawn in Fig. 4.23) similar to the other finned tubes.

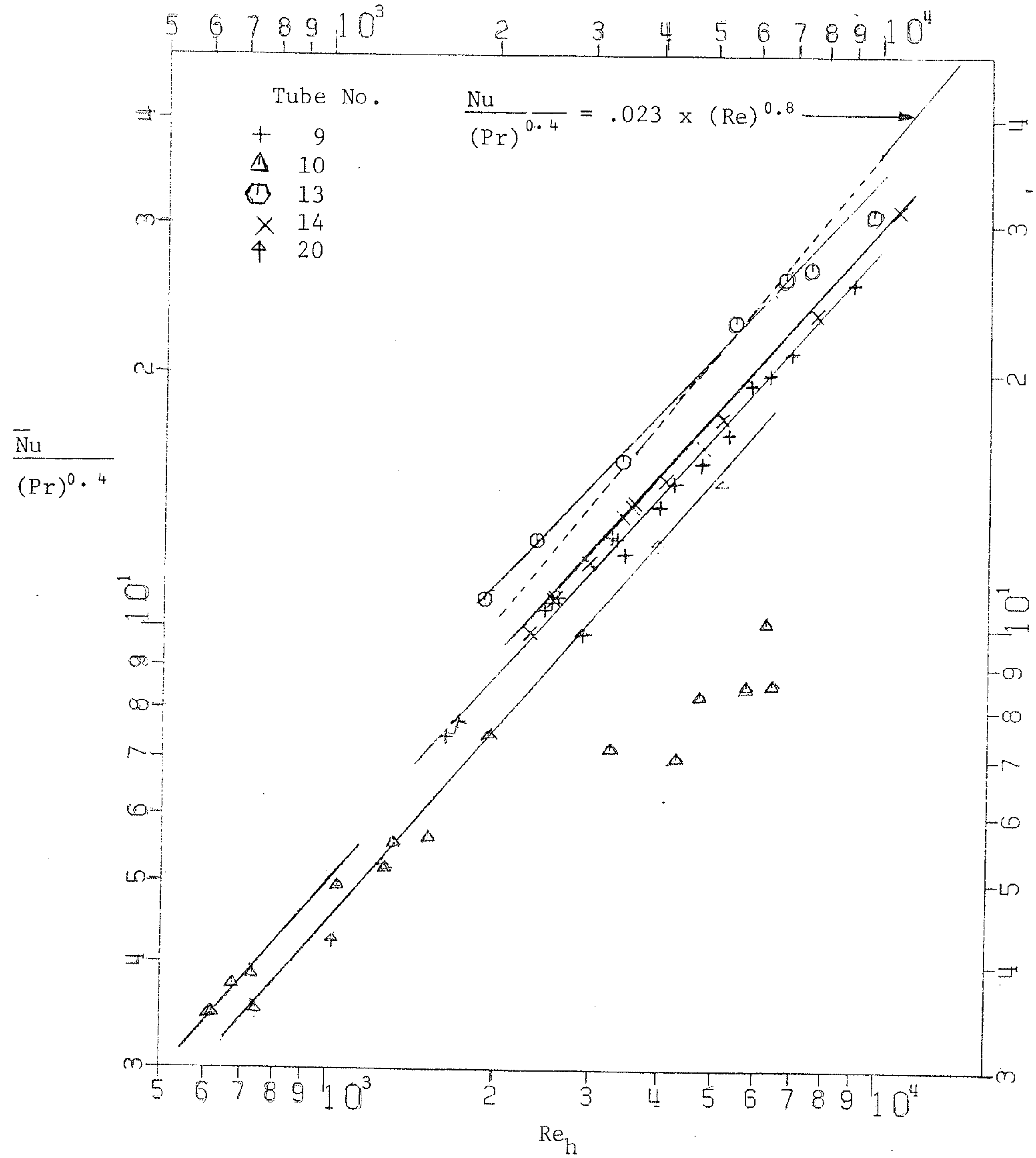

Figure 4.23 Fully developed Nusselt numbers for internally finned tubes (based on hydraulic diameter)

Boelter line is consistent with the predictions of Said [28]; viz, for fixed M and Re_h, that $\overline{Nu}$ first decreases with increasing H to reach a minimum at $H \approx 0.3$ (for $Re_h = 50{,}000$) before increasing with H. At lower Re , the minimum could conceivably shift to $H \approx 0.25$ as is implied by the ranking seen in Figure 4.23.

The individual results for each finned tube are shown in more detail in Figures 4.24 to 4.28 inclusive. Each plot of $Nu/(Pr)^{0.4}$ versus Re_h includes the Carnavos [23] correlation (equation 2.9), which has been extrapolated to $Re_h < 10^4$. As can be seen in the figures, except for tube 10 (Fig. 4.25), the present results are generally in very good agreement with Carnavos [23]. This good agreement includes tube 20 (Fig. 4.28); an outcome which was rather surprising in view of the poor agreement with friction factor, as discussed earlier. For each tube, the experimental data starts a little higher than the Carnavos line and then converges to meet (except tube 10) with the Carnovas line at higher Reynolds numbers. This pattern probably reflects some buoyancy effect at the lower Reynolds numbers.

For tube 10, ($M = 16$; $H = 0.318$), as shown in Figure 4.25, the experimental data crosses the Carnavos line at $Re_h \approx 2000$ and then falls progressively below the line at higher Reynolds numbers. The data was rechecked carefully and appeared to be valid. The reason for this behaviour is not clear. As noted in Section 3.3.3, there were some early difficulties with wall temperature measurements for this tube, but it was thought that the problem was largely corrected. Another partial explanation revolves around two peculiarities of tube 10 relative to the other finned tubes. Tube 10 has, by far, the thinnest tube wall (0.765 mm compared to 1.00 to 1.245 mm for the other tubes - see Table 1 for tube dimensions).

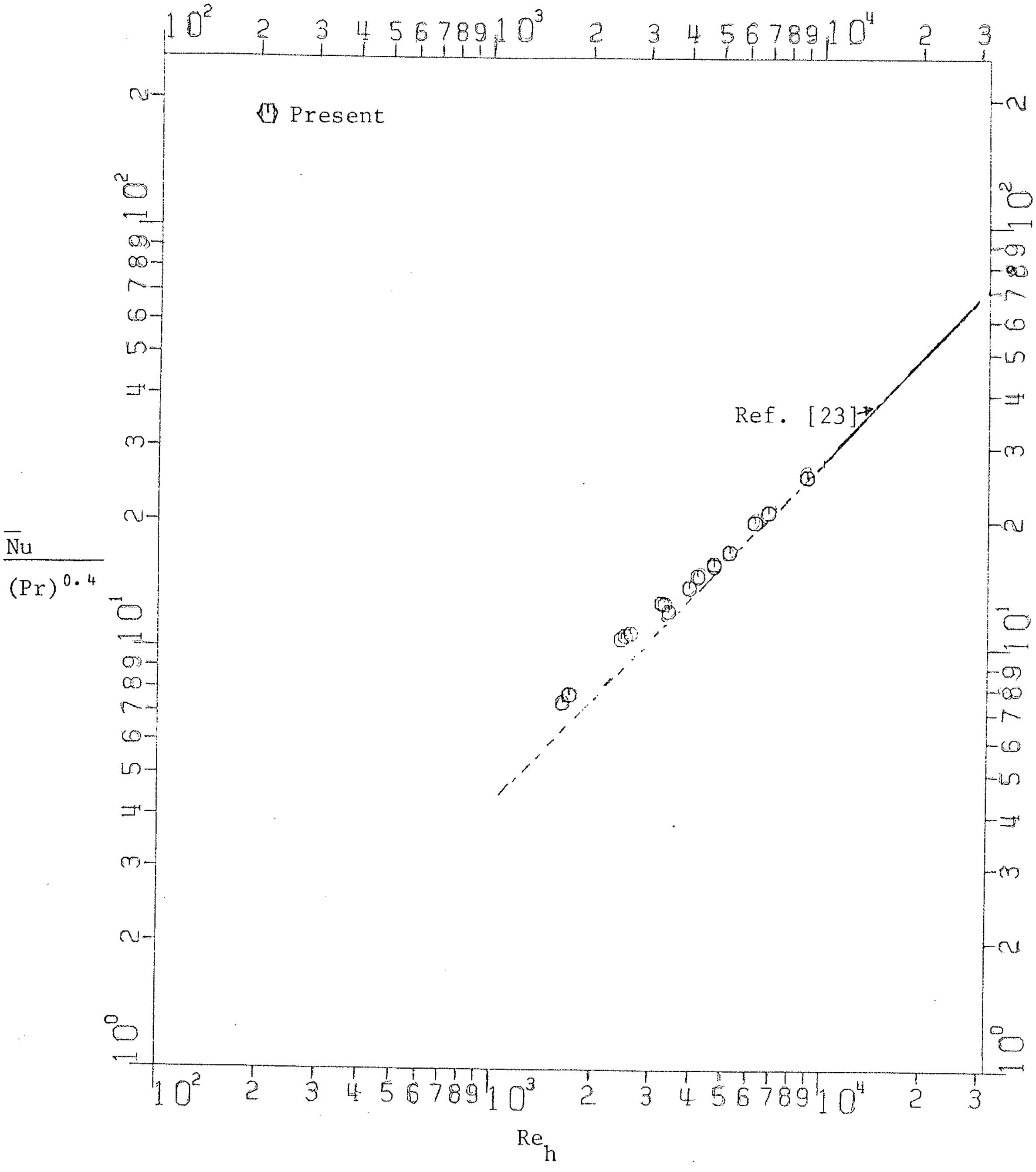

Figure 4.24 Fully developed Nusselt numbers for tube No. 9 (based on hydraulic diameter)

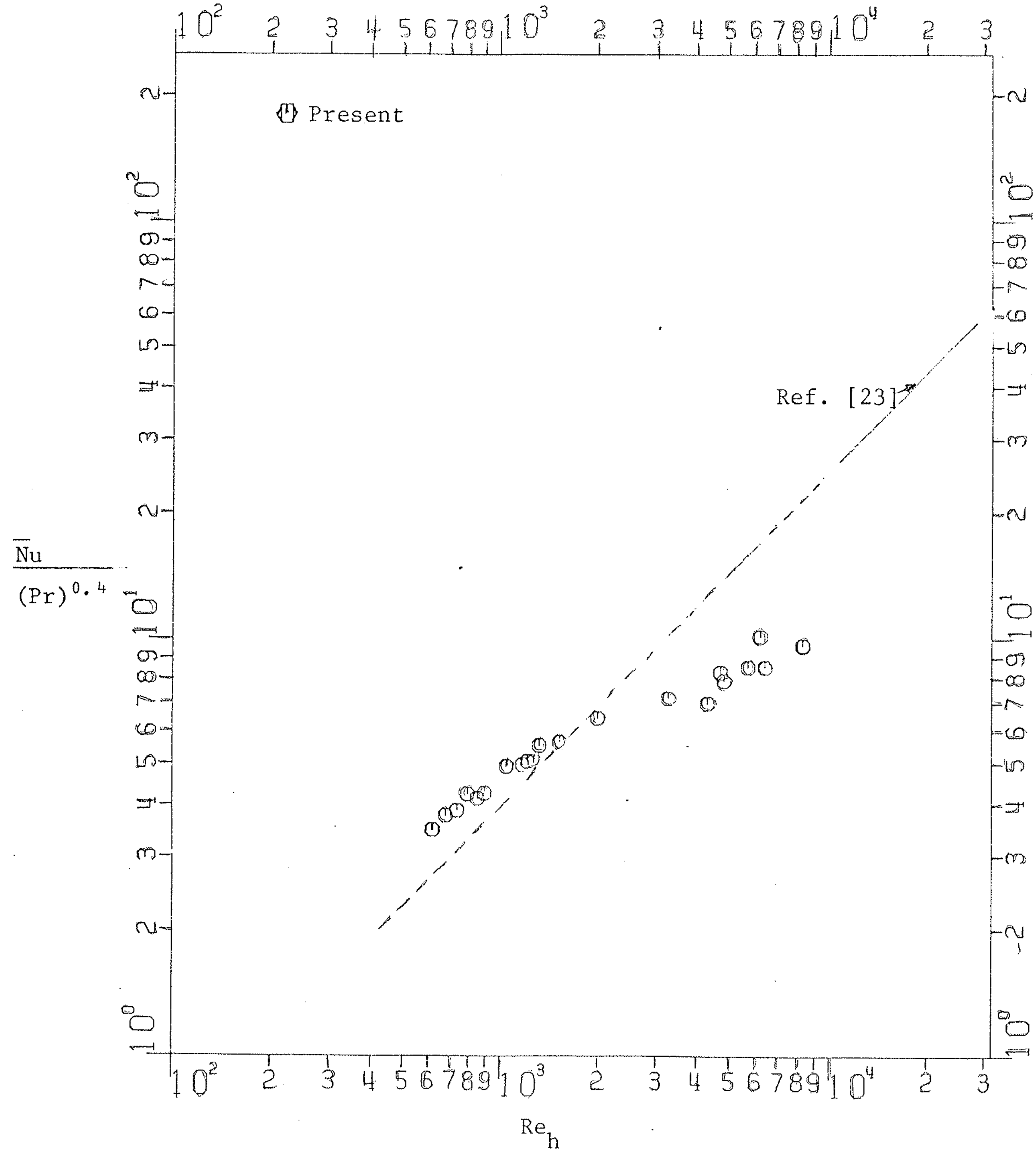

Figure 4.25 Fully developed Nusselt numbers for tube No. 10 (based on hydraulic diameter)

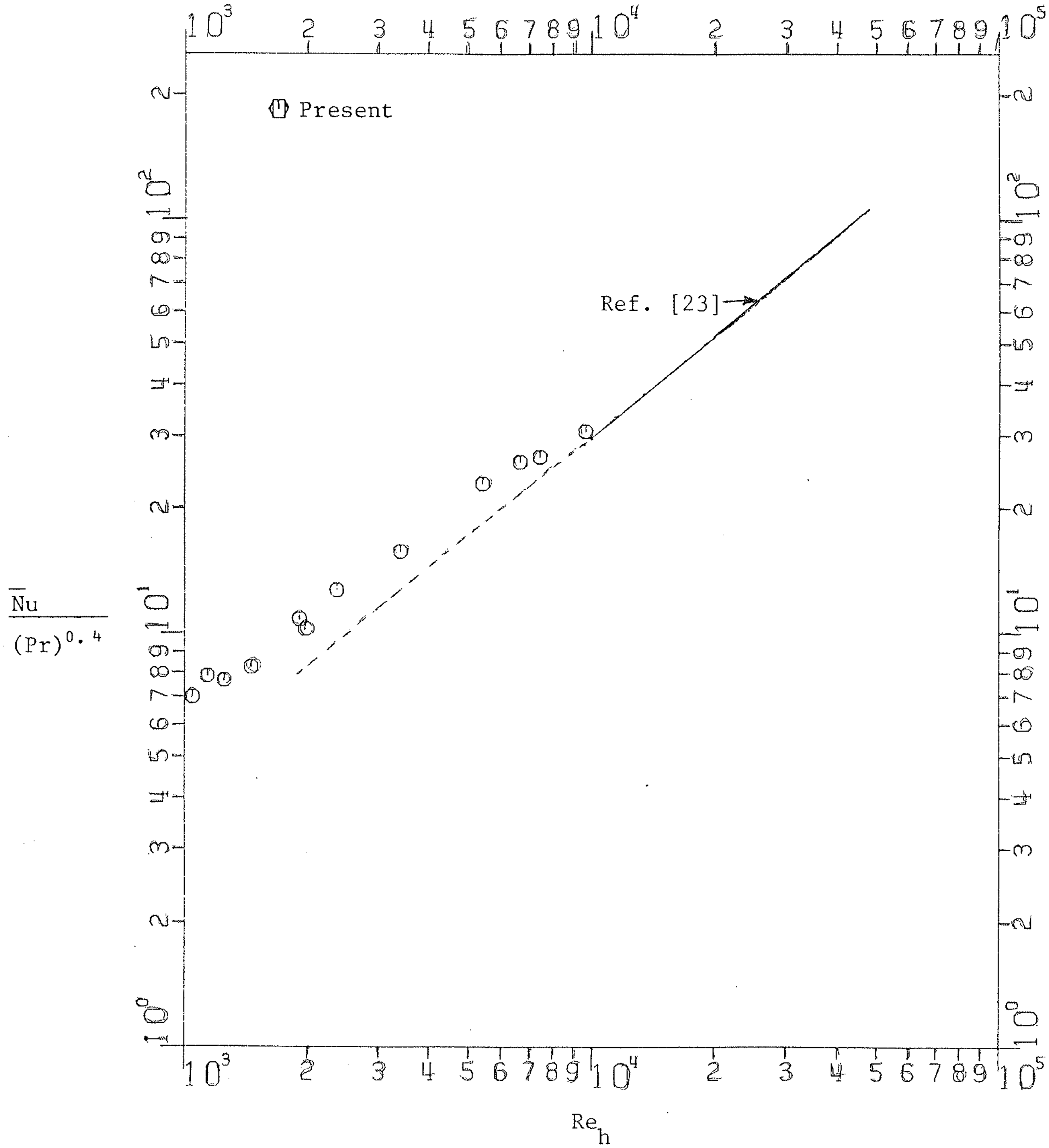

Figure 4.26 Fully developed Nusselt numbers for tube No. 13 (based on hydraulic diameter)

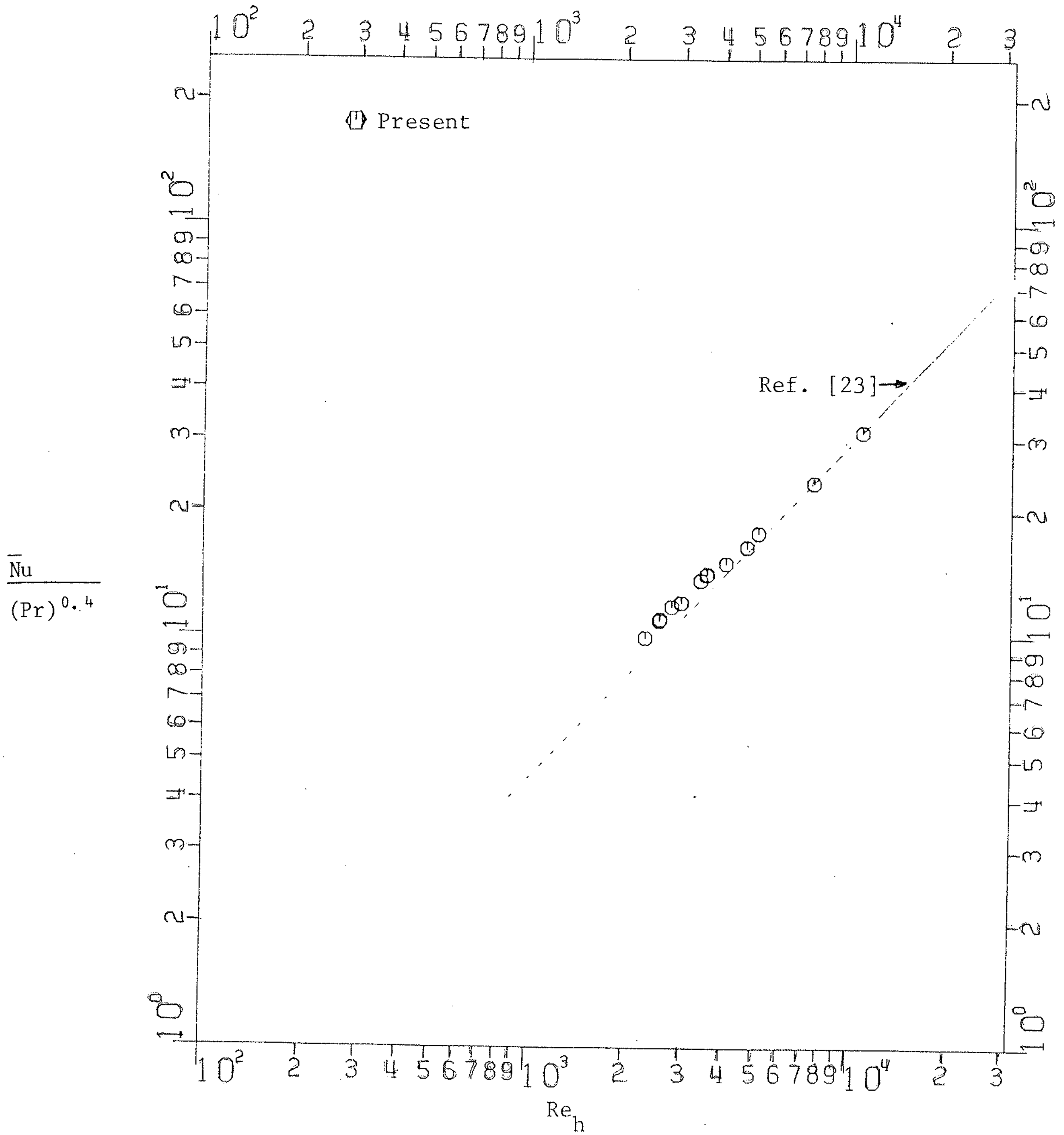

Figure 4.27 Fully developed Nusselt numbers for tube No. 14 (based on hydraulic diameter)

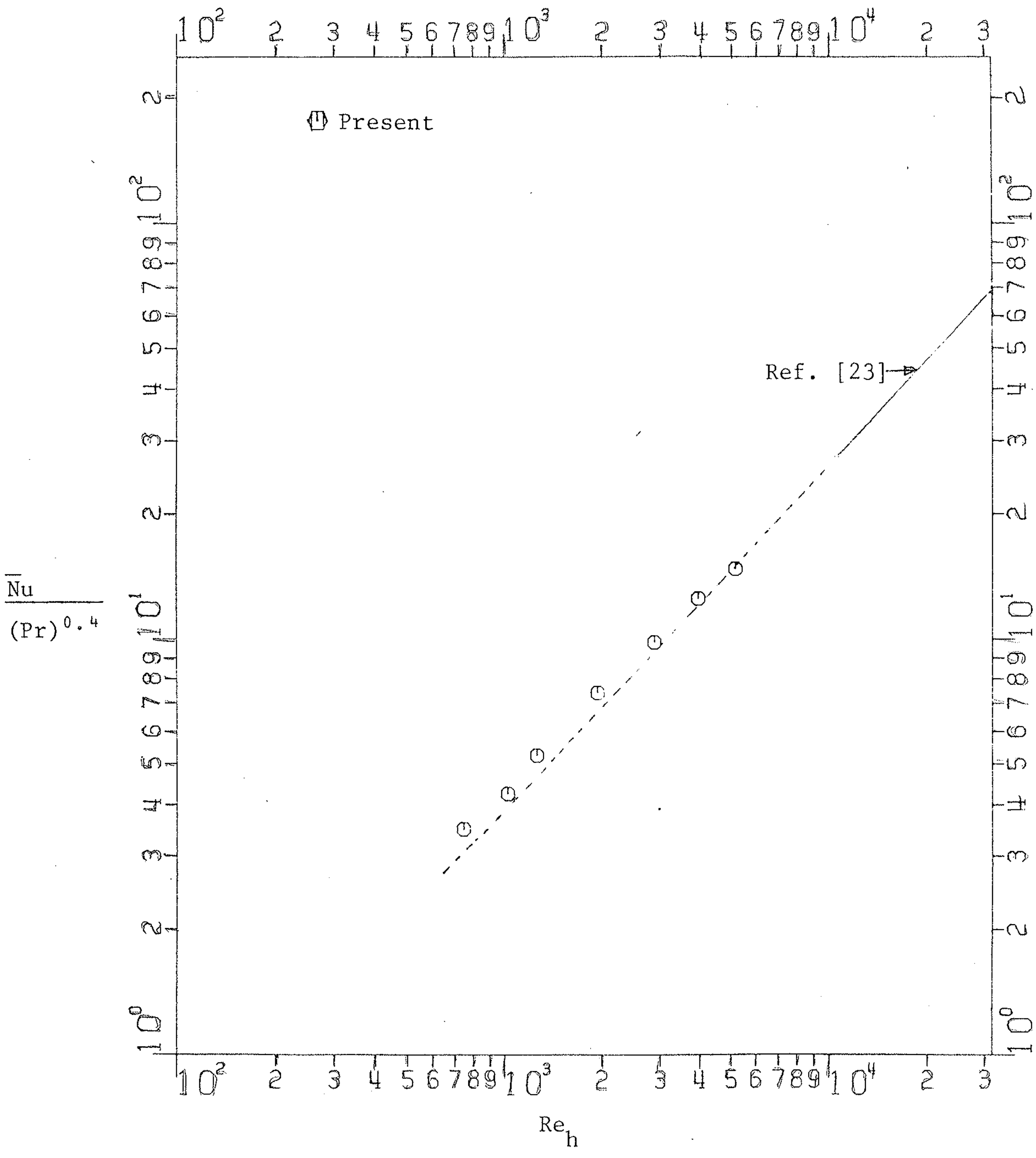

Figure 4.28 Fully developed Nusselt number for tube No. 20 (based on hydraulic diameter)

Also, amongst the straight fin tubes, tube 10 has the thinnest fins (see γ values included in Table 5). In addition (see App. C), all tube 10 tests for $Re_h < 2000$ involved input powers of 240 to 990 watts, whereas for $Re_h > 2000$, input power levels were in the range of 1000 to 1725 watts. At these higher heat flux levels, because of the relatively thin wall and fin, temperature gradients (both circumferentially in the tube wall and especially radially in the long fin), would be higher than for the other finned tubes which would have the same thermal conductivity but wider conduction cross-sections. This means that fin efficiency would be lower; but fin efficiency is also a function of h, the convective heat transfer coefficient. The relationship is such (see, e.g. the detailed discussion in the paper by Watkinson et al, [19]) that efficiency decreases with increasing h (hence increasing Re_h since $h \propto \overline{Nu} \propto Re_h$). The falling efficiency with increasing Re_h is equivalent to a falling apparent h (or $\overline{Nu}$) with increasing Re_h as is the case in Figure 4.25. Unfortunately, estimates of fin tube efficiency using the data of Carnavos [23] for tube 10, indicate values no lower than about 0.97*, which would account for only a small portion of the discrepancy. However, at the same time, this adjustment does not deal with possible circumferential temperature gradients in the tube wall. Because of the relatively thin tube wall for tube 10, suspicion again turns to the possibility that tube wall temperatures were over-estimated at the higher input power levels. In view of these reservations, the

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* It is emphasized that the present Nusselt number results are net to the actual inside surface area [see equation (3.3)] and <u>include</u> the inefficiency of the fins. However, because of the relatively low heat flux levels for the low Re_h region, fin tube efficiencies are close to unity for all tube cases (tube 10 being the worst case), hence the results <u>excluding</u> fin efficiency would be essentially the same as the present results.

data for tube 10 beyond $Re_h \approx 2000$ must be treated as suspect. Nonetheless this data has been retained since error could be neither confirmed nor refuted. Incidentally, the actual data of Carnavos [23] for tube 10 were checked and found to lie only 3 to 5 percent below his correlation line.

The present fully developed Nusselt numbers were compared, not only to Carnavos [23], but also to Watkinson et al, [19] and to Said [28]. The results of the comparisons are summarized in Table 5. For the Carnavos [23] correlation, equation (2.9), the agreement varies from excellent to good, as already mentioned. Tubes 9, 14 and 20 averaged within less than 5 percent difference, whereas tubes 10 and 13 averaged 18.7 percent and 15.8 percent difference, respectively. Also, as reflected in Figures 4.24 to 4.28, apart from tube 10, the agreement for individual data points was best at the higher Reynolds number. Considering the facts that the Carnavos correlation is within ± 10 percent and has been extrapolated to $Re_h < 10^4$, it is considered that the general level of agreement of $\overline{Nu}$ to [23] is very good.

In contrast to the good agreement to [23], the present $\overline{Nu}$ results do not compare well to the correlation of Watkinson et al, [19], equation (2.7). All of the experimental data for tubes 9, 10 and 14 fall considerably below the predictions of equation (2.7). The agreement is best for tube 13, as was also the case for the friction factor comparisons discussed in Section 4.2.1. In fact, the agreement with [19] for tube 13 is better than for [23] (see Table 5), which may be because of its relatively thick fins. Hence the discrepancies for tubes 9, 10 and 14 may be related to fin thickness. On the other hand, Carnavos also experienced poor agrement with [19] and noted that the apparatus used by Watkinson et al did not have the capability

TABLE 5

COMPARISON OF PRESENT $\overline{Nu}$ WITH REFERENCES [23,19 AND 28]

Tube Number	H	M	γ (Deg.)	Ref.[23] % diff.	Ref.[19] % diff.	Ref.[28] % diff.
9	0.248	10	4.84	±4.2	-31.0	+13.2
10	0.318	16	4.05	±18.7	-43.5	±14.5
13	0.325	10	7.66	+15.8	±5.4	+35.2
14	0.216	10	4.54	±4.1	-25.4	+19.5
20	0.282	16	3.42	±2.8	—	—

NOTES:

1) Percentage difference (% diff.) $\equiv \left[\dfrac{\overline{Nu}_{exp} - \overline{Nu}_{corr}}{\overline{Nu}_{exp}}\right] 100.$

2) Each value listed is the average of the percentage difference magnitudes for all data points over the range of Reynolds number for each tube.

3) The (±) designator simply indicates the experimental data is always above (i.e. higher) the pertinent correlation (+), or always below the pertinent correlation (-), or both above and below (±) in the interval.

4) Each listed γ value is the half-fin angle that would be obtained if the actual fin material cross-sectional area was distributed as M identical trapezoidal fins (as per [28])of height H.

for a heat balance and hence the generated data was potentially of a lower accuracy level. Otherwise, it is noted that heated lengths for [19] were comparable to [23], each being roughly of the order of ten entrance lengths, hence average test-section Nusselt numbers should have been no greater than about 2 to 3 percent of the fully developed Nusselt numbers.

Before reviewing the comparison of Said [28], equation (2.11), it is noted that the correlation is based on theoretical/numerical predictions for pure forced convection for $Re_h > 25{,}000$, and involves a perfectly conducting, well-defined trapezoidal fin profile having a half-fin thickness angle $\gamma = 3°$. In view of this, the agreement reported in Table 5 is remarkably good. The largest differences are for tube 13, which has the thickest fins (equivalent $\gamma = 7.66°$).

Turning next to correlation of the present experimental data, a least-squares-fit was obtained using the correlation form:

$$\overline{Nu}/(Pr)^{0.4} = c_1 (Re_h)^{c_2} (A_{fa}/A_{fc})^{c_3} (A_n/A_a)^{c_4} \quad . \qquad (4.4)$$

In view of the good agreement to Carnavos [23], the geometric parameters in equation (2.9) were retained* for the general form. The coefficients for best fit of all the data for $600 < Re_h < 10{,}000$, were $c_1 = 0.023$, $c_2 = 0.787$, $c_3 = 1.08$ and $c_4 = 1.11$. All the data were fitted by equation (4.4) to within a standard deviation** of 6.5 percent.

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* For spiral finned tube 20, $(\sec \alpha)^3$ as per equation (2.9) amounts to only 1.0029, which could safely be ignored.

** Standard deviation $\equiv [(1/N) \sum_1^N (\overline{Nu}_{corr} - \overline{Nu}_{exp})^2]^{\frac{1}{2}}$ where N is the number of data points, and is expressed as a percent of the average $\overline{Nu}_{corr}$ in the Re_h range.

Finally, as was done for the friction factors, the fully developed Nusselt numbers were also determined based on inside diameter and nominal heat transfer area. Results are presented in Figure 4.29 together with the smooth tube line as predicted by the Dittus-Boelter equation. The effect of geometry followed basically the same trend displayed by the friction factors. The enhancement of heat transfer over the smooth tube ranged considerably depending on Reynolds number, being highest for tubes 10 or 13, and lowest for tube 14. Also obvious is the strong dependence of the heat transfer coefficient on both fin height and fin number. Data for tubes 9, 13 and 14 (all with same number of fins) show an increase of Nusselt number with increasing fin height, while the low Re_i data for tubes 10 and 13(both with similar fin height) show an increase of Nusselt number with increasing fin number. Also comparing the results for tubes 10, 13 and 20 suggest a stronger effect of fin height than fin number; a fact reported by many investigators.

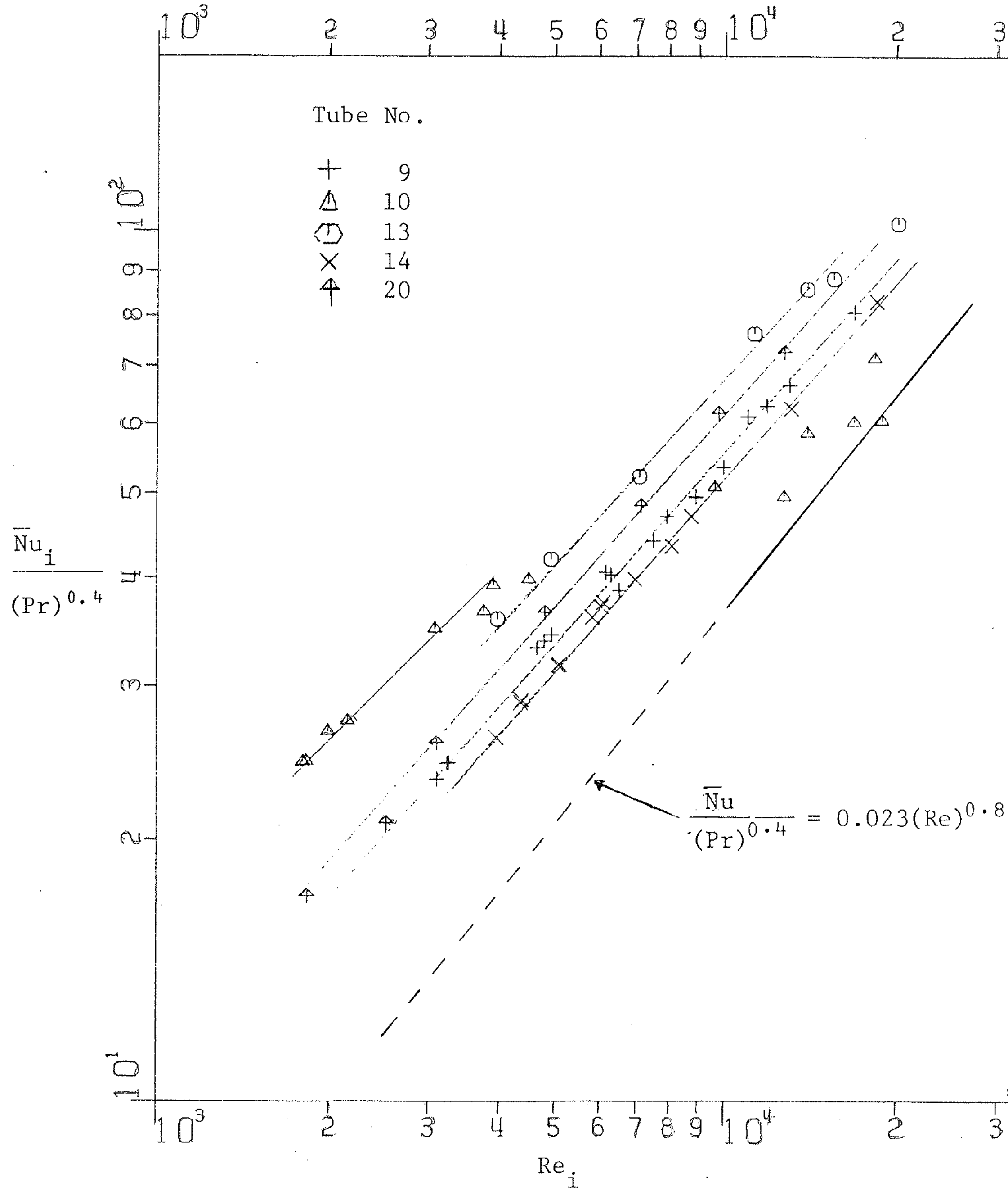

Figure 4.29 Fully developed Nusselt numbers for internally finned tubes (based on inside diameter)

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The heat transfer and fluid flow performance were determined for a smooth tube and five integral inner-finned tubes of various designs for heating water in low Reynolds number turbulent flow. Data were presented for both the thermal entry region and the fully developed region. The flow was hydrodynamically fully developed at the start of the heated section. The tubes were uniformly heated by resistance wires wrapped uniformly around them. From the present experimental results, the following conclusions can be drawn:

1. The present friction factors for the smooth tube were in good agreement with standard predictions at high Reynolds number (Re > 6000). However, at lower Reynolds number, the present friction factor values were somewhat higher. The deviations were associated with a change in slope from a value of about 0.5 at Re < 6000 to about 0.2 (the usual value for smooth tubes in turbulent flow) at higher Re.

2. For the smooth tube, examinations of the axial distributions of top and bottom wall temperatures and local Nusselt numbers, revealed the presence of secondary flow and their developing pattern. Results of similar nature were reported by El-Hawary [10].

3. The present thermal entry length values for the smooth tube were consistent with recommended Engineering Sciences Data [37].

4. The fully developed Nusselt number results for the smooth tube were in good agreement with Ede [4], whereas relative to the Dittus-Boelter correlation, the level of agreement improved gradually at higher Reynolds

number. The effect of free convection was found to be very pronounced at very low Re (laminar) and to decrease in turbulent flow with increasing Re to become negligible at Re $> \sim 6000$.

5. Friction factor results for the internally finned tubes were similar to those for the smooth tube, i.e., a high slope of about 0.55 for $Re_h < 6000$. At higher Re_h, the results merged to attain good agreement with Carnavos [23] except for tube 20.

6. For the finned tubes, the critical Reynolds numbers were found to increase slightly with increasing fin number and to decrease sharply with increasing relative fin height. Overall, the results were in reasonable agreement with both Watkinson et al, [26] and Masliyah and Nandakumar [38].

7. The wall temperature and local Nusselt number results for internally finned tubes revealed the presence of secondary flows and their developing pattern similar to that of the present smooth tube. However, the effect on the heat transfer characteristics were small, compared to the smooth tube, suggesting that the presence of fins tend to suppress buoyancy effects.

8. The thermal entry lengths for the internally finned tubes decreased with increasing fin height. The effect of number of fins and spiralling of fins on thermal entry length was inconclusive. No particular effect of Re_h was noted in the range covered. The thermal entry lengths, based on the inside diameter, were of the same order of magnitude as those for the smooth tube; but based on the hydraulic diameter, these values were significantly higher.

9. With the exception of tube 10, the fully developed Nusselt numbers, based on hydraulic diameter, were in good agreement with Carnavos [23] with the level of agreement improving at higher Reynolds Numbers. At low

Reynolds numbers, the present results were somewhat higher due to the influence of buoyancy effect. The effect of geometry followed basically the same trend displayed by the friction factors. At a given Reynolds number (based on inside diameter), $\overline{Nu}$ increased with both increasing H and M, with fin height having the stronger effect.

Based on the literature survey and the present study, the author wishes to recommend the following to assist in guiding further studies:

1. More friction factor data should be collected in the range of $2000 < Re_h < 20{,}000$ to confirm the changing slope noted for both smooth and internally finned tubes.

2. A more extensive study should be made regarding thermal entry lengths for internally finned tubes, which would cover a wider assortment of finning configurations.

3. A wider range of Rayleigh number should be used to fully understand the effect of secondary flows on the heat transfer characteristics of both smooth and internally finned tubes over a wide range of Reynolds numbers.

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APPENDIX A

LISTING OF COMPUTER PROGRAM FOR DATA REDUCTION

```
      DIMENSION T(80),TF(80),X(80),FLMA(100),FLMB(100),FLMC(100),TC(80)
      DIMENSION NU(60),XP(30),Y(5),X1(60,4),RE(40),RA(40),NUA(40)
      DIMENSION S(30),U(30),NUC(30),QB(30),TEMP(30),TFF(80),XX(30)
      DIMENSION TEMPA(30),NUENT(40)
C
C KC IS THE THERMAL CONDUCTIVITY OF COPPER IN (WATT/METER. DEG C)
C
      KC=.......
C
C L IS THE HEATED SECTION LENGTH IN CENTIMETERS
C
      L=......
C
C PI  IS A MATHMATCAL CONSTANT
C
      PI=3.1415927
C
C D IS IHE INSIDE DIAMETER IN METERS OR THE HYDRAULIC DIAMETER
C
      D=.......
C
C AW IS THE CROSS-SEC. AREA OF THE WALL IN SQUARED CENTIMETERS
C
      AW=.......
C
C AS IS THE NOMINAL SURFACE AREA OF THE TUBE IN(SQUARED METERS)OR THE ACTUAL SURFACE
C                                                                  AREA
      AS=.......
C
C AF IS THE ACTUAL FLOW AREA IN(SQUARED MILLIMETERS)
C
      AF=......
      I=10
      DO 5 J=1,10
      READ,FLMA(I),FLMB(I),FLMC(I)
      I=I+10
    5 CONTINUE
      READ,(X(I),I=1,14)
      READ,(X(I),I=15,23)
      READ,(Y(I),I=1,4)
      DO 2 J=1,54
      READ,(X1(J,I),I=1,4)
    2 CONTINUE
      READ,(U(I),I=1,14)
      READ,(U(I),I=15,23)
      READ,(S(I),I=1,14)
      READ,(S(I),I=15,23)
C
C THE NEXT LOOP IS FOR THE NUMBER OF RUNS
C
      DO 3 N=1,....
C
C R1,R2,R3  ARE THE READINGS OF THE FLOWMETERS IN PERCENT
C R1,R2 ARE FOR THE WORKING FLUID FLOWRATE
C R3 IS FOR THE COOLING WATER FLOWRATE
```

```
C Q IS THE INPUT POWER IN WATTS ,P IS THE PRESSURE DROP READING IN (MA)
C
      READ,R1,R2,R3,Q,P
      READ,(T(I),I=1,10)
      READ,(T(I),I=11,20)
      READ,(T(I),I=21,30)
      READ,(T(I),I=31,40)
      READ,(T(I),I=41,50)
      READ,(T(I),I=51,62)
      CALL CALIBR (T,TC,Y,X1)
      DO 10 I=1,54
      T(I)=TC(I)
   10 CONTINUE
      DO 15 I=1,62
      T(I)=(5./9.)*(T(I)-32.)
   15 CONTINUE
      DO 80 J=1,23
      TEMP(J)=(T(J+2)+T(J+29))/2
   80 CONTINUE
      TA=(T(55)+T(56))/2.
      CALL FLMETR(R1,R2,R3,FLMA,FLMB,FLMC,FLRT,FLRTC,N)
      PRINT 7,N
    7 FORMAT('1',45X,'RUN NUMBER (',I2,')     TUBE NUMBER 14',/)
      CALL HETBAL (Q,FLRT,TA,T)
C
C THE FOLLOWING 10 STATEMENTS ARE FOR CORRECTING THE INLET AND OUTLET
C TEMPERATURE BY CONSIDERING THE AXIAL HEAT CODUCTED OUT OF THE HEATED
C SECTION OF THE TUBE.
C
      T1=(T(1)+T(28))/2.0
      T2=(T(2)+T(29))/2.0
      T3=(T(3)+T(30))/2.0
      B=(T1-T3-0.66667*(T1-T2))/2.66667
      T(55)=T(55)-(1000.0*B*AW*KC)/(100.0*FLRT*CP(T(55)))
      T11=(T(25)+T(52))/2.0
      T12=(T(26)+T(53))/2.0
      T13=(T(27)+T(54))/2.0
      B1=(T13-T11-3.2*(T11-T12))/24.0
      T(56)=T(56)+(1000.0*B1*AW*KC)/(100.0*FLRT*CP(T(56)))
      DO 20 J=1,23
      TF(J)=T(55)*(1.-X(J)/L)+(X(J)/L)*T(56)
   20 CONTINUE
      QC=FLRT/1000.*CP(TA)*(T(56)-T(55))
      CALL NUSELC (FLRT,L,TEMP,TFF,U,Q,QB,NUC,D,AS,AW,KC,S,T,B,B1)
      DO 4 J=1,23
      RA(J)=(9.81*10000.0*BETA(TF(J))*(D**4)*QC*(RO(TF(J))**2)*
     *CP(TF(J)))/(VISC(TF(J))*(K(TF(J))**2)*AS)
    4 CONTINUE
      CALL PRESS(P,DP,DP1,DP2,CF,D,TA,FLRT,AF,N)
      REM=FLRT*D*1000.0/VISC(TA)/AF
      RAM=(9.81*10000.0*BETA(TA)*(D**4)*QC*(RO(TA)**2)*CP(TA))/
     *(VISC(TA)*(K(TA)**2)*AS)
      PRM=PR(TA)
      CALL RENOLD (FLRT,D,TF,PI,RE,AF)
      CALL EXHBAL (FLRT,FLRTC,T)
      CALL NUSELT (FLRT,L,T,TF,X,PI,TA,Q,NU,D,NUA,AS,NUAA,NUENT)
      NUAAA=0.0
      DO 100 J=10,23
      NUAAA=NUAAA+NUC(J)
  100 CONTINUE
      NUAAA=NUAAA/14
      PP=FLRT*DP2/RO(TA)
      RP=PR(TA)**(.4)
      NUPR=NUAA/RP
      NUPRA=NUAAA/RP
      GR=RAM/(PR(TA)*NUAA)
      PRINT 6,REM,RAM,PRM,GR
    6 FORMAT('0',10X,'REM= ',F7.1,20X,'RAM= ',E9.3,15X,
     *'PR= ',F5.2,15X,'GR= ',E9.3)
      PRINT 8,T(55),T(56)
```

```
    8 FORMAT('O',10X,'INLET BULK TEMP= ',F4.1,' DEG C',5X,'OUTLET BULK'
     *,' TEMP= ',F4.1,' DEG C')
      FLRTA=FLRT*3600./1000.
      PRINT 9,FLRTA,DP1,CF
    9 FORMAT('O',10X,'MASS FLOW RATE=',F6.1,' KG/HR',5X,'PRESSURE',
     *' DROP=',F7.1,' PA',5X, 'CF=',F6.4)
      PRINT 27
   27 FORMAT('O',10X,'-----------------------------------------------'
     *,'---------------------------------------------')
      DO 1 J=1,23
      XP(J)=(2.*X(J)/D/RE(J)/PR(TF(J))/100.)
      XX(J)=X(J)/D/100.
    1 CONTINUE
      CALL PRINTS (NU,RE,XP,RA,TF,X,NUA,NUC,TFF,XX,NUENT,T,TEMP)
      PRINT 12,NUAA,NUAAA
   12 FORMAT('O',15X,'FULLY DEVELOPED NUSSELT NUMBER= ',F5.1,2X,F5.1,'*'
     *)
C
C THE FOLLOWING SUBROUTINE CORRECTS THE READINGS OF ALL WALL
C THERMOCOUPLES ACCORDING TO THE CALIBRATION.
C
      SUBROUTINE CALIBR (TR,TC,Y,X)
      DIMENSION Z(5,5),X(60,4),Y(5),TR(80),TC(80)
      DO 10 J=1,54
      DO 20 I=2,4
      Z(I,1)=(Y(1)*(X(J,I)-TR(J))-Y(I)*(X(J,1)-TR(J)))/(X(J,I)-X(J,1))
   20 CONTINUE
      DO 30 I=3,4
      Z(I,2)=(Z(2,1)*(X(J,I)-TR(J))-Z(I,1)*(X(J,2)-TR(J)))/
     *(X(J,I)-X(J,2))
   30 CONTINUE
      TC(J)=(Z(4,2)*(X(J,4)-TR(J))-Z(4,2)*(X(J,3)-TR(J)))/
     *(X(J,4)-X(J,3))
   10 CONTINUE
      RETURN
      END
C
C THE FOLLOWING SUBROUTINE CALCULATES THE PRESSURE DROP
C AND THE FRICTION FACTOR.
C
      SUBROUTINE PRESS(P,DP,DP1,DP2,CF,D,TA,FLRT,AF,N)
      DP=(P-4.)*10./16.
      DP1=DP*RO(TA)*9.81*.0254
      DP2=DP1/6894.76
      CF=DP1*D*RO(TA)*((AF/1000000)**2)/(2.*1.0*(FLRT/1000.)**2)
      RETURN
      END
C
C THE FOLLOWING SUBROUTINE CALCULATES NUSSELT NUMBER AT THE TOP AND
C THE BOTTOM OF EACH STATION IN THE HEATED SECTION
C
      SUBROUTINE NUSELT (FLRT,L,T,TF,X,PI,TA,Q,NU,D,NUA,AS,NUAA,NUENT)
      DIMENSION T(80),TF(80),X(60),NU(60),NUA(40),NUENT(40)
      REAL NU,L,PI,K,NUA,NUAA,NUENT
      QC=FLRT/1000.0*CP(TA)*(T(56)-T(55))
      DO 20 J=1,23
      NU(J)=QC*D/(T(J+2)-TF(J))/AS/K(TF(J))
   20 CONTINUE
      DO 25 J=24,46
      NU(J)=QC*D/(T(J+6)-TF(J-23))/AS/K(TF(J-23))
   25 CONTINUE
      DO 30 J=1,23
      NUA(J)=QC*D/(((T(J+2)+T(J+29))/2.0)-TF(J))/AS/K(TF(J))
   30 CONTINUE
      NUAA=O.
      DO 100 J=10,23
      NUAA=NUAA+NUA(J)
  100 CONTINUE
      NUAA=NUAA/14
      DO 40 J=1,23
```

```
      NUENT(J)=NUA(J)/NUAA
   40 CONTINUE
      RETURN
      END
```

THE FOLLOWING SUBROUTINE CALCULATES NUSSELT NUMBER TAKING INTO CONSIDERATION THE AXIAL WALL CONDUCTION

```
      SUBROUTINE NUSELC (FLRT,L,TEMP,TFF,U,Q,QB,NUC,D,AS,AW,KC,S,T,B,B1)
      DIMENSION TEMP(30),TFF(80),U(30),S(30),NUC(30),QB(30),T(80)
      REAL K,NUC,L,KC
      Q=Q-Q*(.02)
      TFF(1)=T(55)
      QB(1)=Q*S(1)/L +KC*AW*(TEMP(2)-TEMP(1))/(U(2)*100)-KC*AW*B/100.
      TFF(2)=1000.0*QB(1)/FLRT/CP(TFF(1)) +TFF(1)
      TFF(1)=(TFF(2)+TFF(1))/2
      NUC(1)=QB(1)*D*L/S(1)/AS/(TEMP(1)-TFF(1))/K(TFF(1))
      DO 100 J=2,22
      QB(J)=Q*S(J)/L +KC*AW*(TEMP(J+1)-TEMP(J))/(U(J+1)*100)-
     *KC*AW*(TEMP(J)-TEMP(J-1))/(U(J)*100)
      TFF(J+1)=1000.0*QB(J)/FLRT/CP(TFF(J)) +TFF(J)
      TFF(J)=(TFF(J+1)+TFF(J))/2
      NUC(J)=QB(J)*D*L/S(J)/AS/(TEMP(J)-TFF(J))/K(TFF(J))
  100 CONTINUE
      QB(23)=Q*S(23)/L -KC*AW*(TEMP(23)-TEMP(22))/(U(23)*100)-
     *KC*AW*B1/100
      TFF(23)=(TFF(23)+T(56))/2
      NUC(23)=QB(23)*D*L/AS/S(23)/(TEMP(23)-TFF(23))/K(TFF(23))
      RETURN
      END

C THE FOLLOWING SUBROUTINE PRINTS ALL THE RESULTS IN A CERTAIN FORMAT
C
      SUBROUTINE PRINTS (NU,RE,XP,RA,TF,X,NUA,NUC,TFF,XX,NUENT,T,TEMP)
      DIMENSION NU(60),RE(40),XP(30),RA(40),TF(80),X(80),TC(80),NUA(40)
      DIMENSION TEMP(30),NUC(30),TFF(80),XX(30),TEMPA(30),NUENT(40)
      DIMENSION T(80)
      REAL NU,NUA,NUC,NUENT
      PRINT 10
   10 FORMAT('0',10X,'STATION    X    TW(TOP)    TW(BOTTOM) TBULK',
     *'       RE       PR        RA          X+             NU      NUA')
      PRINT 11
   11 FORMAT('0',12X,'NO     CM       DEG C       DEGC     DEG C'
     *,'                                  (AVERAGE)')
      PRINT 21
   21 FORMAT('0',10X,'--------------------------------------------------'
     *,'---------------------------------------------')
      DO 20 J=1,23
      PRINT 30,J,X(J),T(J+29),T(J+2),TF(J),RE(J),PR(TF(J))
     *,RA(J),XP(J),NUA(J),NUC(J)
   30 FORMAT('0',12X,I2,4X,F4.1,4X,F4.1,7X,F4.1,4X,F4.1,4X,F7.1
     *,3X,F4.2,3X,E9.3,3X,F7.5,3X,F5.1,3X,F5.1)
   20 CONTINUE
      RETURN
      END
C
C THE FOLLOWING SUBROUTINE TAKES THE FLOWRATE READINGS OF ALL THE
C FLOWMETERS IN PERCENTAGE AND GIVE THEM BACK IN (GR/SEC) ACCORDING
C TO THE CALIBRATION OF THE FLOWMETERS.
C
      SUBROUTINE FLMETR (R1,R2,R3,FLMA,FLMB,FLMC,FLRT,FLRTC,N)
      DIMENSION FLMA(100),FLMB(100),FLMC(100)
      IF (R1.LE.10) THEN DO
      FLM1=(R1/10.)*FLMA(10)
      ELSE DO
      I=20
      DO 10 J=1,9
      IF (R1.LE.I) THEN DO
      FLM1=((R1-I+10.)/10.)*(FLMA(I)-FLMA(I-10))+FLMA(I-10)
```

```
      GO TO 40
      END IF
      I=I+10
   10 CONTINUE
      END IF
   40 IF (R2.LE.10) THEN DO
      FLM2=(R2/10.)*FLMB(10)
      ELSE DO
      I=20
      DO 20 J=1,9
      IF(R2.LE.I) THEN DO
      FLM2=((R2-I+10.)/10.)*(FLMB(I)-FLMB(I-10))+FLMB(I-10)
      GO TO 50
      END IF
      I=I+10
   20 CONTINUE
      END IF
   50 FLRT=FLM1+FLM2
      IF(R3.LE.10) THEN DO
      FLRTC=(R3/10.)*FLMC(10)
      ELSE DO
      I=20
      DO 30 J=1,9
      IF(R3.LE.I) THEN DO
      FLRTC=((R3-I+10)/10.)*(FLMC(I)-FLMC(I-10))+FLMC(I-10)
      GO TO 60
      END IF
      I=I+10
   30 CONTINUE
      END IF
   60 RETURN
      END
C
C THE FOLLOWING SUBROUTINE CALCULATES THE LOCAL REYNOLDS NUMBER AT
C EACH STATION
C
      SUBROUTINE RENOLD (FLRT,D,TF,PI,RE,AF)
      DIMENSION RE(40),TF(80)
      DO 10 J=1,23
      RE(J)=FLRT*D*1000.0/VISC(TF(J))/AF
   10 CONTINUE
      RETURN
      END
C THIS SUBROUTINE CALCULATES THE HEAT BALANCE IN THE HEATED SECTION
C AND FINDS THE PERCENTAGE OF LOSSES.
C
      SUBROUTINE HETBAL (Q,FLRT,TA,T)
      DIMENSION T(70)
      QC=FLRT/1000.*CP(TA)*(T(56)-T(55))
      ERR=(Q-QC)/Q*100.
      PRINT 10,Q,QC,ERR
   10 FORMAT('0',10X,'INPUT POWER=',F7.1,' W',5X,'HEAT GAINED BY'
     *,' WATER=',F7.1,5X,'HEAT BALANCE ERROR=',F4.1,'%')
      RETURN
      END
C
C THIS SUBROUTINE CALCULATES THE HEAT EXCHANGED BY EACH HEATEXCHANGER
C AND FINDS THE PERCENTAGE OF HEAT LOSSES.
C
      SUBROUTINE EXHBAL (FLRT,FLRTC,T)
      DIMENSION T(70)
      Q1=FLRT/1000.*CP((T(57)+T(58))/2.)*(T(57)-T(58))
      Q2=FLRT/1000.*CP((T(58)+T(59))/2.)*(T(58)-T(59))
      QC1=FLRTC/1000.*CP((T(62)+T(61))/2.)*(T(62)-T(61))
      QC2=FLRTC/1000.*CP((T(61)+T(60))/2.)*(T(61)-T(60))
      HL1=(Q1-QC1)/Q1*100.
      HL2=(Q2-QC2)/Q2*100.
      RETURN
      END
```

```
C THE FOLLOWING FUNCTION CALCULATES THE FLUID THERMAL CONDUCTIVITY
C AT A GIVEN TEMPERATURE.
C
      FUNCTION K(T)
      REAL K
      K=(T-10.)/80.*0.091+0.585
      RETURN
      END
C
C THE FOLLOWING FUNCTION CALCULATES THE SPECIFIC HEAT CP AT A GIVEN
C TEMPERATURE
C
      FUNCTION CP(T)
      IF(T.LT.30.) THEN DO
      CP=4190.-1.15*(T-20.)+.005*(T-20.)**2
      ELSE DO
      IF(T.LT.50.) THEN DO
      CP=4177.-.05*(T-40.)+.015*(T-40.)**2
      ELSE DO
      IF(T.LT.70.) THEN DO
      CP=4183.+.45*(T-60.)-.005*(T-60.)**2
      ELSE DO
      CP=4197.+.95*(T-80.)-.005*(T-80.)**2
      END IF
      END IF
      END IF
      RETURN
      END
C
C THE FOLLOWING FUNCTION CALCULATES PRANDTL NUMBER AT A GIVEN TEMP.
C
      FUNCTION PR(T)
      IF(T.LT.30.) THEN DO
      PR=7.03-.1995*(T-20.)+.00385*(T-20.)**2
      ELSE DO
      IF(T.LT.50.) THEN DO
      PR=4.33-.097*(T-40.)+.0012*(T-40.)**2
      ELSE DO
      IF(T.LT.70.) THEN DO
      PR=3.04-.04535*(T-60.)-.000135*(T-60.)**2
      ELSE DO
      PR=2.245-.0297*(T-80.)+.00031*(T-80.)**2
      END IF
      END IF
      END IF
      RETURN
      END
C
C THE FOLLOWING FUNCTION CALCULATES THE WATER THERMAL EXPANSION
C COEFFICINT AT A GIVEN TEMPERATURE.
C
      FUNCTION BETA(T)
      IF(T.LT.30.) THEN DO
      BETA=.0002+9.5E-6*(T-20.)-5.E-8*(T-20.)**2
      ELSE DO
      IF(T.LT.50.) THEN DO
      BETA=.00038+8.5E-6*(T-40.)-5.E-8*(T-40.)**2
      ELSE DO
      IF(T.LT.70.) THEN DO
      BETA=.00053+6.5E-6*(T-60.)-5.E-8*(T-60.)**2
      ELSE DO
      BETA=.00064+5.E-6*(T-80.)
      END IF
      END IF
      END IF
      RETURN
      END
```

```
C THE FOLLOWING FUNCTION CALCULATES THE WATER DENSITY AT A GIVEN
C TEMPERATURE.
C
      FUNCTION RO(T)
      IF(T.LT.30.) THEN DO
      RO=998.-.2*(T-20.)
      ELSE DO
      IF(T.LT.50.) THEN DO
      RO=992.6-.395*(T-40.)-.0055*(T-40.)**2
      ELSE DO
      IF(T.LT.70.) THEN DO
      RO=983.3-.515*(T-60.)-.0035*(T-60.)**2
      ELSE DO
      RO=971.8-.62*(T-80.)-.002*(T-80.)**2
      END IF
      END IF
      END IF
      RETURN
      END
C
C THIS FUNCTION CALCULATES THE WATER DYNAMIC VISCOSITY AT A GIVEN TEMP.
C
      FUNCTION VISC(T)
      IF(T.LT.30.) THEN DO
      VISC=1.01E-3-.2535E-4*(T-20.)+.465E-6*(T-20.)**2
      ELSE DO
      IF(T.LT.50.) THEN DO
      VISC=.656E-3-.133333E-4*(T-40.)+.135E-6*(T-40.)**2
      ELSE DO
      IF(T.LT.70.) THEN DO
      VISC=.475E-3-.64E-5*(T-60.)-.3E-7*(T-60.)**2
      ELSE DO
      VISC=.359E-3-.45E-5*(T-80.)+.4E-7*(T-80.)**2
      END IF
      END IF
      END IF
      RETURN
      END
$ENTRY
```

APPENDIX B

APPENDIX B

SAMPLE CALCULATIONS

Run No. 1 of tube No. 14 was selected to illustrate the calculation of the different parameters. Local parameter values are calculated only at Station 15, since the same procedure is used for all other stations. Note, the small discrepancies between the following calculated values and those reported in Appendix C, are due to errors introduced in rounding-off some data. Also note that labels shown in brackets immediately following computed values are those labels used in Appendix C. Raw data recorded for the above mentioned run were:

Flow rate ($\dot{m}$)	= 28.19 g/s (101.5 kg/hr)
Input power (Qe)	= 500.0 W
Presure drop reading	= 4.84 mA
Wall bottom temperature (calibrated)	= 40.9°C
Wall top temperature (calibrated)	= 40.8°C
Inlet bulk temperature	= 33.0°C (32.992°C)
Outlet bulk temperature	= 37.0°C (37.049°C)

Dimensional data for tube No. 14 were:

Inside diameter (D_i)	= 13.9 mm
Hydraulic diameter (D_h)	= 8.15 mm
Actual flow area (A_{fa})	= 137.0 $(mm)^2$
Actual surface area (A_a)	= 67.3 $(mm)^2$/mm
Total heated length (L)	= 87.5 cm
Wall cross-sectional area (A_w)	= 61.55 $(mm)^2$

Mean bulk temperature, T_m = (33.0 + 37.0)/2 = 35.0°C

Specific heat at mean bulk temperature, c_p = 4178 J/kg.K

Rate of heat gained by the fluid:

$$Q_f = \dot{m}\, c_p\, \Delta T_b$$

$$= (0.02819)(4178)(37.049 - 32.992) = 477.8 \text{ W}$$

Percentage heat balance error:

$$\text{Error} = 100\,(Q_e - Q_f)/Q_e$$

$$= 100\,(500 - 477.8)/500 = 4.4\%$$

The bulk temperature at Station 15 was evaluated using linear interpolation between inlet and outlet temperatures as follows:

$$T_b = T_{bi} + (T_{bo} - T_{bi})(x/L)$$

$$= 32.992 + (37.049 - 32.992)(45.5/87.5)$$

$$= 35.1°\text{C (TBULK)}$$

At this temperature, the local viscosity is 7.240×10^{-4} N.s/m^2, hence the local Reynolds number (based on hydraulic diameter) is:

$$Re_{hx} = \frac{\dot{m}\, D_h}{\mu_x\, A_{fa}} = \frac{(0.02819)(0.00815)}{(7.240 \times 10^{-4})(0.000137)} = 2316 \text{ (RE)}$$

At the mean bulk temperature (35.0°C), $\mu = 7.254 \times 10^{-4}$ N.s/m^2, hence the corresponding mean Reynolds number is:

$$Re_h = 2312 \text{ (REM)}$$

At Station 15 with T_b = 35.1°C, additional fluid properties are

$$\beta = 3.37 \times 10^{-4} (K)^{-1}, \quad k_f = 0.614 \text{ W/m.K}$$

$$c_p = 4178 \text{ J/kg.K}, \quad \rho = 994.4 \text{ kg/m}^3$$

The local modified Rayleigh number was evaluated as:

$$Ra^*_x = g\beta(D_h)^4 Q_f\, \rho^2\, c_p/(\mu\, k_f^2\, A_a\, L)$$

$$= \frac{(9.81)(3.37 \times 10^{-4})(0.00815)^4(477.8)(994.4)^2(4178)}{(7.240 \times 10^{-4})(0.614)^2(67.3 \times 875 \times 10^{-6})}$$

$$= 0.179 \times 10^7 \text{ (RA)}$$

Similarly the mean modified Rayleigh number evaluated at the mean bulk temperature (35.0°C) is:

$$Ra^* = 0.177 \times 10^7 \text{ (RAM)}$$

The local average Nusselt number was calculated from:

$$Nu_x = \frac{h_x D_h}{k_f} = \frac{Q_f D_h}{A_a L(\overline{T}_w - T_b)k_f}$$

where $\overline{T}_w$ = [TW(TOP) + TW(BOTTOM)]/2

$$= (40.8 + 40.9)/2 = 40.85°C$$

$$Nu_x = \frac{(477.8)(0.00815)}{(67.3 \times 875 \times 10^{-6})(40.85 - 35.1)(0.614)}$$

$$= 18.7 \text{ (NU-AVERAGE)}$$

The fully developed Nusselt number (average of last 14 Nu_x values) is $\overline{Nu}$ = 18.7 and the mean Prandtl number (at 35.0°C) is 4.84, hence the fully developed Grashof number is:

$$Gr = \frac{Ra^*}{Nu\ Pr} = \frac{0.177 \times 10^7}{(18.7)(4.84)} = 0.196 \times 10^5 \text{ (GR)}$$

The reduced length X^+ at Station 15 is:

$$X^+ = \frac{x}{\frac{1}{2} D_h Re_{hx} Pr_x} = \frac{0.455}{\frac{1}{2}(0.00815)(2316)(4.83)} = 0.00998$$

The span of the pressure transucer used for the pressure drop measurement (L_p = 1m) was 0 - 10 inches of water, with an output of 4 mA at $\Delta P = 0$ and an oucput of 20 mA at $\Delta P = 10''H_2O$. Linear interpolation (as per manual instructions) is used to convert the present reading of 4.84 mA to:

$$\Delta P = (10/16)(4.84 - 4.00) = 0.525'' \; H_2O,$$

hence with

$$\rho = 994.4 \text{ kg/m}^3, \text{ and } \Delta P = \rho g(\text{Head}),$$

$$\Delta P = (0.525)(0.0254)(994.4)(9.81) = 130.1 \text{ Pa}$$

The average diabatic friction factor is:

$$f_h = \frac{\Delta P \; D_h \; \rho(A_{fa})^2}{2 \; L_p(\dot{m})^2}$$

$$= \frac{(130.1)(0.00815)(994.4)(0.000137)^2}{2(1)(0.02819)^2}$$

$$= 0.0124 \text{ (CF)}$$

APPENDIX C

APPENDIX C

TABULATION OF ALL EXPERIMENTAL RESULTS

CF	≡	f_h	evaluated at mean bulk temperature
REM	≡	Re_h	evaluated at mean bulk temperature
RAM	≡	Ra^*	evaluated at mean bulk temperature
GR	≡	Gr	evaluated at mean bulk temperature
TW	≡	T_w	
TBULK	≡	T_b	
RE	≡	Re_x	evaluated at local bulk temperature
PR	≡	Pr_x	evaluated at local bulk temperature
X^+	≡	X^+	evaluated at local bulk temperature
RA	≡	Ra_x^*	evaluated at local bulk temperature
NU	≡	Nu_x	evaluated at local bulk temperature

NOTES:

1) The value of the fully developed Nusselt number with a star (*) corresponds to the value taking into consideration the axial conduction of the tube wall. Similarly, the local values (NUA) allow for tube wall conduction.

2) Some of the runs presented here were rejected (due to excessive heat balance error), and were not presented in the results of the last chapter.

3) For all five internally finned tubes (but not for the smooth tube), the values tabulated for RA, RAM and GR are too large by the factor 10^4. For example, the listed value RA = 0.178×10^{11} should read RA = 0.178×10^7. This inadvertent error does not appear elsewhere in this thesis.

4) For all runs for the smooth tube, axial distances from the start of heating for Stations 17 to 23 inclusive, are those listed for Run No. 1.

RUN NUMBER (1)   SMOUTH TUBE

INPUT POWER= 2100.0 W   HEAT GAINED BY WATER= 1879.9   HEAT BALANCE ERROR=10.5%

REM= 3643.0   RAM=0.522E 08   PR= 5.13   GR= 0.407E 06

INLET BULK TEMP 26.2 DEG C   OUTLET BULK TEMP= 38.9 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 558.0 PA   CF=0.0640

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	39.5	39.0	26.3	3205.5	5.92	0.389E 08	0.00020	33.6	82.6
2	6.9	41.4	40.8	26.5	3221.4	5.89	0.394E 08	0.00046	29.9	29.2
3	10.8	42.6	41.7	26.8	3237.2	5.86	0.398E 08	0.00072	28.2	30.5
4	14.9	42.9	43.2	27.0	3253.9	5.82	0.403E 08	0.00099	27.0	30.4
5	20.7	44.6	44.8	27.3	3277.4	5.78	0.410E 08	0.00138	24.9	25.6
6	26.3	45.0	46.2	27.6	3300.1	5.73	0.416E 08	0.00175	24.1	24.9
7	32.0	45.6	46.2	28.0	3323.1	5.69	0.423E 08	0.00213	24.2	27.4
8	37.7	46.6	47.1	28.3	3346.0	5.64	0.430E 08	0.00251	23.3	24.4
9	43.7	47.9	47.3	28.6	3370.1	5.60	0.437E 08	0.00292	22.7	23.1
10	49.5	48.3	47.3	29.0	3393.3	5.55	0.443E 08	0.00330	22.9	23.0
11	57.5	47.4	46.6	29.4	3425.1	5.49	0.453E 08	0.00384	24.5	27.8
12	65.2	48.5	48.2	29.8	3455.5	5.44	0.462E 08	0.00436	23.3	22.3
13	73.9	48.3	47.6	30.3	3490.5	5.38	0.473E 08	0.00495	24.5	25.6
14	80.6	48.7	47.7	30.7	3517.1	5.33	0.482E 08	0.00540	24.6	24.9
15	88.4	48.7	48.2	31.2	3548.3	5.28	0.492E 08	0.00593	24.9	25.1
16	96.1	48.5	49.2	31.6	3579.5	5.23	0.502E 08	0.00646	24.9	25.3
17	107.5	50.3	50.4	32.2	3626.2	5.15	0.517E 08	0.00723	23.7	22.3
18	119.3	50.3	50.6	32.9	3675.3	5.08	0.533E 08	0.00804	24.5	23.6
19	130.8	50.8	50.4	33.6	3723.9	5.00	0.548E 08	0.00883	25.1	23.6
20	142.5	50.5	51.0	34.2	3774.0	4.93	0.564E 08	0.00963	25.8	24.2
21	154.1	52.5	50.5	34.9	3824.4	4.86	0.581E 08	0.01043	25.7	22.3
22	165.3	50.3	51.0	35.5	3873.8	4.79	0.596E 08	0.01121	28.2	26.3
23	190.5	52.1	52.1	36.9	3987.5	4.64	0.633E 08	0.01296	28.1	30.4

FULLY DEVELOPED NUSSELT NUMBER= 25.1   24.8*

RUN NUMBER (2) SMOOTH TUBE

INPUT POWER= 2225.0 W HEAT GAINED BY WATER= 2184.6 HEAT BALANCE ERROR= 1.8%

REM= 6239.2 RAM=0.454E 08 PR= 5.65 GR= 0.186E 06

INLET BULK TEMP 24.3 DEG C OUTLET BULK TEMP= 32.3 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 277.4 PA CF=0.0092

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	35.1	34.8	24.4	5723.8	6.23	0.371E 08	0.00011	48.2	91.6
2	6.9	35.7	35.5	24.5	5742.3	6.20	0.374E 08	0.00024	45.9	43.5
3	10.8	36.2	35.7	24.7	5760.8	6.18	0.377E 08	0.00038	45.1	44.3
4	14.9	35.7	36.6	24.8	5780.3	6.16	0.380E 08	0.00053	44.8	47.6
5	20 7	37.0	37.6	25.0	5807.8	6.12	0.384E 08	0.00073	41.3	39.0
6	26.3	36.8	38.7	25.2	5834.4	6.09	0.389E 08	0.00093	40.3	37.5
7	32.0	36.9	38.1	25.4	5861.5	6.06	0.393E 08	0.00113	41.9	43.0
8	37.7	37.5	38.6	25.6	5888.6	6.03	0.397E 08	0.00134	40.8	39.1
9	43.7	38.5	38.4	25.8	5917.1	6.00	0.402E 08	0.00155	40.1	37.2
10	49.5	38.6	38.2	26.0	5944.7	5.96	0.406E 08	0.00176	41.0	37.6
11	57.5	37.6	37.3	26.3	5982.7	5.92	0.412E 08	0.00204	45.6	46.5
12	65.2	38.9	38.7	26.6	6019.2	5.88	0.418E 08	0.00232	41.4	35.9
13	73.9	38.4	38.3	26.9	6060.4	5.84	0.425E 08	0.00263	44.1	41.7
14	80.6	39.0	38.6	27.1	6092.1	5.80	0.430E 08	0.00287	43.4	39.5
15	88.4	39.4	39.1	27.4	6129.0	5.76	0.436E 08	0.00315	42.8	38.9
16	96.1	39.2	40.4	27.7	6165.3	5.72	0.442E 08	0.00343	41.7	37.7
17	****	40.5	41.1	28.1	6218.9	5.67	0.451E 08	0.00384	39.6	34.3
18	****	40.5	41.3	28.5	6274.2	5.61	0.460E 08	0.00426	40.8	35.5
19	****	40.8	40.9	28.9	6327.8	5.56	0.469E 08	0.00468	42.2	35.9
20	****	40.2	41.3	29.3	6382.1	5.50	0.478E 08	0.00510	44.1	37.1
21	****	41.9	40.1	29.7	6435.6	5.45	0.487E 08	0.00553	44.6	35.5
22	****	39.7	40.9	30.1	6488.3	5.40	0.496E 08	0.00593	49.4	41.4
23	****	41.9	42.3	31.0	6605.0	5.30	0.518E 08	0.00685	45.3	43.5

FULLY DEVELOPED NUSSELT NUMBER= 43.3 38.6*

RUN NUMBER (3)   SMOUTH TUBE

INPUT POWER= 2040.0 W   HEAT GAINED BY WATER= 1954.8   HEAT BALANCE ERROR= 4.2%

REM= 8483.1   RAM=0.403E 08   PR= 5.74   GR= 0.126E 06

INLET BULK TEMP 25.0 DEG C   OUTLET BULK TEMP= 30.2 DEG C

MASS FLOW RATE= 322.3 KG/HR   PRESSURE DROP= 497.2 PA   CF=0.0086

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	32.7	32.6	25.1	8020.3	6.12	0.353E 08	0.00008	59.7	105.2
2	6.9	33.1	32.8	25.1	8036.9	6.11	0.355E 08	0.00018	58.1	57.7
3	10.8	33.3	32.8	25.2	8053.5	6.09	0.357E 08	0.00028	58.1	59.3
4	14.9	32.7	33.6	25.3	8070.9	6.08	0.358E 08	0.00038	58.3	63.2
5	20.7	33.6	34.3	25.5	8095.6	6.06	0.361E 08	0.00053	53.5	52.4
6	26.3	33.5	35.2	25.6	8119.5	6.04	0.363E 08	0.00068	51.8	49.2
7	32.0	33.4	34.6	25.7	8143.8	6.01	0.366E 08	0.00082	54.6	57.7
8	37.7	33.9	35.0	25.9	8168.0	5.99	0.369E 08	0.00097	52.6	51.7
9	43.7	34.9	34.7	26.0	8193.6	5.97	0.371E 08	0.00112	51.5	48.7
10	49.5	34.8	34.4	26.1	8218.3	5.95	0.374E 08	0.00127	53.3	50.8
11	57.5	34.0	33.7	26.3	8252.3	5.93	0.378E 08	0.00148	59.9	62.1
12	65.2	35.0	35.0	26.5	8285.0	5.90	0.381E 08	0.00168	53.2	47.5
13	73.9	34.6	34.5	26.7	8322.0	5.87	0.385E 08	0.00190	57.6	56.2
14	80.6	35.0	34.8	26.8	8350.5	5.85	0.388E 08	0.00208	56.1	52.5
15	88.4	35.3	35.1	27.0	8383.6	5.82	0.392E 08	0.00228	55.3	51.9
16	96.1	35.1	36.3	27.2	8416.2	5.79	0.395E 08	0.00248	53.2	49.5
17	****	36.1	36.8	27.5	8464.5	5.76	0.400E 08	0.00277	50.3	45.2
18	****	36.0	36.8	27.7	8514.3	5.72	0.406E 08	0.00308	52.2	47.0
19	****	36.3	36.4	28.0	8562.8	5.68	0.411E 08	0.00338	54.3	47.8
20	****	35.7	36.7	28.3	8612.0	5.65	0.417E 08	0.00369	57.1	49.6
21	****	37.0	35.5	28.5	8660.7	5.61	0.422E 08	0.00399	58.2	48.7
22	****	35.5	36.4	28.8	8707.5	5.57	0.427E 08	0.00428	62.7	53.5
23	****	36.9	37.3	29.4	8812.3	5.50	0.439E 08	0.00494	58.4	57.7

FULLY DEVELOPED NUSSELT NUMBER= 55.8   51.4*

RUN NUMBER (4) SMOUTH TUBE

INPUT POWER= 2225.0 W HEAT GAINED BY WATER= 2172.6 HEAT BALANCE ERROR= 2.4%

REM= 12143.6 RAM=0.426E 08 PR= 5.83 GR= 0.996E 05

INLET BULK TEMP 25.0 DEG C OUTLET BULK TEMP= 28.9 DEG C

MASS FLOW RATE= 467.5 KG/HR PRESSURE DROP= 991.8 PA CF=0.0082

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	32.1	32.2	25.0	11627.5	6.12	0.384E 08	0.00005	71.4	112.3
2	6.9	32.0	31.9	25.1	11646.0	6.11	0.386E 08	0.00012	74.1	75.2
3	10.8	32.0	31.5	25.2	11664.5	6.10	0.387E 08	0.00019	76.4	78.0
4	14.9	31.3	32.2	25.2	11683.9	6.09	0.389E 08	0.00026	77.4	82.3
5	20.7	32.1	32.9	25.3	11711.4	6.08	0.391E 08	0.00037	70.4	68.0
6	26.3	31.9	33.9	25.4	11737.9	6.06	0.393E 08	0.00047	67.6	63.2
7	32.0	31.8	33.2	25.5	11765.0	6.04	0.395E 08	0.00057	72.1	74.5
8	37.7	32.3	33.6	25.6	11792.0	6.03	0.397E 08	0.00067	69.0	66.8
9	43.7	33.3	33.3	25.7	11820.4	6.01	0.400E 08	0.00077	66.9	61.8
10	49.5	33.2	32.8	25.8	11847.9	6.00	0.402E 08	0.00088	70.8	66.9
11	57.5	32.3	32.1	26.0	11885.8	5.97	0.405E 08	0.00102	81.4	82.6
12	65.2	33.3	33.3	26.1	11922.3	5.95	0.408E 08	0.00116	69.9	61.3
13	73.9	32.7	32.7	26.3	11963.5	5.93	0.411E 08	0.00131	78.7	75.9
14	80.6	33.2	33.0	26.4	11995.2	5.91	0.414E 08	0.00143	75.3	69.3
15	88.4	33.5	33.4	26.5	12032.1	5.89	0.417E 08	0.00157	73.1	67.4
16	96.1	33.2	34.6	26.7	12068.5	5.87	0.420E 08	0.00171	69.6	64.0
17	****	34.4	35.0	26.9	12122.4	5.84	0.424E 08	0.00191	64.5	57.6
18	****	34.3	35.2	27.1	12178.1	5.81	0.428E 08	0.00212	65.9	58.5
19	****	34.4	34.5	27.3	12232.3	5.78	0.433E 08	0.00233	70.4	61.8
20	****	33.6	34.9	27.5	12287.4	5.75	0.437E 08	0.00254	74.6	64.2
21	****	35.1	33.4	27.7	12342.0	5.72	0.442E 08	0.00274	76.6	64.2
22	****	33.7	34.6	27.9	12394.6	5.70	0.446E 08	0.00294	80.1	67.4
23	****	34.8	35.3	28.3	12512.6	5.64	0.456E 08	0.00340	75.0	72.5

FULLY DEVELOPED NUSSELT NUMBER= 73.3 66.7*

RUN NUMBER (5)   SMOUTH TUBE

INPUT POWER= 485.0 W   HEAT GAINED BY WATER= 468.8   HEAT BALANCE ERROR= 3.4%

REM= 3046.4   RAM=0.796E 07   PR= 6.27   GR= 0.553E 05

INLET BULK TEMP 22.5 DEG C   OUTLET BULK TEMP= 25.7 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 559.1 PA   CF=0.0643

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	26.2	26.0	22.6	2937.2	6.54	0.727E 07	0.00020	31.3	78.9
2	6.9	26.7	26.5	22.6	2941.1	6.53	0.730E 07	0.00045	27.5	24.9
3	10.8	27.0	26.9	22.7	2945.0	6.52	0.732E 07	0.00071	25.6	22.5
4	14.9	27.1	27.2	22.8	2949.2	6.51	0.735E 07	0.00098	24.9	27.0
5	20.7	27.4	27.6	22.8	2955.0	6.50	0.738E 07	0.00136	23.1	21.8
6	26.3	27.5	28.0	22.9	2960.6	6.48	0.742E 07	0.00172	22.5	21.8
7	32.0	27.7	28.0	23.0	2966.3	6.47	0.746E 07	0.00210	22.4	23.2
8	37.7	28.0	28.2	23.1	2972.1	6.45	0.749E 07	0.00247	21.7	21.6
9	43.7	28.4	28.2	23.2	2978.1	6.44	0.753E 07	0.00287	21.1	19.4
10	49.5	28.4	28.2	23.2	2983.9	6.42	0.757E 07	0.00325	21.3	20.0
11	57.5	28.2	28.1	23.4	2992.0	6.40	0.762E 07	0.00377	22.5	23.5
12	65.2	28.5	28.5	23.5	2999.7	6.39	0.767E 07	0.00428	21.6	19.5
13	73.9	28.5	28.5	23.6	3008.5	6.36	0.772E 07	0.00485	22.2	21.1
14	80.6	28.6	28.5	23.7	3015.3	6.35	0.776E 07	0.00530	22.5	21.2
15	88.4	28.6	28.6	23.8	3023.1	6.33	0.781E 07	0.00581	22.6	21.1
16	96.1	28.5	28.9	23.9	3030.9	6.31	0.786E 07	0.00632	22.6	21.6
17	****	29.1	29.1	24.1	3042.4	6.28	0.794E 07	0.00707	21.5	18.7
18	****	29.1	29.2	24.2	3054.4	6.26	0.801E 07	0.00785	21.9	19.3
19	****	29.1	29.1	24.4	3066.0	6.23	0.809E 07	0.00861	23.0	20.3
20	****	29.0	29.2	24.5	3077.8	6.20	0.816E 07	0.00939	23.7	20.7
21	****	29.6	29.1	24.7	3089.6	6.18	0.824E 07	0.01016	23.5	18.4
22	****	28.7	29.1	24.9	3100.9	6.15	0.831E 07	0.01090	26.8	24.1
23	****	29.4	29.6	25.2	3126.5	6.09	0.847E 07	0.01258	25.4	25.1

FULLY DEVELOPED NUSSELT NUMBER= 22.9   21.0*

RUN NUMBER (6) SMOUTH TUBE

INPUT POWER= 580.0 W HEAT GAINED BY WATER= 557.5 HEAT BALANCE ERROR= 3.9%

REM= 3108.3 RAM=0.999E 07 PR= 6.13 GR= 0.709E 05

INLET BULK TEMP 23.1 DEG C OUTLET BULK TEMP= 26.9 DEG C

MASS FLOW RATE= 125.1 KG/HR PRESSURE DROP= 559.0 PA CF=0.0643

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	27.2	27.0	23.1	2976.8	6.44	0.899E 07	0.00020	32.8	70.6
2	6.9	27.8	27.7	23.2	2981.5	6.43	0.903E 07	0.00045	28.4	23.7
3	10.8	28.2	28.0	23.3	2986.2	6.42	0.906E 07	0.00071	26.7	26.1
4	14.9	28.3	28.5	23.3	2991.1	6.41	0.910E 07	0.00098	25.6	26.9
5	20.7	28.9	29.1	23.4	2998.1	6.39	0.915E 07	0.00136	23.5	22.2
6	26.3	29.1	29.5	23.5	3004.9	6.37	0.921E 07	0.00173	22.6	21.3
7	32.0	29.2	29.5	23.6	3011.7	6.36	0.926E 07	0.00210	22.6	23.6
8	37.7	29.5	29.8	23.7	3018.6	6.34	0.931E 07	0.00248	21.9	21.5
9	43.7	29.9	29.9	23.8	3025.9	6.32	0.936E 07	0.00287	21.3	19.6
10	49.5	30.0	29.8	23.9	3032.9	6.31	0.942E 07	0.00326	21.6	20.3
11	57.5	29.8	29.7	24.1	3042.5	6.28	0.949E 07	0.00378	22.7	23.7
12	65.2	30.1	30.1	24.2	3051.8	6.26	0.956E 07	0.00429	21.8	19.6
13	73.9	30.2	30.1	24.3	3062.3	6.24	0.964E 07	0.00487	22.4	21.2
14	80.6	30.2	30.1	24.4	3070.4	6.22	0.970E 07	0.00531	22.8	21.7
15	88.4	30.3	30.2	24.6	3079.9	6.20	0.977E 07	0.00583	22.9	21.2
16	96.1	30.2	30.6	24.7	3089.2	6.18	0.985E 07	0.00634	22.9	21.8
17	****	30.9	30.9	24.9	3103.0	6.15	0.995E 07	0.00709	21.6	18.7
18	****	30.9	31.0	25.1	3117.3	6.11	0.101E 08	0.00787	22.1	19.6
19	****	30.9	31.0	25.3	3131.2	6.08	0.102E 08	0.00864	22.8	20.1
20	****	30.9	31.2	25.5	3145.4	6.05	0.103E 08	0.00942	23.2	19.9
21	****	31.5	30.9	25.7	3159.4	6.02	0.104E 08	0.01019	23.5	18.8
22	****	30.6	31.0	25.9	3173.0	5.99	0.105E 08	0.01094	26.3	23.4
23	****	31.4	31.5	26.3	3203.5	5.93	0.107E 08	0.01262	25.2	24.9

FULLY DEVELOPED NUSSELT NUMBER= 23.0 21.1*

RUN NUMBER (7) SMOUTH TUBE

INPUT POWER= 820.0 W HEAT GAINED BY WATER= 759.3 HEAT BALANCE ERROR= 7.4%

REM= 3182.3 RAM=0.149E 08 PR= 5.97 GR= 0.108E 06

INLET BULK TEMP 23.5 DEG C OUTLET BULK TEMP= 28.6 DEG C

MASS FLOW RATE= 125.1 KG/HR PRESSURE DROP= 558.8 PA CF=0.0642

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	3.0	29.1	28.8	23.5	3004.3	6.37	0.130E 08	0.00020	32.4	83.1
2	6.9	30.0	29.7	23.6	3010.7	6.36	0.131E 08	0.00045	28.2	26.0
3	10.8	30.5	30.3	23.7	3017.1	6.34	0.131E 08	0.00071	26.2	25.4
4	14.9	30.6	30.9	23.8	3023.8	6.33	0.132E 08	0.00098	25.4	28.4
5	20.7	31.3	31.6	23.9	3033.2	6.31	0.133E 08	0.00136	23.4	23.2
6	26.3	31.6	32.1	24.1	3042.4	6.28	0.134E 08	0.00173	22.6	22.4
7	32.0	31.8	32.1	24.2	3051.7	6.26	0.135E 08	0.00211	22.6	24.4
8	37.7	32.0	32.5	24.3	3061.1	6.24	0.136E 08	0.00248	22.1	22.9
9	43.7	32.6	32.5	24.5	3070.9	6.22	0.137E 08	0.00288	21.6	21.3
10	49.5	32.8	32.5	24.6	3080.4	6.20	0.138E 08	0.00326	21.8	21.3
11	57.5	32.5	32.3	24.8	3093.6	6.17	0.140E 08	0.00379	22.9	25.3
12	65.2	33.1	33.1	24.9	3106.2	6.14	0.141E 08	0.00430	21.5	19.7
13	73.9	32.9	32.9	25.1	3120.5	6.11	0.143E 08	0.00488	22.5	22.6
14	80.6	33.0	32.8	25.3	3131.5	6.08	0.144E 08	0.00532	23.1	23.2
15	88.4	33.2	33.0	25.5	3144.3	6.05	0.145E 08	0.00584	23.0	22.6
16	96.1	33.1	33.6	25.6	3156.9	6.03	0.147E 08	0.00635	22.6	22.3
17	****	33.9	34.1	25.9	3175.6	5.99	0.149E 08	0.00711	21.6	19.8
18	****	33.9	34.1	26.2	3195.0	5.94	0.151E 08	0.00790	22.3	21.0
19	****	34.1	34.2	26.4	3213.9	5.91	0.153E 08	0.00867	22.7	20.6
20	****	33.9	34.2	26.7	3233.0	5.87	0.155E 08	0.00945	23.7	21.8
21	****	34.7	33.9	27.0	3252.0	5.83	0.157E 08	0.01023	23.7	20.0
22	****	33.7	34.1	27.2	3270.3	5.79	0.159E 08	0.01098	26.2	24.4
23	****	34.6	34.7	27.8	3311.4	5.71	0.164E 08	0.01268	25.3	27.2

FULLY DEVELOPED NUSSELT NUMBER= 23.1 22.3*

RUN NUMBER (8)   SMOUTH TUBE

INPUT POWER= 980.0 W   HEAT GAINED BY WATER= 904.5   HEAT BALANCE ERROR= 7.7%

REM= 3262.1   RAM=0.189E 08   PR= 5.81   GR= 0.140E 06

INLET BULK TEMP 24.1 DEG C   OUTLET BULK TEMP= 30.2 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 558.7 PA   CF=0.0642

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	3.0	30.8	30.5	24.2	3049.9	6.27	0.161E 08	0.00020	32.1	81.6
2	6.9	31.8	31.6	24.3	3057.5	6.25	0.162E 08	0.00045	28.1	25.7
3	10.8	32.4	32.1	24.4	3065.1	6.23	0.163E 08	0.00071	26.4	27.1
4	14.9	32.6	32.9	24.5	3073.1	6.21	0.164E 08	0.00098	25.2	27.7
5	20.7	33.5	33.7	24.6	3084.4	6.19	0.166E 08	0.00136	23.4	23.4
6	26.3	33.7	34.4	24.8	3095.3	6.16	0.167E 08	0.00173	22.6	22.4
7	32.0	34.0	34.3	24.9	3106.4	6.14	0.169E 08	0.00211	22.7	24.9
8	37.7	34.3	34.8	25.1	3117.5	6.11	0.170E 08	0.00249	22.0	23.0
9	43.7	35.0	34.9	25.3	3129.3	6.09	0.172E 08	0.00289	21.4	20.9
10	49.5	35.2	34.9	25.4	3140.6	6.06	0.173E 08	0.00327	21.6	21.2
11	57.5	34.8	34.6	25.6	3156.2	6.03	0.175E 08	0.00380	23.0	25.4
12	65.2	35.3	35.3	25.8	3171.2	6.00	0.177E 08	0.00431	22.0	20.6
13	73.9	35.2	35.0	26.1	3188.2	5.96	0.179E 08	0.00489	23.0	23.3
14	80.6	35.4	35.0	26.3	3201.3	5.93	0.181E 08	0.00534	23.3	23.2
15	88.4	35.5	35.3	26.5	3216.5	5.90	0.183E 08	0.00586	23.3	22.9
16	96.1	35.3	36.0	26.7	3231.5	5.87	0.185E 08	0.00637	23.2	23.1
17	****	36.4	36.5	27.0	3253.7	5.82	0.188E 08	0.00714	22.1	20.4
18	****	36.5	36.7	27.3	3276.6	5.78	0.191E 08	0.00793	22.4	20.9
19	****	36.6	36.6	27.6	3298.9	5.73	0.194E 08	0.00870	23.0	21.2
20	****	36.4	36.9	27.9	3321.6	5.69	0.197E 08	0.00949	23.8	22.0
21	****	37.5	36.6	28.3	3343.9	5.64	0.200E 08	0.01027	23.6	19.7
22	****	36.1	36.7	28.6	3365.5	5.60	0.203E 08	0.01102	26.5	24.8
23	****	37.3	37.4	29.2	3413.7	5.51	0.210E 08	0.01273	25.5	29.4

FULLY DEVELOPED NUSSELT NUMBER= 23.3   22.7*

RUN NUMBER (9)   SMOUTH TUBE

INPUT POWER= 1200.0 W   HEAT GAINED BY WATER= 1154.7   HEAT BALANCE ERROR= 3.8%

REM= 3283.9   RAM=0.235E 08   PR= 5.76   GR= 0.175E 06

INLET BULK TEMP 23.5 DEG C   OUTLET BULK TEMP= 31.4 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 558.7 PA   CF=0.0642

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	32.1	31.7	23.6	3013.1	6.35	0.192E 08	0.00020	32.5	80.2
2	6.9	33.3	33.1	23.8	3022.8	6.33	0.193E 08	0.00045	28.4	24.4
3	10.8	34.1	33.7	23.9	3032.5	6.31	0.195E 08	0.00071	26.8	25.9
4	14.9	34.3	34.5	24.1	3042.7	6.28	0.196E 08	0.00098	25.8	27.6
5	20.7	35.4	35.6	24.3	3057.2	6.25	0.199E 08	0.00136	23.8	22.7
6	26.3	35.7	36.5	24.5	3071.1	6.22	0.201E 08	0.00173	22.9	22.1
7	32.0	36.2	36.6	24.7	3085.4	6.19	0.203E 08	0.00211	22.7	23.3
8	37.7	36.7	37.2	24.9	3099.6	6.15	0.205E 08	0.00249	22.1	21.8
9	43.7	37.4	37.3	25.1	3114.6	6.12	0.208E 08	0.00288	21.7	20.3
10	49.5	37.6	37.2	25.3	3129.1	6.09	0.210E 08	0.00327	22.0	20.9
11	57.5	37.3	36.9	25.5	3149.1	6.04	0.213E 08	0.00380	23.0	24.2
12	65.2	38.1	37.9	25.8	3168.4	6.00	0.216E 08	0.00431	21.8	19.3
13	73.9	37.9	37.8	26.1	3190.1	5.95	0.220E 08	0.00489	22.7	21.8
14	80.6	38.0	37.6	26.3	3206.8	5.92	0.223E 08	0.00534	23.2	22.3
15	88.4	38.3	37.9	26.6	3226.3	5.88	0.226E 08	0.00586	23.1	21.6
16	96.1	38.2	38.8	26.9	3245.5	5.84	0.229E 08	0.00638	22.8	21.5
17	****	39.3	39.5	27.3	3273.9	5.78	0.233E 08	0.00714	22.0	19.3
18	****	39.3	39.6	27.7	3303.2	5.72	0.238E 08	0.00794	22.5	20.1
19	****	39.6	39.6	28.1	3331.6	5.67	0.243E 08	0.00871	23.1	20.1
20	****	39.4	39.8	28.5	3360.5	5.61	0.248E 08	0.00950	23.9	20.9
21	****	40.6	39.5	28.9	3388.9	5.56	0.253E 08	0.01029	23.8	18.9
22	****	38.8	39.6	29.3	3416.3	5.51	0.257E 08	0.01105	26.7	23.7
23	****	40.2	40.4	30.2	3478.0	5.40	0.268E 08	0.01276	26.1	26.4

FULLY DEVELOPED NUSSELT NUMBER= 23.3   21.5*

RUN NUMBER (10)   SMOUTH TUBE

INPUT POWER= 1475.0 W   HEAT GAINED BY WATER= 1372.2   HEAT BALANCE ERROR= 7.0%

REM= 3388.5   RAM=0.310E 08   PR= 5.56   GR= 0.231E 06

INLET BULK TEMP 24.3 DEG C   OUTLET BULK TEMP= 33.6 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 558.5 PA   CF=0.0642

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	3.0	34.4	34.0	24.4	3067.6	6.23	0.246E 08	0.00020	32.5	80.6
2	6.9	35.7	35.4	24.6	3079.2	6.20	0.248E 08	0.00045	28.8	26.2
3	10.8	36.6	36.1	24.7	3090.8	6.17	0.251E 08	0.00071	27.3	27.8
4	14.9	36.8	37.1	24.9	3103.0	6.15	0.253E 08	0.00098	26.4	29.2
5	20.7	38.0	38.3	25.1	3120.2	6.11	0.256E 08	0.00137	24.3	23.9
6	26.3	38.3	39.3	25.4	3136.8	6.07	0.260E 08	0.00174	23.6	23.4
7	32.0	38.8	39.2	25.6	3153.8	6.03	0.263E 08	0.00212	23.7	25.7
8	37.7	39.4	39.9	25.8	3170.7	6.00	0.266E 08	0.00249	22.9	23.4
9	43.7	40.4	40.1	26.1	3188.5	5.96	0.270E 08	0.00289	22.3	21.7
10	49.5	40.7	40.1	26.3	3205.8	5.92	0.273E 08	0.00328	22.5	21.8
11	57.5	40.1	39.7	26.7	3229.5	5.87	0.278E 08	0.00381	23.8	25.9
12	65.2	40.9	40.8	27.0	3252.3	5.83	0.283E 08	0.00433	22.7	21.1
13	73.9	40.8	40.5	27.3	3278.0	5.77	0.288E 08	0.00491	23.7	23.6
14	80.6	41.1	40.5	27.6	3297.8	5.73	0.292E 08	0.00536	23.9	23.3
15	88.4	41.1	40.8	27.9	3320.8	5.69	0.297E 08	0.00589	24.2	23.8
16	96.1	41.2	41.8	28.3	3343.4	5.65	0.301E 08	0.00640	23.7	23.0
17	****	42.5	42.6	28.7	3376.7	5.58	0.308E 08	0.00717	22.7	20.7
18	****	42.6	42.8	29.2	3411.0	5.52	0.315E 08	0.00797	23.3	21.5
19	****	43.0	42.8	29.7	3444.3	5.46	0.322E 08	0.00875	23.8	21.6
20	****	42.8	43.2	30.2	3478.5	5.40	0.329E 08	0.00954	24.5	22.0
21	****	44.1	42.6	30.6	3512.0	5.34	0.337E 08	0.01033	24.7	20.6
22	****	42.2	42.9	31.1	3544.7	5.29	0.345E 08	0.01109	27.5	24.9
23	****	43.7	43.7	32.1	3619.5	5.17	0.361E 08	0.01282	27.0	28.4

FULLY DEVELOPED NUSSELT NUMBER= 24.2   23.0*

RUN NUMBER (11) SMOUTH TUBE

INPUT POWER= 1775.0 W   HEAT GAINED BY WATER= 1621.9   HEAT BALANCE ERROR= 8.6%

REM= 3519.3   RAM=0.408E 08   PR= 5.33   GR= 0.313E 06

INLET BULK TEMP 25.3 DEG C   OUTLET BULK TEMP= 36.3 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 558.3 PA   CF=0.0641

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	37.1	36.6	25.4	3142.5	6.06	0.314E 08	0.00020	32.9	81.2
2	6.9	38.7	38.2	25.6	3156.2	6.03	0.317E 08	0.00046	29.2	27.1
3	10.8	39.6	39.0	25.8	3169.9	6.00	0.320E 08	0.00071	27.8	29.2
4	14.9	39.9	40.2	26.0	3184.4	5.97	0.324E 08	0.00099	26.7	30.0
5	20.7	41.4	41.7	26.3	3204.7	5.92	0.329E 08	0.00137	24.6	24.9
6	26.3	41.9	43.0	26.6	3224.4	5.88	0.333E 08	0.00174	23.5	23.6
7	32.0	42.6	43.0	26.9	3244.4	5.84	0.338E 08	0.00212	23.5	26.0
8	37.7	43.4	43.9	27.1	3264.3	5.80	0.343E 08	0.00250	22.6	23.3
9	43.7	44.7	44.0	27.4	3285.3	5.76	0.348E 08	0.00291	22.1	22.2
10	49.5	44.9	44.2	27.7	3305.5	5.72	0.353E 08	0.00329	22.2	21.7
11	57.5	44.2	43.7	28.1	3333.3	5.67	0.360E 08	0.00383	23.5	26.2
12	65.2	45.4	45.0	28.5	3360.0	5.61	0.366E 08	0.00435	22.3	20.7
13	73.9	45.0	44.5	28.9	3390.1	5.56	0.374E 08	0.00493	23.6	24.0
14	80.6	45.0	44.3	29.2	3413.1	5.52	0.380E 08	0.00539	24.2	24.3
15	88.4	45.1	44.6	29.6	3439.7	5.47	0.386E 08	0.00591	24.4	24.4
16	96.1	45.1	45.8	30.0	3465.9	5.42	0.393E 08	0.00643	24.1	23.7
17	****	46.3	46.6	30.6	3505.4	5.35	0.404E 08	0.00721	23.3	21.9
18	****	46.6	46.8	31.1	3546.1	5.28	0.415E 08	0.00801	23.8	22.4
19	****	47.0	46.7	31.7	3586.2	5.22	0.426E 08	0.00879	24.4	22.5
20	****	46.8	47.3	32.3	3627.6	5.15	0.437E 08	0.00959	25.0	22.9
21	****	48.5	46.7	32.8	3669.2	5.09	0.449E 08	0.01038	25.1	21.1
22	****	46.1	46.8	33.4	3709.9	5.03	0.460E 08	0.01115	28.2	26.1
23	****	47.9	48.0	34.6	3803.2	4.89	0.485E 08	0.01289	27.7	29.4

FULLY DEVELOPED NUSSELT NUMBER= 24.4 23.7*

RUN NUMBER (12) SMOUTH TUBE

INPUT POWER= 2100.0 W HEAT GAINED BY WATER= 1879.9 HEAT BALANCE ERROR=10.5%

REM= 3643.0 RAM=0.522E 08 PR= 5.13 GR= 0.407E 06

INLET BULK TEMP 26.2 DEG C OUTLET BULK TEMP= 38.9 DEG C

MASS FLOW RATE= 125.1 KG/HR PRESSURE DROP= 558.0 PA CF=0.0640

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	39.5	39.0	26.3	3205.5	5.92	0.389E 08	0.00020	33.6	82.6
2	6.9	41.4	40.8	26.5	3221.4	5.89	0.394E 08	0.00046	29.9	29.2
3	10.8	42.6	41.7	26.8	3237.2	5.86	0.398E 08	0.00072	28.2	30.5
4	14.9	42.9	43.2	27.0	3253.9	5.82	0.403E 08	0.00099	27.0	30.4
5	20.7	44.6	44.8	27.3	3277.4	5.78	0.410E 08	0.00138	24.9	25.6
6	26.3	45.0	46.2	27.6	3300.1	5.73	0.416E 08	0.00175	24.1	24.9
7	32.0	45.6	46.2	28.0	3323.1	5.69	0.423E 08	0.00213	24.2	27.4
8	37.7	46.6	47.1	28.3	3346.1	5.64	0.430E 08	0.00251	23.3	24.4
9	43.7	47.9	47.3	28.6	3370.1	5.60	0.437E 08	0.00292	22.7	23.1
10	49.5	48.3	47.3	29.0	3393.3	5.55	0.443E 08	0.00330	22.9	23.0
11	57.5	47.4	46.6	29.4	3425.1	5.49	0.453E 08	0.00384	24.5	27.8
12	65.2	48.5	48.2	29.8	3455.5	5.44	0.462E 08	0.00436	23.3	22.3
13	73.9	48.3	47.6	30.3	3490.5	5.38	0.473E 08	0.00495	24.5	25.6
14	80.6	48.7	47.7	30.7	3517.1	5.33	0.482E 08	0.00540	24.6	24.9
15	88.4	48.7	48.2	31.2	3548.3	5.28	0.492E 08	0.00593	24.9	25.1
16	96.1	48.5	49.2	31.6	3579.5	5.23	0.502E 08	0.00646	24.9	25.3
17	****	50.3	50.4	32.2	3626.2	5.15	0.517E 08	0.00723	23.7	22.3
18	****	50.3	50.6	32.9	3675.3	5.08	0.533E 08	0.00804	24.5	23.6
19	****	50.8	50.4	33.6	3723.9	5.00	0.548E 08	0.00883	25.1	23.6
20	****	50.5	51.0	34.2	3774.0	4.93	0.564E 08	0.00963	25.8	24.2
21	****	52.5	50.5	34.9	3824.4	4.86	0.581E 08	0.01043	25.7	22.3
22	****	50.3	51.0	35.5	3873.8	4.79	0.596E 08	0.01121	28.2	26.3
23	****	52.1	52.1	36.9	3987.5	4.64	0.633E 08	0.01296	28.1	30.4

FULLY DEVELOPED NUSSELT NUMBER= 25.1 24.8*

RUN NUMBER (13) SMOUTH TUBE

INPUT POWER= 2000.0 W HEAT GAINED BY WATER= 1944.7 HEAT BALANCE ERROR= 2.8%

REM= 5912.5 RAM=0.361E 08 PR= 6.00 GR= 0.144E 06

INLET BULK TEMP 22.3 DEG C OUTLET BULK TEMP= 29.4 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 279.4 PA CF=0.0092

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	32.1	31.8	22.4	5454.5	6.58	0.296E 08	0.00011	47.5	91.5
2	6.9	32.7	32.5	22.5	5470.8	6.55	0.298E 08	0.00024	45.0	43.4
3	10.8	33.2	32.7	22.6	5487.0	6.53	0.301E 08	0.00038	44.0	43.9
4	14.9	32.8	33.6	22.8	5504.2	6.51	0.303E 08	0.00052	43.4	46.3
5	20.7	34.0	34.6	22.9	5528.5	6.48	0.306E 08	0.00073	39.9	37.8
6	26.3	33.9	35.6	23.1	5551.9	6.45	0.310E 08	0.00092	39.0	36.7
7	32.0	34.0	35.0	23.3	5575.9	6.41	0.313E 08	0.00113	40.4	42.1
8	37.7	34.4	35.6	23.5	5599.8	6.38	0.316E 08	0.00133	39.3	38.1
9	43.7	35.5	35.3	23.7	5625.0	6.35	0.320E 08	0.00154	38.6	36.1
10	49.5	35.5	35.1	23.8	5649.4	6.32	0.323E 08	0.00174	39.6	36.9
11	57.5	34.6	34.4	24.1	5683.1	6.28	0.328E 08	0.00203	43.4	44.6
12	65.2	35.6	35.6	24.3	5715.6	6.24	0.333E 08	0.00230	40.1	35.4
13	73.9	35.3	35.1	24.6	5752.3	6.19	0.338E 08	0.00261	42.6	41.0
14	80.6	35.8	35.4	24.8	5780.6	6.16	0.342E 08	0.00285	41.9	38.6
15	88.4	36.0	35.9	25.1	5813.6	6.12	0.346E 08	0.00313	41.5	38.3
16	96.1	35.8	37.0	25.3	5846.1	6.08	0.351E 08	0.00340	40.7	37.6
17	****	37.2	37.8	25.7	5894.3	6.02	0.358E 08	0.00381	38.2	33.5
18	****	37.1	37.9	26.0	5944.2	5.97	0.365E 08	0.00423	39.4	34.9
19	****	37.5	37.5	26.4	5992.8	5.91	0.372E 08	0.00465	40.7	35.3
20	****	37.0	37.9	26.8	6042.1	5.86	0.379E 08	0.00507	42.2	36.1
21	****	38.5	36.8	27.1	6090.9	5.80	0.386E 08	0.00548	42.8	34.9
22	****	36.5	37.5	27.5	6138.0	5.75	0.393E 08	0.00589	47.1	40.2
23	****	38.4	38.7	28.3	6243.4	5.64	0.409E 08	0.00680	43.8	42.9

FULLY DEVELOPED NUSSELT NUMBER= 41.7 37.9*

RUN NUMBER (14) SMOUTH TUBE

INPUT POWER= 1750.0 W HEAT GAINED BY WATER= 1703.4 HEAT BALANCE ERROR= 2.7%

REM= 5964.7 RAM=0.322E 08 PR= 5.94 GR= 0.128E 06

INLET BULK TEMP 23.1 DEG C OUTLET BULK TEMP= 29.3 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 282.2 PA CF=0.0093

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	31.6	31.3	23.2	5562.6	6.43	0.272E 08	0.00011	48.1	92.8
2	6.9	32.2	31.9	23.3	5577.0	6.41	0.274E 08	0.00024	45.4	43.2
3	10.8	32.6	32.1	23.4	5591.3	6.39	0.276E 08	0.00038	44.5	44.8
4	14.9	32.3	32.9	23.5	5606.4	6.37	0.278E 08	0.00052	43.8	46.4
5	20.7	33.2	33.7	23.7	5627.8	6.35	0.280E 08	0.00073	40.5	38.4
6	26.3	33.1	34.6	23.8	5648.4	6.32	0.283E 08	0.00093	39.5	37.1
7	32.0	33.1	34.2	24.0	5669.5	6.29	0.285E 08	0.00113	41.0	42.7
8	37.7	33.6	34.6	24.2	5690.5	6.27	0.288E 08	0.00133	39.8	38.4
9	43.7	34.4	34.4	24.3	5712.7	6.24	0.291E 08	0.00154	39.3	36.5
10	49.5	34.4	34.1	24.5	5734.1	6.21	0.293E 08	0.00175	40.5	37.8
11	57.5	33.6	33.4	24.7	5763.7	6.18	0.297E 08	0.00203	44.9	46.3
12	65.2	34.6	34.6	24.9	5792.2	6.14	0.300E 08	0.00230	40.8	35.7
13	73.9	34.3	34.3	25.1	5824.4	6.10	0.304E 08	0.00261	43.1	41.1
14	80.6	34.7	34.4	25.3	5849.2	6.08	0.308E 08	0.00285	42.7	39.5
15	88.4	35.0	34.9	25.5	5878.1	6.04	0.311E 08	0.00313	42.0	38.7
16	96.1	34.9	36.0	25.8	5906.6	6.01	0.315E 08	0.00341	40.8	37.3
17	****	36.0	36.5	26.1	5948.8	5.96	0.320E 08	0.00381	38.7	33.9
18	****	35.9	36.7	26.4	5992.4	5.91	0.326E 08	0.00424	39.9	35.3
19	****	36.3	36.4	26.7	6034.9	5.86	0.331E 08	0.00465	40.9	35.2
20	****	35.8	36.6	27.0	6078.1	5.82	0.336E 08	0.00507	42.9	36.7
21	****	37.2	35.8	27.4	6120.8	5.77	0.342E 08	0.00549	43.2	35.0
22	****	35.5	36.4	27.7	6162.0	5.73	0.347E 08	0.00589	47.5	40.5
23	****	37.2	37.5	28.4	6254.2	5.63	0.359E 08	0.00680	43.6	42.6

FULLY DEVELOPED NUSSELT NUMBER= 42.3 38.3*

RUN NUMBER (15) SMOUTH TUBE

INPUT POWER= 1500.0 W HEAT GAINED BY WATER= 1462.6 HEAT BALANCE ERROR= 2.5%

REM= 5800.6 RAM=0.258E 08 PR= 6.13 GR= 0.102E 06

INLET BULK TEMP 22.3 DEG C OUTLET BULK TEMP= 27.7 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 286.9 PA CF=0.0095

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	3.0	29.7	29.5	22.4	5456.6	6.57	0.222E 08	0.00011	47.2	90.9
2	6.9	30.2	30.0	22.5	5468.8	6.56	0.224E 08	0.00024	44.6	42.6
3	10.8	30.6	30.2	22.6	5481.1	6.54	0.225E 08	0.00038	43.6	42.9
4	14.9	30.2	30.9	22.7	5494.0	6.52	0.226E 08	0.00052	43.3	46.6
5	20.7	31.2	31.6	22.8	5512.2	6.50	0.228E 08	0.00073	39.8	37.7
6	26.3	31.1	32.4	22.9	5529.8	6.48	0.230E 08	0.00092	38.7	36.1
7	32.0	31.1	32.0	23.1	5547.8	6.45	0.232E 08	0.00112	40.1	41.6
8	37.7	31.5	32.4	23.2	5565.8	6.43	0.234E 08	0.00133	39.0	37.8
9	43.7	32.3	32.2	23.4	5584.7	6.40	0.236E 08	0.00154	38.4	36.0
10	49.5	32.3	32.0	23.5	5603.0	6.38	0.238E 08	0.00174	39.2	36.3
11	57.5	31.7	31.5	23.7	5628.3	6.35	0.240E 08	0.00202	43.2	44.5
12	65.2	32.5	32.5	23.9	5652.7	6.32	0.243E 08	0.00230	39.5	34.6
13	73.9	32.2	32.2	24.1	5680.3	6.28	0.246E 08	0.00261	41.9	40.0
14	80.6	32.5	32.3	24.2	5701.5	6.25	0.248E 08	0.00284	41.5	38.3
15	88.4	32.7	32.6	24.4	5726.3	6.22	0.251E 08	0.00312	41.1	37.9
16	96.1	32.6	33.6	24.6	5750.7	6.19	0.253E 08	0.00339	40.0	36.7
17	****	33.6	34.0	24.9	5786.9	6.15	0.257E 08	0.00380	37.9	33.3
18	****	33.6	34.3	25.1	5824.4	6.10	0.261E 08	0.00422	38.8	34.1
19	****	33.8	33.9	25.4	5860.9	6.06	0.265E 08	0.00463	40.3	34.9
20	****	33.4	34.2	25.7	5898.1	6.02	0.269E 08	0.00505	42.0	35.9
21	****	34.6	33.4	26.0	5935.0	5.98	0.273E 08	0.00547	42.3	34.2
22	****	33.0	33.9	26.2	5970.5	5.94	0.277E 08	0.00587	46.8	40.2
23	****	34.6	34.9	26.8	6050.5	5.85	0.285E 08	0.00677	42.8	41.8

FULLY DEVELOPED NUSSELT NUMBER= 41.2 37.3*

RUN NUMBER (16) SMOUTH TUBE

INPUT POWER= 1480.0 W HEAT GAINED BY WATER= 1206.8 HEAT BALANCE ERROR=18.5%

REM= 5596.0 RAM=0.234E 08 PR= 6.39 GR= 0.891E 05

INLET BULK TEMP 21.3 DEG C OUTLET BULK TEMP= 25.7 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 290.7 PA CF=0.0096

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	27.4	27.2	21.3	5314.7	6.77	0.205E 08	0.00010	47.1	100.0
2	6.9	27.7	27.6	21.4	5324.7	6.76	0.206E 08	0.00024	45.1	53.6
3	10.8	28.1	27.8	21.5	5334.7	6.74	0.207E 08	0.00038	43.7	50.6
4	14.9	27.8	28.2	21.6	5345.2	6.73	0.208E 08	0.00052	43.6	56.6
5	20.7	28.6	28.9	21.7	5360.1	6.71	0.210E 08	0.00072	39.7	45.3
6	26.3	28.6	29.5	21.8	5374.5	6.69	0.211E 08	0.00092	38.8	44.3
7	32.0	28.6	29.3	21.9	5389.1	6.67	0.213E 08	0.00112	40.0	49.8
8	37.7	28.9	29.6	22.0	5403.8	6.65	0.214E 08	0.00132	38.6	44.9
9	43.7	29.6	29.5	22.1	5419.3	6.63	0.216E 08	0.00153	38.0	43.3
10	49.5	29.6	29.4	22.2	5434.3	6.60	0.217E 08	0.00173	38.8	44.7
11	57.5	29.6	28.9	22.4	5455.0	6.58	0.219E 08	0.00202	40.9	49.0
12	65.2	29.7	29.7	22.5	5474.9	6.55	0.221E 08	0.00229	39.2	43.1
13	73.9	29.5	29.5	22.7	5497.4	6.52	0.224E 08	0.00259	41.4	47.9
14	80.6	29.7	29.6	22.8	5514.8	6.50	0.225E 08	0.00283	41.3	46.6
15	88.4	29.9	29.8	23.0	5535.1	6.47	0.227E 08	0.00311	41.1	46.5
16	96.1	29.8	30.6	23.1	5555.1	6.44	0.229E 08	0.00338	39.8	44.6
17	****	30.6	31.0	23.4	5584.7	6.40	0.233E 08	0.00378	37.9	40.9
18	****	30.5	31.1	23.6	5615.5	6.36	0.236E 08	0.00420	38.9	42.2
19	****	30.7	30.9	23.8	5645.5	6.32	0.239E 08	0.00461	40.2	42.8
20	****	30.4	31.1	24.0	5676.1	6.29	0.242E 08	0.00502	42.0	44.3
21	****	31.3	30.4	24.3	5706.4	6.25	0.245E 08	0.00544	42.5	42.8
22	****	30.0	30.7	24.5	5735.7	6.21	0.248E 08	0.00584	47.6	50.4
23	****	31.4	31.6	25.0	5801.7	6.13	0.255E 08	0.00674	43.1	50.8

FULLY DEVELOPED NUSSELT NUMBER= 41.0 45.5*

RUN NUMBER (17) SMOOTH TUBE

INPUT POWER= 1000.0 W HEAT GAINED BY WATER= 965.7 HEAT BALANCE ERROR= 3.4%

REM= 5455.5 RAM=0.148E 08 PR= 6.58 GR= 0.550E 05

INLET BULK TEMP 20.6 DEG C OUTLET BULK TEMP= 24.2 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 294.5 PA CF=0.0097

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	25.5	25.4	20.7	5232.2	6.89	0.133E 08	0.00010	47.5	92.8
2	6.9	25.8	25.8	20.8	5240.2	6.88	0.134E 08	0.00024	44.7	42.6
3	10.8	26.1	25.9	20.8	5248.1	6.87	0.134E 08	0.00038	43.7	43.9
4	14.9	25.9	26.3	20.9	5256.4	6.86	0.135E 08	0.00052	43.2	46.9
5	20.7	26.5	26.8	21.0	5268.3	6.84	0.135E 08	0.00072	39.5	37.5
6	26.3	26.5	27.3	21.1	5279.7	6.82	0.136E 08	0.00092	38.6	36.9
7	32.0	26.6	27.1	21.1	5291.3	6.81	0.137E 08	0.00112	39.5	41.1
8	37.7	26.8	27.4	21.2	5303.0	6.79	0.138E 08	0.00132	38.4	37.4
9	43.7	27.3	27.3	21.3	5315.3	6.77	0.139E 08	0.00153	37.8	35.6
10	49.5	27.3	27.1	21.4	5327.2	6.76	0.139E 08	0.00173	38.9	36.8
11	57.5	26.9	26.8	21.5	5343.6	6.73	0.141E 08	0.00201	42.6	44.3
12	65.2	27.4	27.5	21.7	5359.4	6.71	0.142E 08	0.00228	39.0	34.4
13	73.9	27.3	27.2	21.8	5377.3	6.68	0.143E 08	0.00259	41.5	40.4
14	80.6	27.5	27.4	21.9	5391.1	6.66	0.144E 08	0.00282	40.8	37.7
15	88.4	27.6	27.5	22.0	5407.2	6.64	0.145E 08	0.00310	40.9	38.5
16	96.1	27.5	28.2	22.1	5423.0	6.62	0.146E 08	0.00337	39.5	36.5
17	****	28.2	28.4	22.3	5446.6	6.59	0.148E 08	0.00377	37.6	33.5
18	****	28.2	28.6	22.5	5471.0	6.55	0.149E 08	0.00418	38.2	33.8
19	****	28.3	28.3	22.7	5494.9	6.52	0.151E 08	0.00459	40.1	35.2
20	****	28.0	28.4	22.9	5519.1	6.49	0.153E 08	0.00500	42.1	36.6
21	****	28.7	28.0	23.0	5543.2	6.46	0.154E 08	0.00542	42.3	34.6
22	****	27.7	28.3	23.2	5566.5	6.43	0.156E 08	0.00581	47.0	40.9
23	****	28.8	29.0	23.6	5619.1	6.36	0.160E 08	0.00671	42.8	42.2

FULLY DEVELOPED NUSSELT NUMBER= 40.9 37.5*

RUN NUMBER (18) SMOUTH TUBE

INPUT POWER= 2480.0 W HEAT GAINED BY WATER= 2394.8 HEAT BALANCE ERROR= 3.4%

REM= 6385.4 RAM=0.534E 08 PR= 5.50 GR= 0.219E 06

INLET BULK TEMP 25.0 DEG C OUTLET BULK TEMP= 33.8 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 269.9 PA CF=0.0089

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	36.7	36.4	25.1	5822.8	6.11	0.431E 08	0.00011	48.8	92.5
2	6.9	37.4	37.1	25.3	5843.1	6.08	0.435E 08	0.00024	46.5	44.3
3	10.8	37.9	37.1	25.4	5863.4	6.06	0.438E 08	0.00038	46.1	47.4
4	14.9	37.4	38.3	25.6	5884.8	6.03	0.442E 08	0.00053	45.4	48.6
5	20.7	38.7	39.4	25.8	5915.0	6.00	0.448E 08	0.00073	41.9	40.4
6	26.3	38.6	40.7	26.0	5944.2	5.97	0.453E 08	0.00093	40.7	38.4
7	32.0	38.8	40.0	26.3	5973.9	5.93	0.458E 08	0.00114	42.3	43.9
8	37.7	39.2	40.6	26.5	6003.5	5.90	0.463E 08	0.00134	41.3	40.4
9	43.7	40.4	40.3	26.7	6034.7	5.86	0.469E 08	0.00155	40.7	38.3
10	49.5	40.5	40.0	26.9	6064.9	5.83	0.474E 08	0.00176	41.7	39.0
11	57.5	39.4	39.0	27.3	6106.4	5.79	0.482E 08	0.00205	46.3	47.8
12	65.2	40.6	40.6	27.6	6146.2	5.74	0.489E 08	0.00232	42.4	37.3
13	73.9	40.1	39.9	27.9	6191.2	5.70	0.497E 08	0.00264	45.7	44.1
14	80.6	40.7	40.3	28.1	6225.7	5.66	0.504E 08	0.00288	44.7	41.3
15	88.4	41.1	40.9	28.5	6265.8	5.62	0.511E 08	0.00316	44.1	40.6
16	96.1	40.9	42.3	28.7	6305.2	5.58	0.519E 08	0.00344	43.0	39.7
17	****	42.6	43.1	29.2	6363.3	5.52	0.529E 08	0.00385	40.3	35.4
18	****	42.6	43.3	29.7	6423.1	5.46	0.541E 08	0.00428	41.5	36.6
19	****	42.9	42.8	30.1	6482.3	5.41	0.552E 08	0.00469	43.1	37.4
20	****	42.2	43.4	30.6	6541.4	5.35	0.564E 08	0.00512	44.9	38.3
21	****	44.1	42.2	31.0	6600.6	5.30	0.576E 08	0.00554	45.3	36.7
22	****	41.8	43.1	31.4	6658.4	5.25	0.588E 08	0.00595	50.1	42.5
23	****	44.1	44.4	32.4	6790.4	5.13	0.615E 08	0.00687	46.3	45.4

FULLY DEVELOPED NUSSELT NUMBER= 44.2 40.1*

RUN NUMBER (19)   SMOUTH TUBE

INPUT POWER= 2520.0 W   HEAT GAINED BY WATER= 2441.5   HEAT BALANCE ERROR= 3.1%

REM= 6952.1   RAM=0.495E 08   PR= 5.75   GR= 0.178E 06

INLET BULK TEMP 23.6 DEG C   OUTLET BULK TEMP= 31.4 DEG C

MASS FLOW RATE= 264.6 KG/HR   PRESSURE DROP= 344.5 PA   CF=0.0089

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	3.0	34.7	34.5	23.7	6374.8	6.35	0.403E 08	0.00009	52.0	95.7
2	6.9	35.3	35.0	23.8	6395.4	6.33	0.406E 08	0.00021	50.1	48.6
3	10.8	35.7	35.0	23.9	6416.0	6.30	0.410E 08	0.00034	49.8	50.3
4	14.9	35.0	36.0	24.1	6437.8	6.28	0.413E 08	0.00046	49.7	53.5
5	20.7	36.3	37.1	24.3	6468.5	6.25	0.418E 08	0.00064	45.8	44.1
6	26.3	36.1	38.3	24.5	6498.2	6.21	0.422E 08	0.00082	44.6	41.8
7	32.0	36.1	37.6	24.7	6528.4	6.18	0.427E 08	0.00100	46.7	48.6
8	37.7	36.7	38.0	24.9	6558.7	6.15	0.432E 08	0.00118	45.6	44.4
9	43.7	37.8	37.7	25.1	6590.6	6.11	0.437E 08	0.00136	44.8	41.8
10	49.5	37.6	37.3	25.3	6621.4	6.08	0.442E 08	0.00155	46.6	43.9
11	57.5	36.7	36.3	25.6	6663.9	6.04	0.449E 08	0.00180	51.8	53.2
12	65.2	38.0	37.9	25.8	6704.8	6.00	0.455E 08	0.00204	46.7	41.1
13	73.9	37.5	37.4	26.1	6751.0	5.95	0.463E 08	0.00231	50.2	48.2
14	80.6	38.1	37.7	26.4	6786.5	5.91	0.468E 08	0.00253	49.2	45.6
15	88.4	38.6	38.3	26.7	6827.9	5.87	0.475E 08	0.00277	47.9	44.0
16	96.1	38.4	39.8	26.9	6868.7	5.83	0.482E 08	0.00302	46.4	42.7
17	****	40.0	40.6	27.3	6928.9	5.78	0.491E 08	0.00338	43.5	38.4
18	****	39.9	40.8	27.7	6991.2	5.72	0.502E 08	0.00375	44.7	39.3
19	****	40.1	40.1	28.1	7051.6	5.66	0.512E 08	0.00412	47.3	41.3
20	****	39.5	40.7	28.5	7112.9	5.61	0.522E 08	0.00449	48.7	41.4
21	****	41.3	39.4	28.9	7173.3	5.55	0.532E 08	0.00487	49.5	40.5
22	****	39.1	40.3	29.3	7231.4	5.50	0.542E 08	0.00523	54.3	45.9
23	****	41.0	41.5	30.2	7362.4	5.39	0.564E 08	0.00603	50.8	50.1

FULLY DEVELOPED NUSSELT NUMBER= 48.4 44.0*

RUN NUMBER (20) SMOUTH TUBE

INPUT POWER= 2010.0 W HEAT GAINED BY WATER= 1891.2 HEAT BALANCE ERROR= 5.9%

REM= 4829.0 RAM=0.463E 08 PR= 5.32 GR= 0.258E 06

INLET BULK TEMP 26.2 DEG C OUTLET BULK TEMP= 35.5 DEG C

MASS FLOW RATE= 171.5 KG/HR PRESSURE DROP= 159.1 PA CF=0.0097

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	37.0	36.7	26.3	4389.0	5.93	0.371E 08	0.00015	41.4	89.1
2	6.9	38.2	37.8	26.4	4405.0	5.91	0.375E 08	0.00033	37.7	35.8
3	10.8	39.0	38.3	26.6	4421.0	5.88	0.378E 08	0.00052	36.3	37.1
4	14.9	38.8	39.4	26.8	4437.8	5.86	0.381E 08	0.00072	35.4	38.4
5	20.7	39.9	40.6	27.0	4461.5	5.82	0.386E 08	0.00100	32.9	32.8
6	26.3	40.1	41.9	27.2	4484.4	5.79	0.391E 08	0.00127	31.7	30.6
7	32.0	40.5	41.4	27.5	4507.7	5.75	0.395E 08	0.00155	32.4	34.7
8	37.7	41.1	42.0	27.7	4530.9	5.72	0.400E 08	0.00183	31.5	31.5
9	43.7	42.1	41.9	28.0	4555.3	5.68	0.405E 08	0.00212	31.1	30.0
10	49.5	42.2	41.7	28.2	4578.9	5.65	0.410E 08	0.00241	31.8	30.7
11	57.5	41.4	41.1	28.5	4611.2	5.61	0.416E 08	0.00280	34.3	36.5
12	65.2	42.6	42.4	28.9	4642.3	5.56	0.423E 08	0.00318	31.9	29.0
13	73.9	42.4	42.1	29.2	4677.2	5.52	0.430E 08	0.00360	33.4	32.9
14	80.6	42.8	42.3	29.5	4704.0	5.48	0.435E 08	0.00393	33.3	31.9
15	88.4	43.1	42.8	29.8	4735.0	5.44	0.442E 08	0.00432	33.1	31.4
16	96.1	43.0	44.0	30.2	4766.5	5.40	0.449E 08	0.00470	32.4	30.7
17	****	44.4	44.7	30.6	4812.0	5.34	0.459E 08	0.00526	31.1	27.9
18	****	44.2	44.7	31.1	4859.6	5.29	0.470E 08	0.00584	32.4	29.6
19	****	44.7	44.6	31.6	4906.5	5.23	0.480E 08	0.00641	33.1	29.3
20	****	44.2	45.1	32.1	4954.7	5.17	0.491E 08	0.00699	34.4	30.2
21	****	45.9	44.2	32.6	5003.1	5.12	0.502E 08	0.00757	34.6	28.6
22	****	43.7	44.8	33.0	5050.3	5.06	0.513E 08	0.00813	38.5	33.8
23	****	45.8	46.1	34.1	5158.3	4.95	0.537E 08	0.00939	36.4	37.0

FULLY DEVELOPED NUSSELT NUMBER= 33.6 31.4*

RUN NUMBER (21)   SMOOTH TUBE

INPUT POWER= 2225.0 W   HEAT GAINED BY WATER= 2485.5   HEAT BALANCE ERROR=****%

REM= 13892.8   RAM=0.426E 08   PR= 5.83   GR= 0.870E 05

INLET BULK TEMP 25.0 DEG C   OUTLET BULK TEMP= 28.9 DEG C

MASS FLOW RATE= 534.9 KG/HR   PRESSURE DROP= 991.8 PA   CF=0.0062

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	3.0	32.1	32.2	25.0	13301.4	6.13	0.384E 08	0.00005	81.7	112.2
2	6.9	32.0	31.9	25.1	13322.6	6.11	0.386E 08	0.00011	84.8	75.1
3	10.8	32.0	31.5	25.2	13343.8	6.10	0.387E 08	0.00017	87.5	77.8
4	14.9	31.3	32.2	25.2	13366.0	6.09	0.389E 08	0.00023	88.6	82.0
5	20.7	32.1	32.9	25.3	13397.5	6.08	0.391E 08	0.00032	80.6	67.8
6	26.3	31.9	33.9	25.4	13427.9	6.06	0.393E 08	0.00041	77.4	62.9
7	32.0	31.8	33.2	25.5	13458.8	6.04	0.395E 08	0.00049	82.6	74.0
8	37.7	32.3	33.6	25.6	13489.8	6.03	0.397E 08	0.00058	79.0	66.4
9	43.7	33.3	33.3	25.7	13522.3	6.01	0.400E 08	0.00068	76.5	61.3
10	49.5	33.2	32.8	25.8	13553.8	6.00	0.402E 08	0.00077	81.1	66.3
11	57.5	32.3	32.1	26.0	13597.2	5.97	0.405E 08	0.00089	93.2	81.7
12	65.2	33.3	33.3	26.1	13639.0	5.95	0.408E 08	0.00101	80.0	60.7
13	73.9	32.7	32.7	26.3	13686.2	5.93	0.411E 08	0.00115	90.1	74.9
14	80.6	33.2	33.0	26.4	13722.5	5.91	0.414E 08	0.00125	86.2	68.4
15	88.4	33.5	33.4	26.5	13764.8	5.89	0.417E 08	0.00137	83.6	66.4
16	96.1	33.2	34.6	26.7	13806.5	5.87	0.420E 08	0.00149	79.7	63.1
17	****	34.4	35.0	26.9	13868.2	5.84	0.424E 08	0.00167	73.8	56.7
18	****	34.3	35.2	27.1	13932.0	5.81	0.428E 08	0.00185	75.4	57.5
19	****	34.4	34.5	27.3	13994.1	5.78	0.433E 08	0.00203	80.6	60.7
20	****	33.6	34.9	27.5	14057.2	5.75	0.437E 08	0.00222	85.4	63.0
21	****	35.1	33.4	27.7	14119.7	5.72	0.442E 08	0.00240	87.7	62.8
22	****	33.7	34.6	27.9	14179.9	5.70	0.446E 08	0.00257	91.7	65.9
23	****	34.8	35.3	28.3	14315.0	5.64	0.456E 08	0.00297	85.9	71.5

FULLY DEVELOPED NUSSELT NUMBER= 83.9   65.7*

RUN NUMBER (22) SMOUTH TUBE

INPUT POWER= 2224.0 W HEAT GAINED BY WATER= 2136.7 HEAT BALANCE ERROR= 3.9%

REM= 14865.3 RAM=0.346E 08 PR= 6.43 GR= 0.635E 05

INLET BULK TEMP 21.7 DEG C OUTLET BULK TEMP= 24.7 DEG C

MASS FLOW RATE= 624.0 KG/HR PRESSURE DROP= 1409.1 PA CF=0.0065

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	3.0	28.1	28.3	21.8	14363.6	6.69	0.317E 08	0.00004	78.4	119.3
2	6.9	27.8	27.8	21.8	14381.5	6.68	0.318E 08	0.00009	83.9	87.8
3	10.8	27.8	27.3	21.9	14399.3	6.67	0.319E 08	0.00014	88.1	91.9
4	14.9	27.0	28.0	21.9	14418.1	6.66	0.320E 08	0.00020	90.1	97.7
5	20.7	27.8	28.6	22.0	14444.7	6.64	0.322E 08	0.00027	80.9	79.5
6	26.3	27.5	29.5	22.1	14470.3	6.63	0.323E 08	0.00034	77.8	74.0
7	32.0	27.4	28.8	22.2	14496.5	6.62	0.325E 08	0.00042	84.6	89.4
8	37.7	27.8	29.2	22.2	14522.6	6.60	0.326E 08	0.00049	80.1	78.8
9	43.7	28.7	28.7	22.3	14550.2	6.59	0.328E 08	0.00057	78.1	74.3
10	49.5	28.5	28.2	22.4	14576.9	6.58	0.329E 08	0.00065	83.2	80.4
11	57.5	27.7	27.5	22.5	14613.7	6.56	0.332E 08	0.00075	97.7	101.3
12	65.2	28.7	28.7	22.6	14649.1	6.54	0.334E 08	0.00086	81.6	73.4
13	73.9	28.0	28.1	22.7	14689.2	6.52	0.336E 08	0.00097	94.1	93.4
14	80.6	28.6	28.4	22.8	14720.1	6.50	0.338E 08	0.00106	88.2	83.3
15	88.4	28.8	28.7	22.9	14756.1	6.49	0.340E 08	0.00116	85.2	81.1
16	96.1	28.6	29.9	23.0	14791.6	6.47	0.342E 08	0.00126	79.9	75.6
17	****	29.6	30.3	23.1	14844.3	6.44	0.345E 08	0.00141	73.5	67.9
18	****	29.5	30.5	23.3	14898.9	6.42	0.348E 08	0.00157	74.6	68.5
19	****	29.6	29.8	23.4	14952.1	6.39	0.351E 08	0.00172	80.0	73.0
20	****	28.8	30.2	23.6	15006.3	6.36	0.354E 08	0.00188	84.7	75.8
21	****	30.2	28.6	23.7	15060.1	6.34	0.357E 08	0.00203	88.3	77.5
22	****	28.9	29.8	23.9	15112.1	6.31	0.360E 08	0.00218	91.3	80.3
23	****	29.9	30.4	24.2	15229.2	6.26	0.367E 08	0.00251	84.5	84.2

FULLY DEVELOPED NUSSELT NUMBER= 84.8 79.7*

RUN NUMBER (23) SMOUTH TUBE

INPUT POWER= 2273.0 W HEAT GAINED BY WATER= 2539.2 HEAT BALANCE ERROR=****%

REM= 15202.7 RAM=0.374E 08 PR= 6.27 GR= 0.728E 05

INLET BULK TEMP 22.4 DEG C OUTLET BULK TEMP= 25.9 DEG C

MASS FLOW RATE= 624.0 KG/HR PRESSURE DROP= 559.1 PA CF=0.0026

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	3.0	30.1	30.2	22.5	14603.1	6.56	0.338E 08	0.00004	77.3	107.9
2	6.9	29.8	29.7	22.5	14624.4	6.55	0.339E 08	0.00009	82.1	74.0
3	10.8	29.8	29.3	22.6	14645.8	6.54	0.341E 08	0.00014	85.3	76.2
4	14.9	28.9	30.1	22.6	14668.2	6.53	0.342E 08	0.00020	87.2	82.1
5	20.7	29.8	30.8	22.7	14700.0	6.51	0.344E 08	0.00027	78.5	65.8
6	26.3	29.5	31.8	22.8	14730.7	6.50	0.346E 08	0.00035	75.8	61.6
7	32.0	29.3	31.0	22.9	14761.9	6.48	0.348E 08	0.00042	81.7	74.3
8	37.7	29.8	31.4	23.0	14793.2	6.47	0.349E 08	0.00050	77.7	65.9
9	43.7	31.0	31.0	23.1	14826.1	6.45	0.351E 08	0.00057	74.9	63.1
10	49.5	32.0	30.5	23.2	14858.0	6.44	0.353E 08	0.00065	73.3	56.5
11	57.5	29.8	29.5	23.3	14902.0	6.41	0.356E 08	0.00076	93.6	86.0
12	65.2	31.0	31.0	23.4	14944.4	6.39	0.358E 08	0.00086	78.4	59.5
13	73.9	30.2	30.2	23.6	14992.3	6.37	0.361E 08	0.00097	89.3	76.2
14	80.6	30.9	30.6	23.7	15029.2	6.35	0.363E 08	0.00106	83.8	67.6
15	88.4	31.2	31.1	23.8	15072.2	6.33	0.366E 08	0.00117	80.5	65.1
16	96.1	30.8	32.5	23.9	15114.7	6.31	0.368E 08	0.00127	76.7	61.9
17	****	31.9	32.7	24.1	15177.6	6.28	0.372E 08	0.00142	71.7	56.3
18	****	31.7	33.0	24.3	15242.8	6.25	0.376E 08	0.00157	73.1	57.0
19	****	31.9	31.9	24.4	15306.3	6.22	0.380E 08	0.00173	79.0	61.3
20	****	31.0	32.5	24.6	15371.0	6.19	0.384E 08	0.00188	83.0	62.6
21	****	32.5	30.4	24.8	15435.2	6.16	0.388E 08	0.00204	88.4	65.7
22	****	31.0	32.0	25.0	15497.2	6.14	0.391E 08	0.00219	90.7	67.3
23	****	32.1	32.6	25.3	15636.7	6.07	0.400E 08	0.00252	84.2	72.3

FULLY DEVELOPED NUSSELT NUMBER= 81.8 65.4*

RUN NUMBER (24) SMOUTH TUBE

INPUT POWER= 2273.0 W   HEAT GAINED BY WATER= 2662.2   HEAT BALANCE ERROR=****%

REM= 18746.0   RAM=0.364E 08   PR= 6.35   GR= 0.586E 05

INLET BULK TEMP 22.2 DEG C   OUTLET BULK TEMP= 25.2 DEG C

MASS FLOW RATE= 777.6 KG/HR   PRESSURE DROP= 559.1 PA   CF=0.0017

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	29.2	29.5	22.3	18117.8	6.60	0.335E 08	0.00003	87.8	111.2
2	6.9	28.9	28.8	22.3	18140.1	6.59	0.336E 08	0.00007	96.3	83.8
3	10.8	28.8	28.2	22.4	18162.5	6.58	0.337E 08	0.00011	102.2	87.1
4	14.9	27.7	28.9	22.4	18186.0	6.57	0.338E 08	0.00016	106.3	96.2
5	20.7	28.7	29.6	22.5	18219.3	6.55	0.339E 08	0.00022	94.1	75.8
6	26.3	28.4	30.8	22.6	18251.4	6.54	0.341E 08	0.00028	88.6	67.9
7	32.0	28.3	29.9	22.7	18284.2	6.53	0.342E 08	0.00034	96.8	83.8
8	37.7	28.7	30.3	22.7	18316.9	6.51	0.344E 08	0.00040	92.1	74.4
9	43.7	29.8	29.9	22.8	18351.4	6.50	0.346E 08	0.00046	88.9	68.5
10	49.5	29.6	29.3	22.9	18384.8	6.49	0.347E 08	0.00052	94.8	74.2
11	57.5	28.6	28.3	23.0	18430.9	6.47	0.349E 08	0.00061	113.7	96.9
12	65.2	29.7	29.7	23.1	18475.3	6.45	0.351E 08	0.00069	93.9	68.0
13	73.9	28.9	28.9	23.2	18525.4	6.43	0.354E 08	0.00078	109.6	89.0
14	80.6	29.6	29.3	23.3	18564.1	6.42	0.356E 08	0.00085	101.1	77.4
15	88.4	29.9	29.8	23.4	18609.1	6.40	0.358E 08	0.00093	96.6	74.7
16	96.1	29.5	31.2	23.5	18653.6	6.38	0.360E 08	0.00102	90.4	69.4
17	****	30.7	31.5	23.6	18719.5	6.36	0.363E 08	0.00114	83.6	62.9
18	****	30.6	31.9	23.8	18787.7	6.33	0.366E 08	0.00126	83.8	62.0
19	****	30.6	30.6	23.9	18854.3	6.30	0.369E 08	0.00138	93.4	69.4
20	****	29.6	31.2	24.1	18922.1	6.28	0.373E 08	0.00151	98.7	71.1
21	****	31.2	29.1	24.2	18989.3	6.25	0.376E 08	0.00163	105.2	74.7
22	****	29.7	30.7	24.4	19054.3	6.23	0.379E 08	0.00175	106.4	75.1
23	****	30.7	31.2	24.7	19200.5	6.18	0.386E 08	0.00202	99.7	81.1

FULLY DEVELOPED NUSSELT NUMBER= 97.9 74.7*

RUN NUMBER (25)   SMOUTH TUBE

INPUT POWER= 2273.0 W   HEAT GAINED BY WATER= 2742.6   HEAT BALANCE ERROR=****%

REM= 22110.4   RAM=0.340E 08   PR= 6.55   GR= 0.475E 05

INLET BULK TEMP 21.3 DEG C   OUTLET BULK TEMP= 23.8 DEG C

MASS FLOW RATE= 943.2 KG/HR   PRESSURE DROP= 559.2 PA   CF=0.0011

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	28.0	28.2	21.3	21468.5	6.77	0.315E 08	0.00003	95.3	114.6
2	6.9	27.5	27.4	21.4	21491.3	6.76	0.316E 08	0.00006	106.4	90.9
3	10.8	27.4	26.8	21.4	21514.1	6.76	0.317E 08	0.00009	113.3	93.3
4	14.9	26.2	27.5	21.5	21538.1	6.75	0.318E 08	0.00013	118.6	103.7
5	20.7	27.1	28.1	21.5	21572.1	6.74	0.319E 08	0.00018	105.7	83.2
6	26.3	26.9	29.3	21.6	21604.9	6.72	0.320E 08	0.00023	99.0	73.9
7	32.0	26.7	28.5	21.6	21638.3	6.71	0.322E 08	0.00028	108.0	90.7
8	37.7	27.1	28.9	21.7	21671.8	6.70	0.323E 08	0.00033	102.1	80.2
9	43.7	28.3	28.4	21.8	21707.0	6.69	0.324E 08	0.00038	98.1	73.7
10	49.5	28.2	27.8	21.8	21741.1	6.68	0.325E 08	0.00043	104.3	79.1
11	57.5	27.1	26.8	21.9	21788.2	6.66	0.327E 08	0.00050	127.4	105.9
12	65.2	28.2	28.2	22.0	21833.5	6.64	0.329E 08	0.00057	103.5	72.8
13	73.9	27.3	27.3	22.1	21884.8	6.63	0.331E 08	0.00064	124.2	98.6
14	80.6	27.9	27.8	22.2	21924.3	6.61	0.333E 08	0.00070	113.7	84.8
15	88.4	28.3	28.2	22.3	21970.3	6.60	0.334E 08	0.00077	108.4	81.6
16	96.1	27.8	29.6	22.4	22015.8	6.58	0.336E 08	0.00083	101.0	75.6
17	****	29.0	29.8	22.5	22083.1	6.56	0.339E 08	0.00093	92.8	68.2
18	****	28.9	30.2	22.6	22152.9	6.54	0.341E 08	0.00104	92.6	67.0
19	****	28.9	29.0	22.7	22221.0	6.51	0.344E 08	0.00114	103.5	75.2
20	****	28.0	29.5	22.9	22290.4	6.49	0.347E 08	0.00124	109.7	77.2
21	****	29.4	27.4	23.0	22359.2	6.47	0.349E 08	0.00134	119.1	83.1
22	****	28.1	29.0	23.1	22425.7	6.45	0.352E 08	0.00144	117.9	81.3
23	****	28.9	29.4	23.4	22575.5	6.40	0.358E 08	0.00166	111.2	87.9

FULLY DEVELOPED NUSSELT NUMBER= 109.2   81.3*

RUN NUMBER (26)   SMOUTH TUBE

INPUT POWER= 3000.0 W   HEAT GAINED BY WATER= 3349.4   HEAT BALANCE ERROR=****%

REM= 23701.2   RAM=0.531E 08   PR= 6.05   GR= 0.772E 05

INLET BULK TEMP 24.0 DEG C   OUTLET BULK TEMP= 27.0 DEG C

MASS FLOW RATE= 943.2 KG/HR   PRESSURE DROP= 558.9 PA   CF=0.0011

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	31.4	31.7	24.0	22902.8	6.29	0.489E 08	0.00003	103.6	129.0
2	6.9	31.0	30.9	24.1	22931.3	6.28	0.491E 08	0.00006	113.2	102.0
3	10.8	30.9	30.3	24.1	22959.7	6.28	0.492E 08	0.00009	120.5	107.4
4	14.9	29.7	31.1	24.2	22989.7	6.27	0.494E 08	0.00013	125.3	117.0
5	20.7	30.7	31.8	24.2	23032.0	6.25	0.496E 08	0.00018	111.0	94.3
6	26.3	30.5	33.2	24.3	23073.0	6.24	0.498E 08	0.00023	104.4	85.0
7	32.0	30.4	32.1	24.4	23114.6	6.23	0.500E 08	0.00028	114.0	103.2
8	37.7	30.9	32.7	24.5	23156.3	6.22	0.502E 08	0.00033	106.4	89.5
9	43.7	32.1	32.1	24.5	23200.2	6.20	0.505E 08	0.00038	103.1	84.4
10	49.5	32.0	31.6	24.6	23242.6	6.19	0.507E 08	0.00043	109.6	90.4
11	57.5	30.8	30.5	24.7	23301.1	6.17	0.510E 08	0.00050	132.4	117.3
12	65.2	32.0	32.0	24.8	23357.4	6.15	0.513E 08	0.00057	108.9	84.3
13	73.9	31.1	31.1	25.0	23421.1	6.14	0.516E 08	0.00065	126.9	107.7
14	80.6	31.9	31.6	25.0	23470.1	6.12	0.519E 08	0.00071	117.1	94.6
15	88.4	32.2	32.0	25.2	23527.2	6.10	0.522E 08	0.00077	112.5	91.7
16	96.1	31.7	33.6	25.3	23583.6	6.09	0.525E 08	0.00084	105.1	85.0
17	****	32.9	33.9	25.4	23667.1	6.06	0.529E 08	0.00094	97.5	77.6
18	****	32.9	34.2	25.6	23753.5	6.04	0.534E 08	0.00105	98.2	77.0
19	****	32.9	32.9	25.7	23837.7	6.01	0.538E 08	0.00115	108.9	85.3
20	****	31.9	33.5	25.9	23923.3	5.99	0.543E 08	0.00125	114.9	87.6
21	****	33.5	31.3	26.0	24008.2	5.97	0.548E 08	0.00135	121.9	91.7
22	****	32.0	33.1	26.2	24090.1	5.94	0.552E 08	0.00145	122.4	91.3
23	****	33.1	33.5	26.5	24274.4	5.89	0.562E 08	0.00168	115.4	98.3

FULLY DEVELOPED NUSSELT NUMBER= 113.7   91.4*

RUN NUMBER (27) SMOUTH TUBE

INPUT POWER= 3000.0 W HEAT GAINED BY WATER= 2827.7 HEAT BALANCE ERROR= 5.7%

REM= 8605.4 RAM=0.612E 08 PR= 5.65 GR= 0.194E 06

INLET BULK TEMP 24.5 DEG C OUTLET BULK TEMP= 32.0 DEG C

MASS FLOW RATE= 322.3 KG/HR PRESSURE DROP= 558.6 PA CF=0.0097

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	3.0	35.7	35.8	24.6	7936.6	6.19	0.506E 08	0.00008	58.9	105.1
2	6.9	36.4	36.1	24.7	7960.6	6.17	0.510E 08	0.00018	57.1	57.8
3	10.8	36.8	36.0	24.9	7984.6	6.15	0.514E 08	0.00028	56.8	57.8
4	14.9	35.9	37.0	25.0	8009.9	6.13	0.518E 08	0.00038	57.5	63.5
5	20.7	37.0	38.1	25.2	8045.6	6.10	0.523E 08	0.00053	53.3	53.2
6	26.3	36.8	39.3	25.4	8080.1	6.07	0.528E 08	0.00067	51.8	50.5
7	32.0	36.8	38.5	25.6	8115.2	6.04	0.534E 08	0.00082	54.3	57.7
8	37.7	37.4	39.0	25.8	8150.3	6.01	0.539E 08	0.00097	52.6	53.1
9	43.7	38.8	38.8	26.0	8187.3	5.98	0.545E 08	0.00112	51.2	49.2
10	49.5	38.8	38.2	26.1	8223.0	5.95	0.551E 08	0.00127	53.0	51.3
11	57.5	37.6	37.2	26.4	8272.2	5.91	0.558E 08	0.00148	59.7	63.1
12	65.2	39.0	39.0	26.7	8319.5	5.87	0.566E 08	0.00168	53.1	48.5
13	73.9	38.4	38.3	27.0	8373.0	5.83	0.574E 08	0.00190	57.7	57.3
14	80.6	39.1	38.6	27.2	8414.1	5.80	0.581E 08	0.00208	56.3	53.8
15	88.4	39.4	39.2	27.4	8461.8	5.76	0.589E 08	0.00228	55.2	52.6
16	96.1	39.1	40.8	27.7	8508.9	5.72	0.596E 08	0.00248	53.4	50.9
17	****	40.7	41.6	28.1	8578.4	5.67	0.607E 08	0.00278	50.1	46.0
18	****	40.6	41.6	28.5	8650.1	5.62	0.619E 08	0.00309	51.7	47.4
19	****	40.8	40.8	28.8	8719.7	5.57	0.630E 08	0.00339	54.5	49.2
20	****	40.0	41.4	29.2	8790.1	5.52	0.642E 08	0.00370	56.9	50.4
21	****	42.0	39.7	29.6	8859.5	5.47	0.653E 08	0.00400	58.1	49.7
22	****	39.7	41.1	30.0	8926.2	5.42	0.664E 08	0.00430	62.7	54.6
23	****	41.7	42.2	30.8	9078.8	5.32	0.692E 08	0.00496	58.5	59.2

FULLY DEVELOPED NUSSELT NUMBER= 55.8 52.4*

RUN NUMBER (28) SMOUTH TUBE

INPUT POWER= 3000.0 W HEAT GAINED BY WATER= 2775.6 HEAT BALANCE ERROR= 7.5%

REM= 5032.4 RAM=0.759E 08 PR= 5.08 GR= 0.439E 06

INLET BULK TEMP 26.0 DEG C OUTLET BULK TEMP= 39.8 DEG C

MASS FLOW RATE= 171.5 KG/HR PRESSURE DROP= 557.9 PA CF=0.0341

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	3.0	41.6	41.4	26.2	4382.6	5.94	0.553E 08	0.00014	42.0	90.6
2	6.9	43.5	43.0	26.4	4406.0	5.90	0.560E 08	0.00033	38.2	36.7
3	10.8	44.7	43.6	26.7	4429.5	5.87	0.566E 08	0.00052	36.7	37.8
4	14.9	44.3	45.2	26.9	4454.2	5.83	0.574E 08	0.00072	36.0	40.4
5	20.7	46.2	47.0	27.3	4489.0	5.78	0.584E 08	0.00100	33.2	33.4
6	26.3	46.5	48.8	27.6	4522.5	5.73	0.594E 08	0.00128	32.0	31.6
7	32.0	46.8	48.3	28.0	4556.5	5.68	0.605E 08	0.00155	32.7	35.6
8	37.7	47.8	49.1	28.3	4590.5	5.63	0.615E 08	0.00183	31.7	32.3
9	43.7	49.3	49.0	28.7	4626.1	5.59	0.626E 08	0.00213	31.2	30.8
10	49.5	49.6	48.7	29.1	4660.3	5.54	0.636E 08	0.00241	31.8	31.2
11	57.5	48.5	47.8	29.5	4707.3	5.48	0.651E 08	0.00281	34.3	37.0
12	65.2	50.1	49.8	30.0	4753.1	5.42	0.665E 08	0.00318	32.0	29.8
13	73.9	49.6	49.2	30.5	4803.9	5.35	0.682E 08	0.00361	33.7	33.8
14	80.6	50.2	49.4	31.0	4843.5	5.31	0.696E 08	0.00395	33.7	33.0
15	88.4	50.8	50.2	31.4	4890.0	5.25	0.711E 08	0.00433	33.4	32.2
16	96.1	50.5	51.9	31.9	4936.4	5.19	0.727E 08	0.00471	33.0	32.0
17	****	52.5	53.0	32.6	5006.1	5.11	0.750E 08	0.00528	31.5	28.9
18	****	52.4	53.0	33.3	5079.3	5.03	0.775E 08	0.00587	32.7	30.3
19	****	52.9	52.7	34.0	5151.8	4.95	0.799E 08	0.00645	33.7	30.5
20	****	52.4	53.4	34.7	5226.8	4.87	0.824E 08	0.00704	34.8	31.0
21	****	54.7	52.1	35.4	5302.3	4.80	0.850E 08	0.00762	35.2	29.6
22	****	51.6	52.9	36.1	5376.4	4.72	0.874E 08	0.00819	39.1	34.8
23	****	54.5	54.7	37.7	5547.0	4.56	0.931E 08	0.00947	37.2	38.8

FULLY DEVELOPED NUSSELT NUMBER= 34.0 32.3*

RUN NUMBER (1)   TUBE NUMBER 9

INPUT POWER= 1140.0 W   HEAT GAINED BY WATER= 1420.8   HEAT BALANCE ERROR=****%

REM= 5788.7   RAM= 0.681E 10   PR= 6.67   GR= 0.246E 08

INLET BULK TEMP= 19.6 DEG C   OUTLET BULK TEMP= 24.1 DEG C

MASS FLOW RATE= 271.4 KG/HR   PRESSURE DROP= 3637.1 PA   CF=0.0094

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	23.8	24.0	19.7	5485.5	7.09	0.590E 10	0.00014	64.7	57.0
2	3.5	24.7	25.7	19.8	5499.7	7.07	0.594E 10	0.00033	50.9	38.8
3	5.5	25.7	25.7	19.9	5513.9	7.05	0.599E 10	0.00052	47.2	36.4
4	7.5	25.6	26.2	20.0	5528.1	7.03	0.603E 10	0.00071	46.6	36.5
5	10.5	26.0	26.5	20.2	5549.4	7.00	0.609E 10	0.00099	44.8	34.7
6	13.5	26.8	26.5	20.3	5570.8	6.97	0.615E 10	0.00128	43.1	33.3
7	16.5	27.1	27.0	20.5	5592.3	6.94	0.622E 10	0.00156	41.4	31.5
8	19.5	27.0	26.5	20.6	5613.8	6.91	0.628E 10	0.00185	44.6	34.3
9	22.5	26.9	26.9	20.8	5635.3	6.88	0.635E 10	0.00213	44.8	34.5
10	25.5	26.9	28.3	20.9	5656.8	6.85	0.641E 10	0.00242	41.0	30.9
11	29.5	27.7	27.7	21.1	5685.6	6.81	0.650E 10	0.00280	41.4	31.4
12	33.5	28.9	28.0	21.3	5714.5	6.77	0.658E 10	0.00318	38.4	28.6
13	37.5	28.0	28.5	21.5	5743.5	6.73	0.667E 10	0.00356	40.9	30.5
14	41.5	28.1	28.2	21.7	5772.5	6.69	0.676E 10	0.00394	42.7	31.6
15	45.5	28.2	28.2	22.0	5801.5	6.66	0.685E 10	0.00432	43.7	32.0
16	49.5	28.0	28.4	22.2	5830.7	6.62	0.693E 10	0.00471	45.2	33.1
17	54.5	29.0	29.4	22.4	5867.1	6.57	0.704E 10	0.00519	40.0	28.9
18	59.5	28.8	29.3	22.7	5903.7	6.52	0.716E 10	0.00567	42.9	30.8
19	64.5	29.0	28.9	22.9	5940.3	6.48	0.727E 10	0.00615	45.3	32.4
20	69.5	29.4	30.9	23.2	5977.0	6.43	0.738E 10	0.00663	39.3	27.8
21	74.5	29.7	30.3	23.4	6013.7	6.39	0.749E 10	0.00711	41.3	29.1
22	79.5	29.8	29.9	23.7	6050.5	6.35	0.761E 10	0.00760	44.1	31.1
23	84.5	31.2	33.1	24.0	6087.4	6.30	0.772E 10	0.00808	33.3	25.4

FULLY DEVELOPED NUSSELT NUMBER= 41.4   30.3*

RUN NUMBER (2)   TUBE NUMBER 9

INPUT POWER= 740.0 W   HEAT GAINED BY WATER= 712.4   HEAT BALANCE ERROR= 3.7%

REM= 1639.9   RAM= 0.917E 10   PR= 4.00   GR= 0.177E 09

INLET BULK TEMP= 37.3 DEG C   OUTLET BULK TEMP= 49.8 DEG C

MASS FLOW RATE= 48.7 KG/HR   PRESSURE DROP= 263.9 PA   CF=0.0211

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	42.4	42.4	37.5	1450.7	4.58	0.730E 10	0.00083	26.9	34.7
2	3.5	44.3	44.6	37.8	1459.2	4.55	0.738E 10	0.00193	19.8	19.6
3	5.5	45.8	45.7	38.1	1467.7	4.52	0.747E 10	0.00304	17.2	17.5
4	7.5	46.6	46.8	38.4	1476.2	4.49	0.755E 10	0.00415	15.9	16.5
5	10.5	47.8	47.9	38.8	1489.1	4.45	0.768E 10	0.00581	14.5	15.0
6	13.5	49.0	48.7	39.2	1502.2	4.41	0.781E 10	0.00748	13.6	14.0
7	16.5	49.6	49.5	39.6	1515.3	4.37	0.794E 10	0.00915	13.3	13.5
8	19.5	49.6	49.2	40.1	1528.6	4.32	0.807E 10	0.01083	14.1	14.8
9	22.5	49.6	49.5	40.5	1542.0	4.28	0.820E 10	0.01250	14.5	15.4
10	25.5	50.0	50.4	40.9	1555.5	4.24	0.834E 10	0.01418	14.1	14.8
11	29.5	51.2	51.0	41.5	1573.7	4.19	0.852E 10	0.01643	13.7	14.3
12	33.5	52.4	51.8	42.1	1592.0	4.13	0.870E 10	0.01868	13.1	13.6
13	37.5	53.0	52.8	42.6	1610.6	4.08	0.888E 10	0.02093	12.8	13.4
14	41.5	53.6	53.3	43.2	1629.4	4.03	0.907E 10	0.02319	12.8	13.4
15	45.5	53.9	53.6	43.8	1648.5	3.98	0.926E 10	0.02545	13.1	13.8
16	49.5	54.3	54.1	44.4	1667.7	3.93	0.944E 10	0.02771	13.3	14.1
17	54.5	55.3	55.2	45.1	1692.0	3.87	0.968E 10	0.03055	12.8	13.4
18	59.5	55.8	55.6	45.8	1716.6	3.81	0.992E 10	0.03340	13.1	13.9
19	64.5	56.5	56.1	46.5	1741.5	3.75	0.102E 11	0.03624	13.3	14.2
20	69.5	57.7	58.0	47.2	1766.7	3.69	0.104E 11	0.03910	12.3	12.9
21	74.5	58.5	58.5	47.9	1792.2	3.64	0.107E 11	0.04195	12.3	13.0
22	79.5	59.3	58.9	48.6	1818.0	3.58	0.109E 11	0.04481	12.3	13.1
23	84.5	59.9	60.1	49.4	1844.1	3.53	0.112E 11	0.04767	12.1	13.3

FULLY DEVELOPED NUSSELT NUMBER= 12.9 13.6*

RUN NUMBER (3)   TUBE NUMBER 9

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 950.9   HEAT BALANCE ERROR= 4.9%

REM= 1723.0   RAM= 0.133E 11   PR= 3.79   GR= 0.266E 09

INLET BULK TEMP= 37.6 DEG C   OUTLET BULK TEMP= 54.3 DEG C

MASS FLOW RATE= 48.7 KG/HR   PRESSURE DROP= 268.3 PA   CF=0.0214

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	44.6	44.7	37.9	1463.2	4.54	0.991E 10	0.00083	26.3	34.2
2	3.5	47.1	47.6	38.3	1474.6	4.50	0.101E 11	0.00194	19.4	19.5
3	5.5	49.1	48.9	38.7	1486.1	4.46	0.102E 11	0.00305	17.0	17.5
4	7.5	50.1	50.3	39.1	1497.7	4.42	0.104E 11	0.00416	15.8	16.6
5	10.5	51.5	51.6	39.6	1515.2	4.37	0.106E 11	0.00583	14.7	15.5
6	13.5	53.3	52.8	40.2	1532.9	4.31	0.108E 11	0.00750	13.7	14.2
7	16.5	54.0	53.5	40.8	1550.9	4.26	0.111E 11	0.00918	13.5	14.1
8	19.5	53.9	53.5	41.4	1569.0	4.20	0.113E 11	0.01086	14.2	15.1
9	22.5	54.2	53.7	41.9	1587.4	4.15	0.116E 11	0.01254	14.5	15.6
10	25.5	54.5	55.2	42.5	1606.0	4.10	0.118E 11	0.01423	14.1	15.1
11	29.5	56.2	56.0	43.3	1631.0	4.03	0.121E 11	0.01648	13.6	14.4
12	33.5	57.8	56.9	44.0	1656.5	3.96	0.125E 11	0.01875	13.1	13.9
13	37.5	58.2	58.1	44.8	1682.3	3.89	0.128E 11	0.02101	13.1	13.9
14	41.5	59.0	58.6	45.6	1708.4	3.83	0.131E 11	0.02328	13.1	14.0
15	45.5	59.5	59.2	46.3	1735.0	3.77	0.135E 11	0.02556	13.3	14.3
16	49.5	59.9	59.8	47.1	1761.8	3.70	0.138E 11	0.02784	13.6	14.8
17	54.5	61.3	61.1	48.0	1795.9	3.63	0.143E 11	0.03069	13.2	14.1
18	59.5	61.8	61.7	49.0	1830.5	3.56	0.147E 11	0.03355	13.5	14.7
19	64.5	63.0	62.4	49.9	1865.5	3.48	0.152E 11	0.03641	13.5	14.8
20	69.5	64.4	64.9	50.9	1886.7	3.44	0.155E 11	0.03928	12.5	13.5
21	74.5	65.4	65.3	51.9	1906.8	3.40	0.159E 11	0.04216	12.7	13.9
22	79.5	66.4	65.8	52.8	1927.6	3.36	0.162E 11	0.04505	12.9	14.2
23	84.5	67.3	67.5	53.8	1949.1	3.32	0.166E 11	0.04795	12.6	14.0

FULLY DEVELOPED NUSSELT NUMBER= 13.2   14.3*

RUN NUMBER (4) TUBE NUMBER 9

INPUT POWER= 1240.0 W HEAT GAINED BY WATER= 1176.9 HEAT BALANCE ERROR= 5.1%

REM= 1712.7 RAM= 0.171E 11 PR= 3.70 GR= 0.355E 09

INLET BULK TEMP= 36.5 DEG C OUTLET BULK TEMP= 57.8 DEG C

MASS FLOW RATE= 47.3 KG/HR PRESSURE DROP= 251.2 PA CF=0.0213

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	45.4	45.5	36.8	1391.0	4.65	0.117E 11	0.00085	25.4	33.2
2	3.5	48.5	49.3	37.3	1404.8	4.60	0.120E 11	0.00199	18.9	18.9
3	5.5	51.1	50.8	37.8	1418.8	4.55	0.122E 11	0.00313	16.6	17.1
4	7.5	52.2	52.5	38.3	1432.9	4.50	0.125E 11	0.00427	15.6	16.4
5	10.5	54.1	54.2	39.0	1454.3	4.42	0.128E 11	0.00599	14.4	15.2
6	13.5	56.2	55.5	39.8	1476.0	4.35	0.132E 11	0.00771	13.6	14.2
7	16.5	57.3	56.6	40.5	1498.0	4.28	0.136E 11	0.00944	13.2	13.7
8	19.5	57.4	56.3	41.2	1520.4	4.21	0.139E 11	0.01117	13.9	14.9
9	22.5	57.7	56.9	42.0	1543.1	4.14	0.143E 11	0.01291	14.1	15.2
10	25.5	58.0	58.8	42.7	1566.1	4.08	0.147E 11	0.01465	13.8	14.7
11	29.5	59.9	59.5	43.7	1597.3	3.99	0.152E 11	0.01698	13.4	14.4
12	33.5	62.1	60.6	44.6	1629.1	3.91	0.158E 11	0.01932	12.9	13.7
13	37.5	62.7	62.4	45.6	1661.5	3.82	0.163E 11	0.02166	12.7	13.5
14	41.5	63.6	62.9	46.6	1694.4	3.74	0.168E 11	0.02401	12.9	13.8
15	45.5	64.3	63.5	47.5	1727.8	3.67	0.174E 11	0.02636	13.1	14.1
16	49.5	64.7	64.3	48.5	1761.8	3.59	0.180E 11	0.02872	13.4	14.6
17	54.5	66.4	65.9	49.7	1805.0	3.50	0.187E 11	0.03166	13.0	14.0
18	59.5	67.4	66.8	51.0	1834.0	3.44	0.192E 11	0.03462	13.2	14.3
19	64.5	68.3	67.5	52.2	1859.1	3.39	0.198E 11	0.03759	13.5	14.9
20	69.5	70.1	70.5	53.4	1885.3	3.33	0.203E 11	0.04058	12.5	13.6
21	74.5	71.4	71.1	54.6	1912.5	3.28	0.209E 11	0.04357	12.7	13.9
22	79.5	72.7	71.7	55.8	1940.8	3.23	0.214E 11	0.04658	12.9	14.3
23	84.5	73.9	73.8	57.0	1970.4	3.17	0.220E 11	0.04959	12.6	14.1

FULLY DEVELOPED NUSSELT NUMBER= 13.1 14.1*

RUN NUMBER (5)   TUBE NUMBER 9

INPUT POWER= 1450.0 W   HEAT GAINED BY WATER= 1381.4   HEAT BALANCE ERROR= 4.7%

REM= 2609.8   RAM= 0.183E 11   PR= 3.93   GR= 0.247E 09

INLET BULK TEMP= 36.6 DEG C   OUTLET BULK TEMP= 52.1 DEG C

MASS FLOW RATE= 76.3 KG/HR   PRESSURE DROP= 581.7 PA   CF=0.0190

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	44.5	44.6	36.8	2241.7	4.65	0.138E 11	0.00053	33.3	40.8
2	3.5	46.9	47.8	37.2	2257.9	4.61	0.140E 11	0.00123	25.3	25.4
3	5.5	49.0	48.8	37.5	2274.2	4.58	0.142E 11	0.00194	22.7	23.2
4	7.5	49.4	50.0	37.9	2290.7	4.54	0.144E 11	0.00265	21.7	22.7
5	10.5	50.8	51.1	38.4	2315.5	4.49	0.147E 11	0.00371	20.5	21.3
6	13.5	52.1	51.7	38.9	2340.7	4.43	0.150E 11	0.00477	19.8	20.7
7	16.5	52.7	52.6	39.5	2366.1	4.38	0.153E 11	0.00584	19.5	20.1
8	19.5	52.8	52.2	40.0	2391.9	4.33	0.156E 11	0.00691	20.5	21.7
9	22.5	53.1	52.8	40.5	2417.9	4.28	0.160E 11	0.00798	20.6	21.9
10	25.5	53.5	54.9	41.1	2444.1	4.23	0.163E 11	0.00906	19.5	20.4
11	29.5	55.2	55.1	41.8	2479.6	4.16	0.167E 11	0.01049	19.1	20.2
12	33.5	56.9	55.8	42.5	2515.6	4.10	0.172E 11	0.01193	18.4	19.3
13	37.5	56.7	56.9	43.2	2552.1	4.03	0.176E 11	0.01337	18.7	19.7
14	41.5	57.3	57.2	43.9	2589.0	3.97	0.181E 11	0.01482	19.0	20.2
15	45.5	57.7	57.6	44.6	2626.5	3.91	0.185E 11	0.01627	19.5	20.7
16	49.5	58.0	58.3	45.3	2664.4	3.85	0.190E 11	0.01772	19.8	21.2
17	54.5	59.6	60.0	46.2	2712.5	3.77	0.196E 11	0.01954	18.7	19.8
18	59.5	60.1	60.3	47.1	2761.3	3.70	0.202E 11	0.02136	19.3	20.7
19	64.5	60.9	60.7	48.0	2810.9	3.63	0.208E 11	0.02319	19.6	21.2
20	69.5	62.3	63.8	48.9	2861.1	3.56	0.214E 11	0.02501	17.7	18.8
21	74.5	63.3	63.8	49.8	2912.1	3.50	0.220E 11	0.02684	18.2	19.6
22	79.5	64.2	64.0	50.6	2947.5	3.45	0.225E 11	0.02867	18.7	20.3
23	84.5	65.7	66.6	51.5	2976.6	3.41	0.229E 11	0.03051	17.2	18.8

FULLY DEVELOPED NUSSELT NUMBER= 18.8   20.1*

RUN NUMBER (6)   TUBE NUMBER 9

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 948.8   HEAT BALANCE ERROR= 5.1%

REM= 2458.4   RAM= 0.113E 11   PR= 4.20   GR= 0.144E 09

INLET BULK TEMP= 36.0 DEG C   OUTLET BULK TEMP= 46.7 DEG C

MASS FLOW RATE= 76.3 KG/HR   PRESSURE DROP= 596.4 PA   CF=0.0195

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	41.4	41.5	36.2	2214.6	4.71	0.924E 10	0.00053	33.8	41.6
2	3.5	43.1	43.7	36.5	2225.6	4.69	0.934E 10	0.00123	25.4	25.6
3	5.5	44.5	44.5	36.7	2236.6	4.66	0.943E 10	0.00194	22.7	23.4
4	7.5	44.9	45.3	36.9	2247.7	4.64	0.952E 10	0.00264	21.7	22.7
5	10.5	45.8	46.0	37.3	2264.4	4.60	0.967E 10	0.00370	20.6	21.6
6	13.5	46.8	46.6	37.7	2281.3	4.56	0.981E 10	0.00476	19.6	20.4
7	16.5	47.3	47.1	38.0	2298.2	4.52	0.995E 10	0.00582	19.3	20.0
8	19.5	47.3	46.9	38.4	2315.4	4.49	0.101E 11	0.00689	20.3	21.6
9	22.5	47.5	47.3	38.8	2332.6	4.45	0.102E 11	0.00795	20.4	21.8
10	25.5	47.8	48.6	39.1	2350.0	4.41	0.104E 11	0.00902	19.5	20.6
11	29.5	48.8	48.9	39.6	2373.4	4.37	0.106E 11	0.01045	19.0	20.2
12	33.5	50.0	49.4	40.1	2397.0	4.32	0.108E 11	0.01188	18.3	19.3
13	37.5	50.1	50.2	40.6	2420.9	4.27	0.110E 11	0.01331	18.4	19.5
14	41.5	50.5	50.5	41.1	2444.9	4.23	0.112E 11	0.01474	18.7	19.8
15	45.5	50.8	50.6	41.6	2469.3	4.18	0.114E 11	0.01618	19.2	20.6
16	49.5	51.0	51.2	42.1	2493.8	4.13	0.116E 11	0.01762	19.4	21.0
17	54.5	52.0	52.2	42.7	2524.8	4.08	0.119E 11	0.01942	18.5	19.8
18	59.5	52.4	52.5	43.3	2556.2	4.02	0.121E 11	0.02122	19.1	20.5
19	64.5	52.9	52.8	43.9	2588.0	3.97	0.124E 11	0.02303	19.5	21.2
20	69.5	53.9	54.7	44.5	2620.1	3.92	0.127E 11	0.02485	17.8	19.0
21	74.5	54.6	54.9	45.1	2652.6	3.87	0.129E 11	0.02666	18.1	19.6
22	79.5	55.3	55.0	45.7	2685.4	3.81	0.132E 11	0.02848	18.5	20.2
23	84.5	56.1	56.7	46.3	2718.6	3.76	0.135E 11	0.03030	17.2	19.0

FULLY DEVELOPED NUSSELT NUMBER= 18.6   20.0*

RUN NUMBER (7)   TUBE NUMBER 9

INPUT POWER= 1250.0 W   HEAT GAINED BY WATER= 1174.9   HEAT BALANCE ERROR= 6.0%

REM= 2531.6   RAM= 0.148E 11   PR= 4.07   GR= 0.193E 09

INLET BULK TEMP= 36.2 DEG C   OUTLET BULK TEMP= 49.4 DEG C

MASS FLOW RATE= 76.3 KG/HR   PRESSURE DROP= 589.8 PA   CF=0.0192

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	42.9	43.0	36.4	2224.5	4.69	0.116E 11	0.00053	33.8	42.0
2	3.5	45.0	45.7	36.7	2238.1	4.66	0.117E 11	0.00123	25.5	25.9
3	5.5	46.8	46.5	37.0	2251.8	4.63	0.118E 11	0.00194	22.8	23.7
4	7.5	47.2	47.7	37.3	2265.7	4.60	0.120E 11	0.00264	21.7	23.0
5	10.5	48.3	48.5	37.8	2286.6	4.55	0.122E 11	0.00370	20.6	21.9
6	13.5	49.5	49.2	38.2	2307.7	4.50	0.124E 11	0.00477	19.7	20.9
7	16.5	50.1	49.9	38.7	2329.0	4.46	0.127E 11	0.00583	19.3	20.3
8	19.5	50.1	49.6	39.2	2350.5	4.41	0.129E 11	0.00690	20.3	21.9
9	22.5	50.3	50.2	39.6	2372.2	4.37	0.131E 11	0.00797	20.5	22.1
10	25.5	50.7	51.8	40.1	2394.1	4.32	0.133E 11	0.00904	19.5	20.8
11	29.5	52.1	52.0	40.7	2423.7	4.27	0.136E 11	0.01047	19.1	20.5
12	33.5	53.6	52.7	41.3	2453.6	4.21	0.140E 11	0.01190	18.3	19.6
13	37.5	53.4	53.7	41.9	2483.8	4.15	0.143E 11	0.01334	18.6	20.0
14	41.5	53.9	53.9	42.5	2514.4	4.10	0.146E 11	0.01478	19.0	20.5
15	45.5	54.3	54.2	43.1	2545.4	4.04	0.149E 11	0.01622	19.4	21.0
16	49.5	54.5	54.8	43.7	2576.8	3.99	0.152E 11	0.01767	19.7	21.6
17	54.5	55.8	56.1	44.4	2616.4	3.92	0.156E 11	0.01948	18.7	20.3
18	59.5	56.3	56.5	45.2	2656.6	3.86	0.161E 11	0.02130	19.3	21.1
19	64.5	57.1	56.8	45.9	2697.4	3.80	0.165E 11	0.02312	19.5	21.6
20	69.5	58.2	59.3	46.7	2738.7	3.73	0.169E 11	0.02494	17.8	19.4
21	74.5	59.1	59.5	47.4	2780.5	3.67	0.173E 11	0.02676	18.1	20.0
22	79.5	59.8	59.6	48.2	2822.9	3.62	0.178E 11	0.02859	18.6	20.8
23	84.5	61.0	61.7	49.0	2865.7	3.56	0.182E 11	0.03042	17.3	19.3

FULLY DEVELOPED NUSSELT NUMBER= 18.8   20.5*

RUN NUMBER (8)   TUBE NUMBER 9

INPUT POWER= 1440.0 W   HEAT GAINED BY WATER= 1361.1   HEAT BALANCE ERROR= 5.5%

REM= 3326.4   RAM= 0.167E 11   PR= 4.13   GR= 0.180E 09

INLET BULK TEMP= 36.4 DEG C   OUTLET BULK TEMP= 47.9 DEG C

MASS FLOW RATE= 101.5 KG/HR   PRESSURE DROP= 943.7 PA   CF=0.0174

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	43.2	43.4	36.6	2971.9	4.67	0.135E 11	0.00040	38.1	45.8
2	3.5	45.0	46.0	36.9	2987.8	4.64	0.136E 11	0.00093	29.4	29.8
3	5.5	46.7	46.5	37.1	3003.7	4.62	0.138E 11	0.00146	26.8	27.7
4	7.5	46.8	47.5	37.4	3019.8	4.59	0.139E 11	0.00199	26.0	27.3
5	10.5	47.7	48.1	37.8	3044.1	4.55	0.142E 11	0.00278	25.0	26.3
6	13.5	48.8	48.5	38.2	3068.5	4.51	0.144E 11	0.00358	24.2	25.5
7	16.5	49.3	49.2	38.6	3093.2	4.47	0.146E 11	0.00438	23.7	24.7
8	19.5	49.4	48.8	39.0	3118.0	4.43	0.148E 11	0.00518	24.9	26.6
9	22.5	49.6	49.5	39.4	3143.1	4.39	0.151E 11	0.00598	24.8	26.5
10	25.5	49.9	51.3	39.8	3168.4	4.35	0.153E 11	0.00679	23.3	24.6
11	29.5	51.2	51.3	40.3	3202.4	4.30	0.156E 11	0.00786	23.0	24.5
12	33.5	52.7	51.8	40.8	3236.8	4.25	0.159E 11	0.00893	22.1	23.3
13	37.5	52.2	52.7	41.3	3271.5	4.20	0.162E 11	0.01001	22.7	24.2
14	41.5	52.7	52.9	41.9	3306.6	4.15	0.165E 11	0.01109	23.0	24.6
15	45.5	53.1	53.1	42.4	3342.1	4.10	0.169E 11	0.01217	23.4	25.1
16	49.5	53.3	53.7	42.9	3377.9	4.06	0.172E 11	0.01326	23.7	25.7
17	54.5	54.7	55.2	43.6	3423.2	4.00	0.176E 11	0.01461	22.0	23.5
18	59.5	55.0	55.3	44.2	3469.1	3.94	0.180E 11	0.01597	23.0	24.8
19	64.5	55.6	55.5	44.9	3515.5	3.88	0.184E 11	0.01734	23.4	25.5
20	69.5	56.7	58.2	45.6	3562.5	3.83	0.189E 11	0.01870	21.0	22.5
21	74.5	57.4	58.0	46.2	3610.0	3.77	0.193E 11	0.02007	21.7	23.5
22	79.5	58.1	58.0	46.9	3658.0	3.72	0.197E 11	0.02144	22.2	24.4
23	84.5	59.4	60.5	47.5	3706.6	3.67	0.201E 11	0.02281	20.0	21.9

FULLY DEVELOPED NUSSELT NUMBER= 22.5 24.1*

RUN NUMBER (9)   TUBE NUMBER 9

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 718.2   HEAT BALANCE ERROR= 4.2%

REM= 3257.9   RAM= 0.551E 10   PR= 5.32   GR= 0.414E 08

INLET BULK TEMP= 28.3 DEG C   OUTLET BULK TEMP= 33.3 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 1471.7 PA   CF=0.0179

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	31.7	31.9	28.4	3103.5	5.62	0.493E 10	0.00032	40.7	47.8
2	3.5	32.5	33.0	28.5	3110.8	5.61	0.496E 10	0.00074	32.0	32.1
3	5.5	33.3	33.3	28.7	3118.2	5.59	0.499E 10	0.00116	29.1	29.6
4	7.5	33.4	33.7	28.8	3125.5	5.58	0.501E 10	0.00158	28.4	29.4
5	10.5	33.7	33.9	28.9	3136.5	5.55	0.505E 10	0.00221	27.9	29.0
6	13.5	34.2	34.1	29.1	3147.5	5.53	0.509E 10	0.00284	26.8	27.6
7	16.5	34.5	34.4	29.3	3158.4	5.51	0.513E 10	0.00348	26.2	26.9
8	19.5	34.4	34.2	29.4	3169.4	5.49	0.517E 10	0.00411	28.0	29.3
9	22.5	34.5	34.5	29.6	3180.3	5.47	0.521E 10	0.00475	27.9	29.2
10	25.5	34.6	35.2	29.8	3191.1	5.45	0.525E 10	0.00538	26.3	27.3
11	29.5	35.3	35.4	30.0	3206.2	5.42	0.531E 10	0.00623	25.5	26.6
12	33.5	36.0	35.5	30.2	3220.7	5.39	0.537E 10	0.00708	24.7	25.6
13	37.5	35.8	36.1	30.5	3235.2	5.37	0.542E 10	0.00793	24.7	25.7
14	41.5	36.0	36.0	30.7	3249.8	5.34	0.548E 10	0.00878	25.3	26.5
15	45.5	36.1	36.1	30.9	3264.4	5.31	0.554E 10	0.00963	25.8	27.0
16	49.5	36.2	36.4	31.1	3279.2	5.28	0.560E 10	0.01048	26.1	27.5
17	54.5	36.8	37.0	31.4	3297.7	5.25	0.567E 10	0.01155	24.8	25.8
18	59.5	36.8	37.0	31.7	3316.4	5.22	0.575E 10	0.01262	26.0	27.3
19	64.5	37.2	37.0	32.0	3335.1	5.19	0.582E 10	0.01369	26.2	27.8
20	69.5	37.7	38.2	32.3	3354.0	5.15	0.590E 10	0.01476	23.7	24.8
21	74.5	37.9	38.2	32.5	3373.0	5.12	0.597E 10	0.01583	24.3	25.6
22	79.5	38.3	38.2	32.8	3392.2	5.09	0.605E 10	0.01690	24.9	26.5
23	84.5	38.9	39.4	33.1	3411.4	5.06	0.613E 10	0.01798	22.3	23.9

FULLY DEVELOPED NUSSELT NUMBER= 25.1   26.3*

RUN NUMBER (10) TUBE NUMBER 9

INPUT POWER= 1150.0 W HEAT GAINED BY WATER= 1077.9 HEAT BALANCE ERROR= 6.3%

REM= 3434.5 RAM= 0.909E 10 PR= 5.09 GR= 0.763E 08

INLET BULK TEMP= 29.2 DEG C OUTLET BULK TEMP= 36.5 DEG C

MASS FLOW RATE= 126.6 KG/HR PRESSURE DROP= 1438.2 PA CF=0.0171

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	1.5	34.2	34.5	29.3	3199.2	5.51	0.772E 10	0.00031	40.7	48.5
2	3.5	35.5	36.1	29.5	3210.1	5.49	0.778E 10	0.00073	32.2	33.0
3	5.5	36.5	36.5	29.6	3221.0	5.46	0.784E 10	0.00115	29.6	30.9
4	7.5	36.7	37.0	29.8	3231.9	5.44	0.790E 10	0.00156	28.9	30.7
5	10.5	37.2	37.4	30.1	3248.8	5.41	0.799E 10	0.00219	28.1	29.9
6	13.5	37.9	37.8	30.3	3265.1	5.38	0.809E 10	0.00282	26.9	28.5
7	16.5	38.3	38.2	30.6	3281.5	5.35	0.818E 10	0.00345	26.5	27.9
8	19.5	38.2	37.9	30.8	3297.9	5.32	0.828E 10	0.00408	28.0	30.1
9	22.5	38.3	38.3	31.1	3314.5	5.29	0.838E 10	0.00471	28.0	30.2
10	25.5	38.5	39.5	31.3	3331.2	5.26	0.848E 10	0.00534	26.4	28.2
11	29.5	39.5	39.6	31.6	3353.5	5.22	0.861E 10	0.00618	25.7	27.5
12	33.5	40.6	39.8	32.0	3376.1	5.19	0.874E 10	0.00702	24.7	26.3
13	37.5	40.2	40.6	32.3	3398.8	5.15	0.888E 10	0.00787	25.0	26.8
14	41.5	40.4	40.6	32.6	3421.6	5.11	0.901E 10	0.00871	25.8	52.1
15	45.5	40.7	****	33.0	3444.7	5.07	0.915E 10	0.00956	2.2	-1.6
16	49.5	40.7	41.0	33.3	3467.9	5.03	0.928E 10	0.01041	26.8	50.0
17	54.5	41.7	42.0	33.7	3497.2	4.99	0.946E 10	0.01147	24.9	26.8
18	59.5	41.8	42.1	34.1	3526.8	4.94	0.963E 10	0.01254	25.9	28.2
19	64.5	42.3	42.2	34.6	3556.6	4.89	0.980E 10	0.01360	26.3	28.9
20	69.5	43.0	44.1	35.0	3586.7	4.85	0.998E 10	0.01467	23.5	25.5
21	74.5	43.5	44.0	35.4	3617.1	4.80	0.102E 11	0.01574	24.1	26.4
22	79.5	44.0	43.9	35.8	3647.7	4.76	0.103E 11	0.01681	24.8	27.5
23	84.5	45.0	45.8	36.2	3678.7	4.71	0.105E 11	0.01789	22.0	24.2

FULLY DEVELOPED NUSSELT NUMBER= 23.4 28.3*

RUN NUMBER (11) TUBE NUMBER 9

INPUT POWER= 1450.0 W HEAT GAINED BY WATER= 1338.9 HEAT BALANCE ERROR= 7.7%

REM= 3968.0 RAM= 0.155E 11 PR= 4.28 GR= 0.145E 09

INLET BULK TEMP= 36.0 DEG C OUTLET BULK TEMP= 45.1 DEG C

MASS FLOW RATE= 125.1 KG/HR PRESSURE DROP= 1347.6 PA CF=0.0163

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	42.0	42.2	36.1	3626.7	4.72	0.130E 11	0.00032	42.0	50.9
2	3.5	43.5	44.5	36.3	3642.1	4.70	0.131E 11	0.00075	32.6	33.8
3	5.5	44.9	44.8	36.5	3657.7	4.68	0.132E 11	0.00118	30.0	31.8
4	7.5	45.0	45.6	36.8	3673.3	4.66	0.134E 11	0.00161	29.2	31.5
5	10.5	45.7	46.1	37.1	3696.8	4.62	0.135E 11	0.00225	28.2	30.5
6	13.5	46.6	46.4	37.4	3720.4	4.59	0.137E 11	0.00290	27.4	29.6
7	16.5	47.2	47.1	37.7	3744.3	4.56	0.139E 11	0.00355	26.4	28.3
8	19.5	47.2	46.7	38.0	3768.3	4.53	0.140E 11	0.00419	27.8	30.4
9	22.5	47.3	47.2	38.3	3792.4	4.50	0.142E 11	0.00484	27.8	30.5
10	25.5	47.5	49.0	38.6	3816.7	4.46	0.144E 11	0.00549	25.9	28.1
11	29.5	48.7	48.8	39.1	3849.4	4.42	0.146E 11	0.00636	25.6	28.1
12	33.5	50.2	49.3	39.5	3882.4	4.38	0.149E 11	0.00723	24.2	26.2
13	37.5	49.6	50.1	39.9	3915.6	4.34	0.151E 11	0.00810	25.0	27.5
14	41.5	49.9	50.1	40.3	3949.1	4.30	0.154E 11	0.00897	25.6	28.2
15	45.5	50.3	50.3	40.7	3983.0	4.26	0.156E 11	0.00984	25.9	28.6
16	49.5	50.3	50.7	41.2	4017.1	4.22	0.159E 11	0.01072	26.5	29.7
17	54.5	51.5	52.0	41.7	4060.1	4.17	0.162E 11	0.01181	24.5	27.1
18	59.5	51.7	52.1	42.2	4103.6	4.12	0.165E 11	0.01291	25.5	28.5
19	64.5	52.2	52.1	42.7	4147.5	4.07	0.168E 11	0.01401	26.2	29.6
20	69.5	53.2	54.7	43.3	4191.8	4.03	0.171E 11	0.01511	23.1	25.6
21	74.5	53.7	54.4	43.8	4236.7	3.98	0.174E 11	0.01621	24.0	27.1
22	79.5	54.2	54.2	44.3	4281.9	3.93	0.178E 11	0.01732	24.9	28.5
23	84.5	55.5	56.6	44.8	4327.6	3.89	0.181E 11	0.01842	21.9	24.7

FULLY DEVELOPED NUSSELT NUMBER= 24.9 27.7*

RUN NUMBER (12) TUBE NUMBER 9

INPUT POWER= 1160.0 W HEAT GAINED BY WATER= 1133.1 HEAT BALANCE ERROR= 2.3%

REM= 4191.5 RAM= 0.943E 10 PR= 5.12 GR= 0.644E 08

INLET BULK TEMP= 29.4 DEG C OUTLET BULK TEMP= 35.7 DEG C

MASS FLOW RATE= 155.5 KG/HR PRESSURE DROP= 1904.9 PA CF=0.0150

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.1	34.3	29.5	3944.5	5.48	0.819E 10	0.00025	45.3	51.2
2	3.5	35.2	35.9	29.7	3955.9	5.46	0.825E 10	0.00059	36.3	35.7
3	5.5	36.2	36.2	29.8	3967.4	5.45	0.830E 10	0.00093	33.6	33.4
4	7.5	36.2	36.6	29.9	3978.8	5.43	0.835E 10	0.00127	33.0	33.5
5	10.5	36.7	36.9	30.2	3996.7	5.40	0.844E 10	0.00178	32.3	32.7
6	13.5	37.4	37.2	30.4	4013.8	5.38	0.853E 10	0.00230	31.0	31.3
7	16.5	37.7	37.7	30.6	4031.1	5.35	0.861E 10	0.00281	30.1	30.1
8	19.5	37.7	37.3	30.8	4048.4	5.32	0.870E 10	0.00332	31.8	32.4
9	22.5	37.8	37.7	31.0	4065.8	5.30	0.879E 10	0.00383	31.7	32.4
10	25.5	37.9	39.0	31.2	4083.3	5.27	0.888E 10	0.00435	29.6	29.9
11	29.5	38.8	38.9	31.5	4106.8	5.24	0.900E 10	0.00503	29.1	29.5
12	33.5	39.8	39.0	31.8	4130.4	5.21	0.912E 10	0.00572	27.9	28.1
13	37.5	39.3	39.7	32.1	4154.1	5.17	0.924E 10	0.00640	28.8	29.1
14	41.5	39.5	39.7	32.4	4178.1	5.14	0.936E 10	0.00709	29.4	29.8
15	45.5	39.9	39.8	32.7	4202.1	5.11	0.948E 10	0.00778	29.7	30.1
16	49.5	39.8	40.2	32.9	4226.4	5.07	0.960E 10	0.00847	30.1	30.8
17	54.5	40.7	41.1	33.3	4256.9	5.03	0.976E 10	0.00933	28.0	28.2
18	59.5	40.8	41.1	33.7	4287.7	4.99	0.991E 10	0.01020	29.3	29.7
19	64.5	41.1	41.0	34.0	4318.7	4.95	0.101E 11	0.01106	30.0	30.7
20	69.5	41.8	42.9	34.4	4349.9	4.91	0.102E 11	0.01193	26.7	26.9
21	74.5	42.1	42.7	34.7	4381.4	4.88	0.104E 11	0.01280	27.7	28.2
22	79.5	42.5	42.4	35.1	4413.2	4.84	0.105E 11	0.01367	28.7	29.5
23	84.5	43.5	44.3	35.4	4445.2	4.80	0.107E 11	0.01454	24.9	25.9

FULLY DEVELOPED NUSSELT NUMBER= 28.6 29.0*

RUN NUMBER (13) TUBE NUMBER 9

INPUT POWER= 1470.0 W HEAT GAINED BY WATER= 1423.5 HEAT BALANCE ERROR= 3.2%

REM= 4708.6 RAM= 0.151E 11 PR= 4.50 GR= 0.117E 09

INLET BULK TEMP= 34.4 DEG C OUTLET BULK TEMP= 42.2 DEG C

MASS FLOW RATE= 155.5 KG/HR PRESSURE DROP= 1814.5 PA CF=0.0143

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	40.0	40.1	34.5	4360.3	4.90	0.129E 11	0.00026	47.9	54.7
2	3.5	41.3	42.3	34.7	4376.2	4.88	0.130E 11	0.00060	37.3	36.9
3	5.5	42.6	42.5	34.8	4392.1	4.86	0.131E 11	0.00095	34.5	34.7
4	7.5	42.6	43.3	35.0	4408.1	4.84	0.132E 11	0.00129	33.8	34.7
5	10.5	43.3	43.8	35.3	4432.1	4.81	0.134E 11	0.00181	32.3	32.9
6	13.5	44.1	43.9	35.6	4456.4	4.78	0.135E 11	0.00232	31.5	32.2
7	16.5	44.7	44.6	35.8	4480.7	4.76	0.137E 11	0.00284	30.3	30.6
8	19.5	44.7	44.2	36.1	4505.2	4.73	0.138E 11	0.00336	31.8	32.7
9	22.5	44.7	44.7	36.4	4529.9	4.70	0.140E 11	0.00388	31.9	32.9
10	25.5	44.9	46.4	36.6	4554.7	4.67	0.141E 11	0.00440	29.6	30.1
11	29.5	46.0	46.1	37.0	4588.0	4.63	0.143E 11	0.00509	29.4	30.2
12	33.5	47.4	46.4	37.4	4621.5	4.59	0.146E 11	0.00579	27.8	28.3
13	37.5	46.7	47.2	37.7	4655.3	4.56	0.148E 11	0.00649	28.8	29.6
14	41.5	47.0	47.1	38.1	4689.4	4.52	0.150E 11	0.00718	29.5	30.3
15	45.5	47.3	47.4	38.4	4723.7	4.48	0.152E 11	0.00788	29.8	30.6
16	49.5	47.4	47.7	38.8	4758.3	4.45	0.154E 11	0.00858	30.2	31.3
17	54.5	48.5	49.0	39.2	4801.9	4.40	0.157E 11	0.00946	27.8	28.4
18	59.5	48.5	49.0	39.7	4845.9	4.36	0.160E 11	0.01033	29.2	30.0
19	64.5	48.8	48.9	40.1	4890.3	4.32	0.162E 11	0.01121	30.4	31.5
20	69.5	49.8	51.4	40.6	4935.1	4.27	0.165E 11	0.01209	26.4	27.0
21	74.5	50.2	50.9	41.0	4980.3	4.23	0.168E 11	0.01298	27.7	28.5
22	79.5	50.6	50.6	41.5	5026.0	4.19	0.171E 11	0.01386	28.9	30.1
23	84.5	51.9	53.1	41.9	5072.0	4.15	0.174E 11	0.01474	24.9	26.1

FULLY DEVELOPED NUSSELT NUMBER= 28.6 29.4*

RUN NUMBER (14)   TUBE NUMBER 9

INPUT POWER= 1160.0 W   HEAT GAINED BY WATER= 1135.2   HEAT BALANCE ERROR= 2.1%

REM= 4708.1   RAM= 0.907E 10   PR= 5.22   GR= 0.562E 08

INLET BULK TEMP= 28.9 DEG C   OUTLET BULK TEMP= 34.4 DEG C

MASS FLOW RATE= 177.8 KG/HR   PRESSURE DROP= 2370.5 PA   CF=0.0143

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	1.5	33.3	33.6	29.0	4462.9	5.55	0.802E 10	0.00022	48.5	54.2
2	3.5	34.2	35.0	29.1	4474.4	5.53	0.806E 10	0.00052	39.1	38.4
3	5.5	35.2	35.2	29.2	4486.0	5.51	0.811E 10	0.00082	36.1	35.9
4	7.5	35.2	35.6	29.4	4497.5	5.50	0.816E 10	0.00111	35.6	36.0
5	10.5	35.6	35.9	29.6	4514.8	5.47	0.823E 10	0.00156	34.5	34.9
6	13.5	36.3	36.1	29.7	4532.0	5.45	0.830E 10	0.00201	33.2	33.5
7	16.5	36.6	36.5	29.9	4549.1	5.43	0.837E 10	0.00245	32.2	32.2
8	19.5	36.6	36.2	30.1	4567.2	5.41	0.844E 10	0.00290	34.2	34.7
9	22.5	36.6	36.5	30.3	4584.3	5.38	0.852E 10	0.00335	34.1	34.7
10	25.5	36.7	37.8	30.5	4601.6	5.36	0.860E 10	0.00379	31.9	32.1
11	29.5	37.5	37.6	30.7	4624.7	5.33	0.870E 10	0.00439	31.4	31.7
12	33.5	38.5	37.8	31.0	4647.9	5.30	0.880E 10	0.00499	29.9	30.1
13	37.5	38.1	38.3	31.2	4671.3	5.27	0.891E 10	0.00559	30.8	31.1
14	41.5	38.2	38.4	31.5	4694.8	5.24	0.901E 10	0.00619	31.4	31.7
15	45.5	38.5	38.5	31.7	4718.5	5.21	0.912E 10	0.00679	31.9	32.2
16	49.5	38.3	38.7	32.0	4742.3	5.18	0.922E 10	0.00739	32.8	33.4
17	54.5	39.2	39.5	32.3	4772.2	5.15	0.936E 10	0.00814	30.3	30.4
18	59.5	39.2	39.5	32.6	4802.3	5.11	0.949E 10	0.00890	31.8	32.2
19	64.5	39.5	39.4	32.9	4832.7	5.07	0.962E 10	0.00965	32.8	33.4
20	69.5	40.0	41.2	33.3	4863.2	5.04	0.976E 10	0.01041	29.0	29.1
21	74.5	40.3	40.9	33.6	4894.0	5.00	0.989E 10	0.01116	30.3	30.6
22	79.5	40.7	40.6	33.9	4925.0	4.97	0.100E 11	0.01192	31.4	32.1
23	84.5	41.7	42.5	34.2	4956.2	4.93	0.102E 11	0.01268	26.8	27.7

FULLY DEVELOPED NUSSELT NUMBER= 30.9   31.3*

RUN NUMBER (15)   TUBE NUMBER 9

INPUT POWER= 1470.0 W   HEAT GAINED BY WATER= 1398.6   HEAT BALANCE ERROR= 4.9%

REM= 5252.2   RAM= 0.141E 11   PR= 4.63   GR= 0.976E 08

INLET BULK TEMP= 33.7 DEG C   OUTLET BULK TEMP= 40.4 DEG C

MASS FLOW RATE= 177.8 KG/HR   PRESSURE DROP= 2305.8 PA   CF=0.0139

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	38.8	39.1	33.8	4917.0	4.98	0.123E 11	0.00022	51.2	58.7
2	3.5	40.0	41.0	34.0	4932.4	4.96	0.124E 11	0.00052	40.2	40.5
3	5.5	41.1	41.1	34.1	4947.7	4.94	0.125E 11	0.00083	37.4	38.5
4	7.5	41.1	41.7	34.3	4963.2	4.93	0.126E 11	0.00113	36.7	38.3
5	10.5	41.7	42.2	34.5	4986.4	4.90	0.127E 11	0.00158	35.3	36.7
6	13.5	42.6	42.3	34.7	5009.8	4.88	0.128E 11	0.00203	33.9	35.3
7	16.5	43.0	42.9	35.0	5033.3	4.85	0.129E 11	0.00248	32.8	33.8
8	19.5	43.0	42.5	35.2	5056.9	4.82	0.131E 11	0.00293	34.6	36.3
9	22.5	43.0	43.0	35.4	5080.7	4.80	0.132E 11	0.00339	34.5	36.4
10	25.5	43.1	44.6	35.6	5104.5	4.77	0.133E 11	0.00384	32.0	33.2
11	29.5	44.1	44.3	36.0	5136.5	4.74	0.135E 11	0.00444	31.8	33.4
12	33.5	45.5	44.5	36.3	5168.7	4.71	0.137E 11	0.00505	29.9	31.1
13	37.5	44.7	45.2	36.6	5201.2	4.68	0.139E 11	0.00566	31.2	32.8
14	41.5	44.9	45.2	36.9	5233.8	4.64	0.140E 11	0.00627	32.0	33.6
15	45.5	45.2	45.3	37.2	5266.7	4.61	0.142E 11	0.00687	32.4	34.1
16	49.5	45.2	45.7	37.5	5299.8	4.58	0.144E 11	0.00748	32.9	34.9
17	54.5	46.2	46.7	37.9	5341.4	4.54	0.146E 11	0.00825	30.5	32.0
18	59.5	46.1	46.5	38.3	5383.4	4.50	0.148E 11	0.00901	32.4	34.2
19	64.5	46.4	46.4	38.7	5425.8	4.46	0.151E 11	0.00978	33.6	35.8
20	69.5	47.2	48.8	39.0	5468.5	4.42	0.153E 11	0.01054	29.2	30.6
21	74.5	47.5	48.2	39.4	5511.5	4.39	0.155E 11	0.01131	30.8	32.7
22	79.5	47.9	47.8	39.8	5554.9	4.35	0.158E 11	0.01208	32.3	34.7
23	84.5	49.1	50.4	40.2	5598.6	4.31	0.160E 11	0.01285	27.3	29.2

FULLY DEVELOPED NUSSELT NUMBER= 31.3   33.0*

RUN NUMBER (16)   TUBE NUMBER 9

INPUT POWER= 1450.0 W   HEAT GAINED BY WATER= 1406.2   HEAT BALANCE ERROR= 3.0%

REM= 6251.2   RAM= 0.145E 11   PR= 4.58   GR= 0.863E 08

INLET BULK TEMP= 34.6 DEG C   OUTLET BULK TEMP= 40.4 DEG C

MASS FLOW RATE= 209.8 KG/HR   PRESSURE DROP= 584.9 PA   CF=0.0025

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	39.1	39.4	34.7	5909.0	4.88	0.129E 11	0.00019	58.4	64.9
2	3.5	40.0	41.1	34.9	5924.7	4.86	0.130E 11	0.00045	46.3	45.9
3	5.5	41.0	41.0	35.0	5940.5	4.85	0.130E 11	0.00070	43.8	44.2
4	7.5	40.9	41.6	35.1	5956.3	4.83	0.131E 11	0.00096	43.0	43.9
5	10.5	41.4	41.9	35.3	5980.2	4.81	0.132E 11	0.00134	41.4	42.2
6	13.5	42.3	42.1	35.5	6004.1	4.79	0.133E 11	0.00172	39.6	40.2
7	16.5	42.7	42.5	35.7	6028.1	4.77	0.134E 11	0.00211	38.1	38.5
8	19.5	42.7	42.2	35.9	6052.3	4.75	0.136E 11	0.00249	40.0	40.9
9	22.5	42.6	42.6	36.1	6076.5	4.73	0.137E 11	0.00288	40.5	41.6
10	25.5	42.6	44.2	36.3	6100.9	4.71	0.138E 11	0.00326	37.1	37.6
11	29.5	43.5	43.6	36.6	6133.5	4.68	0.139E 11	0.00377	37.6	38.5
12	33.5	44.9	43.8	36.8	6166.3	4.65	0.141E 11	0.00429	34.9	35.4
13	37.5	44.0	44.4	37.1	6199.3	4.62	0.142E 11	0.00480	36.9	37.7
14	41.5	44.1	44.4	37.4	6232.5	4.60	0.144E 11	0.00532	38.0	38.8
15	45.5	44.4	44.5	37.6	6265.9	4.57	0.145E 11	0.00583	38.4	39.2
16	49.5	44.3	44.8	37.9	6299.5	4.54	0.147E 11	0.00635	39.2	40.4
17	54.5	45.3	45.9	38.2	6341.7	4.51	0.149E 11	0.00700	35.6	36.2
18	59.5	45.2	45.7	38.5	6384.2	4.47	0.151E 11	0.00764	37.8	38.7
19	64.5	45.6	45.6	38.9	6427.0	4.44	0.153E 11	0.00829	38.8	40.0
20	69.5	46.2	47.8	39.2	6470.1	4.41	0.155E 11	0.00894	33.5	34.1
21	74.5	46.4	47.1	39.5	6513.5	4.38	0.157E 11	0.00959	36.0	36.9
22	79.5	46.7	46.7	39.9	6557.2	4.34	0.159E 11	0.01024	38.1	39.6
23	84.5	48.1	49.2	40.2	6601.2	4.31	0.161E 11	0.01089	30.9	32.1

FULLY DEVELOPED NUSSELT NUMBER= 36.6   37.5*

RUN NUMBER (17)   TUBE NUMBER 9

INPUT POWER= 1460.0 W   HEAT GAINED BY WATER= 1415.0   HEAT BALANCE ERROR= 3.1%

REM= 6850.3   RAM= 0.141E 11   PR= 4.66   GR= 0.776E 08

INLET BULK TEMP= 34.1 DEG C   OUTLET BULK TEMP= 39.3 DEG C

MASS FLOW RATE= 233.5 KG/HR   PRESSURE DROP= 722.8 PA   CF=0.0025

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	38.4	38.8	34.2	6510.6	4.93	0.127E 11	0.00017	60.2	66.4
2	3.5	39.2	40.3	34.3	6526.3	4.92	0.128E 11	0.00040	49.0	48.7
3	5.5	40.2	40.2	34.4	6542.0	4.91	0.128E 11	0.00063	46.2	46.6
4	7.5	40.0	40.7	34.6	6557.7	4.89	0.129E 11	0.00086	46.0	47.0
5	10.5	40.5	40.9	34.7	6581.4	4.87	0.130E 11	0.00120	44.5	45.2
6	13.5	41.1	41.0	34.9	6605.2	4.85	0.131E 11	0.00155	43.4	44.3
7	16.5	41.6	41.5	35.1	6629.1	4.83	0.132E 11	0.00189	41.0	41.4
8	19.5	41.6	41.1	35.3	6653.0	4.81	0.133E 11	0.00223	43.5	44.5
9	22.5	41.5	41.5	35.5	6677.1	4.80	0.134E 11	0.00258	43.9	45.2
10	25.5	41.5	43.2	35.6	6701.3	4.78	0.135E 11	0.00292	39.6	40.1
11	29.5	42.5	42.5	35.9	6733.6	4.75	0.136E 11	0.00338	40.0	41.1
12	33.5	43.8	42.9	36.1	6766.2	4.73	0.138E 11	0.00385	36.6	37.0
13	37.5	42.9	43.3	36.4	6798.9	4.70	0.139E 11	0.00431	39.0	39.9
14	41.5	43.0	43.2	36.6	6831.7	4.67	0.140E 11	0.00477	40.4	41.2
15	45.5	42.7	43.4	36.8	6864.8	4.65	0.142E 11	0.00523	42.5	43.6
16	49.5	43.1	43.7	37.1	6898.0	4.63	0.143E 11	0.00569	41.8	43.0
17	54.5	44.1	44.7	37.4	6939.7	4.59	0.145E 11	0.00627	37.3	37.9
18	59.5	43.9	44.4	37.7	6981.8	4.56	0.147E 11	0.00685	40.4	41.4
19	64.5	44.3	44.1	38.0	7024.0	4.53	0.148E 11	0.00743	42.3	43.7
20	69.5	44.9	46.5	38.3	7066.6	4.50	0.150E 11	0.00802	35.4	35.9
21	74.5	45.1	45.8	38.6	7109.4	4.47	0.152E 11	0.00860	38.0	39.0
22	79.5	45.3	45.4	38.8	7152.5	4.44	0.154E 11	0.00918	40.6	42.1
23	84.5	46.7	47.9	39.1	7195.9	4.41	0.155E 11	0.00976	32.3	33.5

FULLY DEVELOPED NUSSELT NUMBER= 39.0   40.0*

RUN NUMBER (18)   TUBE NUMBER 9

INPUT POWER= 1440.0 W   HEAT GAINED BY WATER= 1384.5   HEAT BALANCE ERROR= 3.9%

REM= 8897.8   RAM= 0.151E 11   PR= 4.44   GR= 0.732E 08

INLET BULK TEMP= 36.8 DEG C   OUTLET BULK TEMP= 40.9 DEG C

MASS FLOW RATE= 290.3 KG/HR   PRESSURE DROP= 1051.6 PA   CF=0.0024

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	1.5	40.5	40.9	36.9	8547.3	4.64	0.139E 11	0.00014	67.8	73.8
2	3.5	40.8	42.1	37.0	8563.6	4.63	0.140E 11	0.00032	58.6	59.6
3	5.5	41.8	41.9	37.1	8579.9	4.62	0.140E 11	0.00051	54.5	55.1
4	7.5	41.5	42.2	37.2	8596.2	4.61	0.141E 11	0.00069	55.0	56.7
5	10.5	41.9	42.4	37.3	8620.7	4.60	0.142E 11	0.00097	53.6	55.1
6	13.5	42.6	42.3	37.5	8645.4	4.58	0.142E 11	0.00125	51.9	53.4
7	16.5	43.0	42.8	37.6	8670.1	4.57	0.143E 11	0.00153	49.2	50.2
8	19.5	43.0	42.6	37.8	8694.8	4.55	0.144E 11	0.00181	51.3	52.9
9	22.5	42.8	42.9	37.9	8719.7	4.54	0.145E 11	0.00209	52.1	54.1
10	25.5	42.8	44.4	38.0	8744.6	4.53	0.146E 11	0.00236	46.3	47.3
11	29.5	43.5	43.7	38.2	8777.9	4.51	0.147E 11	0.00274	47.8	49.5
12	33.5	44.8	43.8	38.4	8811.4	4.49	0.148E 11	0.00311	43.7	44.6
13	37.5	43.9	44.2	38.6	8845.0	4.47	0.149E 11	0.00348	47.2	48.7
14	41.5	43.9	44.1	38.8	8878.8	4.45	0.150E 11	0.00385	49.1	50.7
15	45.5	44.2	44.3	39.0	8912.6	4.43	0.151E 11	0.00423	49.0	50.6
16	49.5	44.0	44.5	39.2	8946.6	4.41	0.152E 11	0.00460	50.2	52.3
17	54.5	44.9	45.5	39.4	8989.3	4.39	0.154E 11	0.00507	44.1	45.3
18	59.5	44.8	45.2	39.6	9032.2	4.37	0.155E 11	0.00554	47.8	49.5
19	64.5	45.0	44.9	39.9	9075.3	4.34	0.156E 11	0.00600	50.5	52.7
20	69.5	45.5	47.0	40.1	9118.6	4.32	0.158E 11	0.00647	41.6	42.7
21	74.5	45.7	46.3	40.3	9162.2	4.30	0.159E 11	0.00694	45.2	46.9
22	79.5	45.8	45.8	40.6	9205.9	4.28	0.161E 11	0.00741	48.9	51.3
23	84.5	47.1	48.3	40.8	9249.8	4.25	0.162E 11	0.00788	37.2	38.9

FULLY DEVELOPED NUSSELT NUMBER= 46.3   47.9*

RUN NUMBER (1)   TUBE NUMBER 10

INPUT POWER= 500.0 W   HEAT GAINED BY WATER= 473.5   HEAT BALANCE ERROR= 5.3%

REM= 1963.8   RAM= 0.140E 09   PR= 6.35   GR= 0.151E 07

INLET BULK TEMP= 21.6 DEG C   OUTLET BULK TEMP= 25.8 DEG C

MASS FLOW RATE= 97.7 KG/HR   PRESSURE DROP= 3654.4 PA   CF=0.0110

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	24.0	24.3	21.7	1870.9	6.70	0.124E 09	0.00088	16.6	17.9
2	3.5	24.4	23.7	21.8	1875.3	6.69	0.124E 09	0.00206	18.2	19.5
3	5.5	24.4	24.3	21.9	1879.6	6.67	0.125E 09	0.00324	16.3	17.2
4	7.5	25.0	24.6	22.0	1884.0	6.65	0.126E 09	0.00442	14.4	14.8
5	10.5	24.8	24.7	22.1	1890.6	6.63	0.127E 09	0.00619	15.5	16.5
6	13.5	25.3	25.3	22.3	1897.2	6.60	0.128E 09	0.00796	13.3	13.9
7	16.5	26.0	25.3	22.4	1903.7	6.57	0.129E 09	0.00973	12.5	13.0
8	19.5	25.6	25.6	22.5	1910.3	6.55	0.130E 09	0.01151	13.3	14.0
9	22.5	25.7	25.6	22.7	1916.9	6.52	0.131E 09	0.01328	13.7	14.4
10	25.5	25.8	25.6	22.8	1923.5	6.50	0.133E 09	0.01506	14.4	15.3
11	29.5	26.0	26.0	23.0	1932.4	6.46	0.134E 09	0.01743	13.5	14.1
12	33.5	25.3	25.7	23.2	1941.2	6.43	0.136E 09	0.01981	17.4	18.9
13	37.5	26.3	26.6	23.4	1950.0	6.40	0.137E 09	0.02219	13.2	14.0
14	41.5	26.8	26.8	23.6	1958.9	6.36	0.139E 09	0.02457	12.5	13.3
15	45.5	27.0	27.3	23.8	1967.8	6.33	0.140E 09	0.02695	12.0	12.6
16	49.5	26.7	26.7	24.0	1976.6	6.30	0.142E 09	0.02934	15.0	16.3
17	54.5	27.0	27.4	24.2	1987.7	6.26	0.144E 09	0.03233	13.6	14.5
18	59.5	26.7	27.3	24.4	1998.8	6.22	0.146E 09	0.03532	15.9	17.3
19	64.5	26.9	27.5	24.7	2009.9	6.18	0.148E 09	0.03832	16.3	17.8
20	69.5	27.8	27.8	24.9	2021.1	6.14	0.150E 09	0.04132	14.0	15.1
21	74.5	27.5	27.9	25.2	2032.2	6.10	0.152E 09	0.04433	16.0	17.6
22	79.5	27.8	28.0	25.4	2043.3	6.07	0.154E 09	0.04734	16.0	17.7
23	84.5	28.4	28.6	25.6	2054.4	6.03	0.156E 09	0.05035	14.0	15.1

FULLY DEVELOPED NUSSELT NUMBER= 14.5   15.7*

RUN NUMBER (2)   TUBE NUMBER 10

INPUT POWER= 1725.0 W   HEAT GAINED BY WATER= 1622.7   HEAT BALANCE ERROR= 5.9%

REM= 2368.7   RAM= 0.698E 09   PR= 5.28   GR= 0.106E 08

INLET BULK TEMP= 24.2 DEG C   OUTLET BULK TEMP= 38.1 DEG C

MASS FLOW RATE= 100.3 KG/HR   PRESSURE DROP= 3648.5 PA   CF=0.0105

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	1.5	33.5	34.2	24.4	2049.3	6.22	0.499E 09	0.00087	14.7	15.9
2	3.5	36.2	32.3	24.7	2064.6	6.17	0.508E 09	0.00203	14.6	15.5
3	5.5	35.8	35.4	25.1	2079.9	6.12	0.517E 09	0.00319	13.2	13.9
4	7.5	38.0	37.0	25.4	2095.2	6.07	0.526E 09	0.00435	11.4	11.7
5	10.5	37.7	36.9	25.9	2118.1	5.99	0.540E 09	0.00610	12.1	13.0
6	13.5	39.2	40.0	26.3	2141.0	5.92	0.553E 09	0.00786	10.4	10.9
7	16.5	42.3	40.4	26.8	2163.9	5.85	0.567E 09	0.00962	9.5	9.8
8	19.5	39.9	40.4	27.3	2186.7	5.78	0.581E 09	0.01138	10.7	11.4
9	22.5	40.3	39.7	27.8	2209.4	5.71	0.595E 09	0.01315	11.3	11.9
10	25.5	40.1	39.1	28.2	2232.1	5.65	0.609E 09	0.01493	12.1	13.0
11	29.5	40.5	41.3	28.9	2262.2	5.56	0.628E 09	0.01730	11.5	12.0
12	33.5	37.3	38.7	29.5	2292.0	5.48	0.647E 09	0.01968	16.2	17.8
13	37.5	41.0	43.5	30.1	2322.0	5.40	0.666E 09	0.02206	11.3	12.0
14	41.5	43.3	44.2	30.8	2351.7	5.33	0.687E 09	0.02445	10.6	11.4
15	45.5	43.9	47.2	31.4	2381.9	5.25	0.707E 09	0.02685	9.7	10.1
16	49.5	42.2	42.2	32.1	2412.5	5.18	0.728E 09	0.02925	13.5	14.9
17	54.5	43.1	45.7	32.8	2451.4	5.09	0.755E 09	0.03227	11.8	12.7
18	59.5	41.7	45.1	33.6	2490.9	5.00	0.782E 09	0.03529	13.9	15.3
19	64.5	42.3	45.6	34.4	2531.2	4.91	0.810E 09	0.03833	14.4	15.9
20	69.5	46.3	47.5	35.2	2572.3	4.82	0.838E 09	0.04137	11.7	12.6
21	74.5	44.9	47.9	36.0	2614.0	4.73	0.866E 09	0.04443	13.1	14.4
22	79.5	46.0	47.5	36.8	2656.5	4.65	0.895E 09	0.04749	13.7	15.3
23	84.5	49.5	49.5	37.6	2699.7	4.57	0.924E 09	0.05057	11.4	12.4

FULLY DEVELOPED NUSSELT NUMBER= 12.5 13.6*

RUN NUMBER (3)   TUBE NUMBER 10

INPUT POWER= 1725.0 W   HEAT GAINED BY WATER= 1675.8   HEAT BALANCE ERROR= 2.9%

REM= 4818.4   RAM= 0.514E 09   PR= 6.23   GR= 0.499E 07

INLET BULK TEMP= 21.3 DEG C   OUTLET BULK TEMP= 27.4 DEG C

MASS FLOW RATE= 235.9 KG/HR   PRESSURE DROP= 4037.4 PA   CF=0.0021

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	29.2	30.3	21.4	4488.8	6.75	0.431E 09	0.00037	17.4	18.1
2	3.5	31.3	27.3	21.6	4504.2	6.72	0.435E 09	0.00085	18.6	19.2
3	5.5	30.4	29.8	21.7	4519.6	6.70	0.438E 09	0.00134	17.2	17.7
4	7.5	32.4	31.5	21.9	4535.1	6.67	0.442E 09	0.00183	14.3	14.0
5	10.5	31.5	30.8	22.1	4558.4	6.63	0.448E 09	0.00256	16.0	16.5
6	13.5	33.0	33.6	22.3	4581.6	6.59	0.454E 09	0.00330	13.1	13.2
7	16.5	35.8	33.7	22.5	4605.0	6.56	0.460E 09	0.00403	11.8	11.7
8	19.5	33.0	33.2	22.7	4628.4	6.52	0.466E 09	0.00477	13.9	14.2
9	22.5	33.2	32.3	22.9	4651.8	6.48	0.472E 09	0.00551	14.6	14.8
10	25.5	32.7	31.7	23.1	4675.2	6.45	0.478E 09	0.00625	15.9	16.2
11	29.5	32.6	33.4	23.4	4706.5	6.40	0.486E 09	0.00723	14.9	14.9
12	33.5	29.2	30.9	23.7	4737.9	6.35	0.494E 09	0.00822	22.5	23.5
13	37.5	32.5	34.8	24.0	4769.3	6.30	0.502E 09	0.00921	14.8	14.8
14	41.5	34.4	35.1	24.2	4800.7	6.25	0.510E 09	0.01020	13.7	13.9
15	45.5	34.6	37.6	24.5	4832.2	6.21	0.518E 09	0.01119	12.3	12.3
16	49.5	32.9	32.4	24.8	4863.7	6.16	0.526E 09	0.01219	18.2	18.9
17	54.5	33.5	35.6	25.1	4903.1	6.11	0.536E 09	0.01343	15.2	15.3
18	59.5	31.5	35.0	25.5	4942.5	6.05	0.547E 09	0.01468	18.5	18.9
19	64.5	31.4	34.7	25.8	4981.9	6.00	0.557E 09	0.01593	19.8	20.3
20	69.5	34.9	36.0	26.2	5021.3	5.94	0.567E 09	0.01719	15.5	15.6
21	74.5	33.1	36.3	26.5	5060.6	5.89	0.578E 09	0.01844	17.5	17.9
22	79.5	34.4	35.4	26.9	5099.9	5.84	0.588E 09	0.01970	17.8	18.2
23	84.5	36.9	36.6	27.2	5139.2	5.79	0.599E 09	0.02096	15.0	15.4

FULLY DEVELOPED NUSSELT NUMBER= 16.5 16.9*

RUN NUMBER (4)   TUBE NUMBER 10

INPUT POWER= 512.0 W   HEAT GAINED BY WATER= 454.8   HEAT BALANCE ERROR=11.2%

REM= 844.4   RAM= 0.344E 09   PR= 3.85   GR= 0.126E 08

INLET BULK TEMP= 38.0 DEG C   OUTLET BULK TEMP= 52.6 DEG C

MASS FLOW RATE= 26.8 KG/HR   PRESSURE DROP= 724.9 PA   CF=0.0289

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	40.7	41.5	38.3	732.0	4.50	0.266E 09	0.00336	13.4	16.3
2	3.5	43.0	41.8	38.6	737.0	4.47	0.269E 09	0.00784	10.0	11.1
3	5.5	43.4	43.0	38.9	742.0	4.43	0.273E 09	0.01234	8.8	10.6
4	7.5	46.3	44.1	39.3	747.0	4.40	0.276E 09	0.01683	6.4	7.0
5	10.5	48.5	44.3	39.8	754.6	4.35	0.282E 09	0.02359	5.7	6.3
6	13.5	46.6	45.1	40.3	762.3	4.30	0.287E 09	0.03036	6.7	8.0
7	16.5	46.8	45.6	40.8	770.1	4.26	0.292E 09	0.03715	6.9	8.3
8	19.5	48.6	46.6	41.3	778.0	4.21	0.298E 09	0.04395	5.9	7.1
9	22.5	51.5	47.0	41.8	785.9	4.16	0.304E 09	0.05076	5.0	5.5
10	25.5	49.0	47.0	42.3	793.9	4.12	0.309E 09	0.05758	6.5	8.1
11	29.5	47.9	48.3	42.9	804.7	4.06	0.317E 09	0.06670	7.3	9.0
12	33.5	47.8	47.8	43.6	815.6	4.00	0.324E 09	0.07584	8.9	11.8
13	37.5	49.1	49.8	44.3	826.7	3.94	0.332E 09	0.08500	7.2	9.2
14	41.5	50.4	50.8	44.9	837.9	3.88	0.340E 09	0.09417	6.6	8.4
15	45.5	51.2	51.6	45.6	849.3	3.83	0.348E 09	0.10337	6.5	8.2
16	49.5	50.9	51.8	46.3	860.8	3.77	0.356E 09	0.11258	7.3	10.1
17	54.5	52.2	52.9	47.1	875.3	3.70	0.366E 09	0.12411	6:8	9.2
18	59.5	52.4	52.9	47.9	890.0	3.64	0.376E 09	0.13566	7.8	11.3
19	64.5	53.4	54.2	48.8	904.9	3.57	0.386E 09	0.14723	7.3	10.6
20	69.5	55.1	55.6	49.6	920.1	3.51	0.397E 09	0.15880	6.5	9.1
21	74.5	55.6	56.1	50.4	932.2	3.46	0.406E 09	0.17036	6.8	10.0
22	79.5	55.3	56.4	51.2	940.8	3.43	0.414E 09	0.18201	8.1	13.3
23	84.5	57.8	58.8	52.1	949.6	3.39	0.421E 09	0.19369	6.0	7.6

FULLY DEVELOPED NUSSELT NUMBER= 7.1   9.7*

RUN NUMBER (5)   TUBE NUMBER 10

INPUT POWER= 695.0 W   HEAT GAINED BY WATER= 634.7   HEAT BALANCE ERROR= 8.7%

REM= 890.9   RAM= 0.525E 09   PR= 3.63   GR= 0.202E 08

INLET BULK TEMP= 37.8 DEG C   OUTLET BULK TEMP= 58.1 DEG C

MASS FLOW RATE= 26.8 KG/HR   PRESSURE DROP= 720.9 PA   CF=0.0287

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	42.2	43.5	38.2	730.8	4.51	0.369E 09	0.00336	11.3	13.9
2	3.5	45.2	43.4	38.6	737.7	4.46	0.376E 09	0.00785	9.4	10.3
3	5.5	45.9	45.2	39.1	744.7	4.42	0.383E 09	0.01234	8.2	9.7
4	7.5	49.8	46.7	39.6	751.7	4.37	0.389E 09	0.01684	6.1	6.4
5	10.5	53.1	47.0	40.3	762.4	4.30	0.400E 09	0.02362	5.4	5.7
6	13.5	50.3	48.2	41.0	773.3	4.24	0.411E 09	0.03041	6.3	7.2
7	16.5	50.4	48.9	41.7	784.3	4.17	0.421E 09	0.03722	6.6	7.6
8	19.5	52.7	50.1	42.4	795.4	4.11	0.432E 09	0.04404	5.8	6.7
9	22.5	57.3	50.5	43.1	806.7	4.04	0.443E 09	0.05089	4.8	5.1
10	25.5	53.6	50.6	43.7	818.2	3.98	0.454E 09	0.05775	6.2	7.4
11	29.5	51.7	52.3	44.7	833.7	3.90	0.470E 09	0.06691	7.2	8.4
12	33.5	51.5	51.6	45.6	849.5	3.82	0.485E 09	0.07611	8.7	10.9
13	37.5	53.3	54.3	46.5	865.5	3.75	0.500E 09	0.08532	7.1	8.5
14	41.5	54.9	55.5	47.5	881.8	3.67	0.516E 09	0.09456	6.7	8.1
15	45.5	56.0	56.8	48.4	898.3	3.60	0.532E 09	0.10381	6.5	7.8
16	49.5	55.7	56.8	49.3	915.1	3.53	0.548E 09	0.11307	7.5	9.5
17	54.5	57.4	58.3	50.5	932.8	3.46	0.567E 09	0.12464	7.0	8.7
18	59.5	57.8	58.5	51.6	944.8	3.41	0.582E 09	0.13630	7.9	10.4
19	64.5	59.0	60.1	52.8	957.3	3.36	0.597E 09	0.14800	7.6	10.0
20	69.5	61.4	61.9	54.0	970.3	3.31	0.612E 09	0.15973	6.7	8.6
21	74.5	62.0	62.9	55.1	983.8	3.26	0.628E 09	0.17151	7.0	9.3
22	79.5	61.8	63.5	56.3	997.9	3.21	0.644E 09	0.18333	8.0	11.5
23	84.5	65.3	66.7	57.4	1012.5	3.16	0.660E 09	0.19518	5.9	7.2

FULLY DEVELOPED NUSSELT NUMBER= 7.1 9.0*

RUN NUMBER (6)   TUBE NUMBER 10

INPUT POWER= 300.0 W   HEAT GAINED BY WATER= 268.0   HEAT BALANCE ERROR=10.7%

REM= 789.2   RAM= 0.180E 09   PR= 4.14   GR= 0.581E 07

INLET BULK TEMP= 37.7 DEG C   OUTLET BULK TEMP= 46.3 DEG C

MASS FLOW RATE= 26.8 KG/HR   PRESSURE DROP= 758.4 PA   CF=0.0303

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	38.7	39.2	37.8	725.4	4.55	0.154E 09	0.00336	20.1	24.4
2	3.5	40.2	39.6	38.0	728.3	4.53	0.155E 09	0.00783	11.8	12.7
3	5.5	40.3	40.4	38.2	731.2	4.51	0.156E 09	0.01232	10.4	12.4
4	7.5	41.9	40.9	38.4	734.1	4.49	0.157E 09	0.01680	7.5	8.2
5	10.5	43.1	41.1	38.7	738.5	4.46	0.159E 09	0.02354	6.6	7.3
6	13.5	42.3	41.4	39.0	743.0	4.43	0.161E 09	0.03028	7.9	9.3
7	16.5	42.3	41.7	39.3	747.4	4.40	0.163E 09	0.03704	8.2	9.9
8	19.5	43.2	42.5	39.6	751.9	4.37	0.165E 09	0.04380	6.9	8.1
9	22.5	44.7	42.7	39.9	756.4	4.34	0.167E 09	0.05057	5.8	6.4
10	25.5	43.6	42.7	40.2	760.9	4.31	0.169E 09	0.05734	7.5	9.3
11	29.5	43.3	43.6	40.6	767.0	4.28	0.171E 09	0.06639	7.7	9.4
12	33.5	43.3	43.1	41.0	773.2	4.24	0.174E 09	0.07545	9.8	13.0
13	37.5	44.0	44.4	41.4	779.4	4.20	0.176E 09	0.08453	7.9	10.0
14	41.5	44.8	45.2	41.7	785.6	4.16	0.179E 09	0.09362	6.9	8.6
15	45.5	45.4	45.4	42.1	791.9	4.13	0.181E 09	0.10272	6.8	8.7
16	49.5	45.2	45.8	42.5	798.2	4.09	0.184E 09	0.11184	7.5	10.1
17	54.5	46.1	46.3	43.0	806.2	4.05	0.187E 09	0.12325	7.0	9.3
18	59.5	46.1	46.3	43.5	814.3	4.00	0.191E 09	0.13468	8.2	11.7
19	64.5	46.7	47.2	44.0	822.4	3.96	0.194E 09	0.14613	7.6	10.7
20	69.5	47.8	48.0	44.5	830.6	3.92	0.197E 09	0.15759	6.5	8.9
21	74.5	48.1	48.4	45.0	838.9	3.88	0.201E 09	0.16908	6.8	9.6
22	79.5	47.7	48.4	45.5	847.3	3.83	0.204E 09	0.18057	8.6	13.9
23	84.5	49.2	50.0	46.0	855.7	3.79	0.208E 09	0.19209	6.1	7.7

FULLY DEVELOPED NUSSELT NUMBER= 7.5   10.1*

RUN NUMBER (7)   TUBE NUMBER 10

INPUT POWER= 500.0 W   HEAT GAINED BY WATER= 474.5   HEAT BALANCE ERROR= 5.1%

REM= 1169.1   RAM= 0.334E 09   PR= 4.03   GR= 0.953E 07

INLET BULK TEMP= 38.0 DEG C   OUTLET BULK TEMP= 48.5 DEG C

MASS FLOW RATE= 38.7 KG/HR   PRESSURE DROP= 1248.9 PA   CF=0.0239

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	40.3	41.2	38.1	1054.6	4.51	0.276E 09	0.00233	15.1	17.3
2	3.5	42.3	41.1	38.4	1059.7	4.49	0.278E 09	0.00543	12.0	12.4
3	5.5	42.5	42.1	38.6	1064.9	4.47	0.281E 09	0.00854	10.8	12.0
4	7.5	45.0	43.0	38.9	1070.1	4.44	0.284E 09	0.01165	7.7	7.8
5	10.5	47.1	43.0	39.2	1078.0	4.41	0.288E 09	0.01632	6.8	6.8
6	13.5	45.1	43.7	39.6	1085.9	4.37	0.292E 09	0.02099	8.2	8.8
7	16.5	45.0	44.0	39.9	1093.9	4.33	0.296E 09	0.02568	8.7	9.5
8	19.5	46.7	44.8	40.3	1101.9	4.30	0.300E 09	0.03037	7.2	7.4
9	22.5	46.8	45.0	40.7	1110.1	4.27	0.304E 09	0.03507	7.5	7.9
10	25.5	46.9	45.0	41.0	1118.2	4.23	0.308E 09	0.03977	8.0	8.6
11	29.5	45.6	46.0	41.5	1129.2	4.19	0.314E 09	0.04606	9.1	9.7
12	33.5	45.4	45.5	42.0	1140.3	4.14	0.319E 09	0.05235	11.4	12.6
13	37.5	46.2	47.1	42.5	1151.5	4.10	0.325E 09	0.05866	9.4	5.7
14	41.5	****	47.9	43.0	1162.7	4.05	0.331E 09	0.06497	-1.4	-2.7
15	45.5	47.7	48.5	43.4	1174.1	4.01	0.336E 09	0.07130	8.4	5.4
16	49.5	48.0	48.5	43.9	1185.6	3.97	0.342E 09	0.07764	9.1	10.0
17	54.5	47.7	49.4	44.5	1200.2	3.92	0.349E 09	0.08557	9.7	10.8
18	59.5	48.7	49.3	45.1	1214.8	3.87	0.357E 09	0.09352	10.1	11.3
19	64.5	48.6	50.1	45.7	1229.7	3.81	0.364E 09	0.10148	10.6	12.0
20	69.5	49.4	51.2	46.3	1244.6	3.76	0.372E 09	0.10945	9.8	11.1
21	74.5	50.8	51.5	46.9	1259.8	3.72	0.379E 09	0.11744	9.2	10.3
22	79.5	50.7	51.6	47.5	1275.1	3.67	0.387E 09	0.12543	10.7	12.6
23	84.5	52.8	53.7	48.1	1290.5	3.62	0.395E 09	0.13344	7.6	8.3

FULLY DEVELOPED NUSSELT NUMBER= 8.7   9.0*

RUN NUMBER (8)   TUBE NUMBER 10

INPUT POWER= 700.0 W   HEAT GAINED BY WATER= 671.8   HEAT BALANCE ERROR= 4.0%

REM= 1211.3   RAM= 0.503E 09   PR= 3.88   GR= 0.148E 08

INLET BULK TEMP= 37.5 DEG C   OUTLET BULK TEMP= 52.4 DEG C

MASS FLOW RATE= 38.7 KG/HR   PRESSURE DROP= 1218.6 PA   CF=0.0233

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	41.4	42.6	37.8	1046.9	4.55	0.385E 09	0.00232	13.3	15.1
2	3.5	44.0	42.2	38.1	1054.2	4.52	0.390E 09	0.00543	11.4	11.8
3	5.5	44.5	43.7	38.5	1061.5	4.48	0.395E 09	0.00853	9.9	10.9
4	7.5	48.2	45.1	38.8	1068.9	4.45	0.401E 09	0.01164	7.1	7.1
5	10.5	51.4	45.0	39.3	1080.0	4.40	0.409E 09	0.01632	6.3	6.2
6	13.5	48.2	46.1	39.8	1091.3	4.35	0.417E 09	0.02101	7.6	8.0
7	16.5	48.0	46.6	40.3	1102.6	4.30	0.425E 09	0.02570	8.0	8.5
8	19.5	50.2	47.5	40.9	1114.1	4.25	0.433E 09	0.03040	6.9	7.1
9	22.5	50.6	47.9	41.4	1125.8	4.20	0.441E 09	0.03512	7.1	7.3
10	25.5	50.8	47.8	41.9	1137.5	4.15	0.450E 09	0.03984	7.5	7.8
11	29.5	48.5	49.1	42.6	1153.3	4.09	0.461E 09	0.04615	8.9	9.4
12	33.5	49.0	48.3	43.2	1169.3	4.03	0.473E 09	0.05248	10.3	11.1
13	37.5	49.7	50.8	43.9	1185.6	3.97	0.484E 09	0.05882	8.7	9.2
14	41.5	51.0	51.7	44.6	1202.0	3.91	0.496E 09	0.06517	8.2	8.6
15	45.5	51.8	52.7	45.3	1218.7	3.85	0.508E 09	0.07153	7.9	8.3
16	49.5	51.4	52.4	46.0	1235.5	3.79	0.520E 09	0.07791	9.3	10.1
17	54.5	52.6	53.8	46.8	1256.9	3.73	0.535E 09	0.08590	8.6	9.1
18	59.5	52.9	53.7	47.7	1278.6	3.66	0.550E 09	0.09390	9.8	10.7
19	64.5	53.8	54.8	48.5	1300.5	3.59	0.566E 09	0.10191	9.4	10.3
20	69.5	55.8	56.3	49.4	1322.8	3.53	0.582E 09	0.10993	8.2	8.8
21	74.5	55.9	56.9	50.2	1343.2	3.47	0.597E 09	0.11792	8.9	9.7
22	79.5	56.2	57.2	51.1	1355.8	3.43	0.608E 09	0.12599	9.7	10.8
23	84.5	58.7	60.0	51.9	1368.7	3.40	0.620E 09	0.13408	7.3	7.9

FULLY DEVELOPED NUSSELT NUMBER= 8.8   9.4*

RUN NUMBER (9)   TUBE NUMBER 10

INPUT POWER= 902.0 W   HEAT GAINED BY WATER= 864.2   HEAT BALANCE ERROR= 4.2%

REM= 1271.7   RAM= 0.702E 09   PR= 3.68   GR= 0.219E 08

INLET BULK TEMP= 37.8 DEG C   OUTLET BULK TEMP= 57.0 DEG C

MASS FLOW RATE= 38.7 KG/HR   PRESSURE DROP= 1198.7 PA   CF=0.0229

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	1.5	43.1	43.8	38.1	1054.6	4.51	0.502E 09	0.00233	13.5	15.5
2	3.5	46.5	44.1	38.6	1064.0	4.47	0.511E 09	0.00543	10.7	11.0
3	5.5	47.3	46.1	39.0	1073.5	4.43	0.520E 09	0.00854	9.3	9.6
4	7.5	47.9	47.9	39.5	1083.1	4.38	0.528E 09	0.01166	8.5	8.7
5	10.5	48.5	47.9	40.1	1097.7	4.32	0.542E 09	0.01635	8.8	9.3
6	13.5	49.8	49.5	40.8	1112.4	4.26	0.556E 09	0.02105	8.1	8.3
7	16.5	50.0	50.0	41.4	1127.4	4.19	0.569E 09	0.02576	8.3	8.8
8	19.5	51.1	51.1	42.1	1142.5	4.13	0.583E 09	0.03048	7.9	8.2
9	22.5	51.4	51.3	42.7	1157.8	4.07	0.597E 09	0.03521	8.3	8.7
10	25.5	51.5	51.3	43.4	1173.3	4.01	0.612E 09	0.03996	8.9	9.5
11	29.5	51.9	52.9	44.3	1194.3	3.94	0.631E 09	0.04630	8.7	9.1
12	33.5	51.5	52.5	45.2	1215.7	3.86	0.651E 09	0.05266	10.4	11.3
13	37.5	53.7	55.3	46.0	1237.3	3.79	0.670E 09	0.05903	8.4	8.8
14	41.5	55.2	56.2	46.9	1259.3	3.72	0.690E 09	0.06542	8.1	8.6
15	45.5	56.3	57.8	47.8	1281.7	3.65	0.711E 09	0.07182	7.7	8.0
16	49.5	55.8	57.5	48.7	1304.3	3.58	0.731E 09	0.07822	8.8	9.6
17	54.5	57.3	58.8	49.7	1333.0	3.50	0.758E 09	0.08624	8.5	9.1
18	59.5	57.5	58.9	50.8	1352.5	3.44	0.779E 09	0.09427	9.6	10.5
19	64.5	58.8	60.3	51.9	1369.1	3.40	0.798E 09	0.10235	9.3	10.1
20	69.5	61.2	62.0	53.0	1386.3	3.35	0.817E 09	0.11046	8.1	8.8
21	74.5	61.3	62.8	54.1	1404.2	3.30	0.837E 09	0.11859	8.8	9.6
22	79.5	61.3	63.3	55.2	1422.7	3.25	0.858E 09	0.12675	9.8	11.1
23	84.5	65.2	67.0	56.3	1441.9	3.21	0.878E 09	0.13493	7.1	7.6

FULLY DEVELOPED NUSSELT NUMBER= 8.7   9.4*

RUN NUMBER (10)   TUBE NUMBER 10

INPUT POWER= 990.0 W   HEAT GAINED BY WATER= 944.4   HEAT BALANCE ERROR= 4.6%

REM= 1519.9   RAM= 0.697E 09   PR= 3.91   GR= 0.183E 08

INLET BULK TEMP= 36.3 DEG C   OUTLET BULK TEMP= 52.9 DEG C

MASS FLOW RATE= 49.0 KG/HR   PRESSURE DROP= 1786.6 PA   CF=0.0213

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	42.0	42.1	36.6	1292.4	4.67	0.515E 09	0.00183	14.5	16.6
2	3.5	45.3	42.6	37.0	1302.3	4.63	0.523E 09	0.00428	11.3	11.6
3	5.5	45.9	44.6	37.4	1312.4	4.60	0.532E 09	0.00673	10.0	10.4
4	7.5	46.5	46.5	37.7	1322.5	4.56	0.540E 09	0.00919	9.0	9.2
5	10.5	46.9	46.3	38.3	1337.8	4.50	0.552E 09	0.01288	9.5	10.0
6	13.5	48.1	47.9	38.9	1353.3	4.44	0.564E 09	0.01658	8.6	8.9
7	16.5	48.2	48.2	39.4	1369.0	4.39	0.577E 09	0.02028	9.0	9.5
8	19.5	49.1	49.1	40.0	1384.9	4.33	0.590E 09	0.02400	8.6	9.0
9	22.5	49.2	49.1	40.6	1401.0	4.28	0.603E 09	0.02772	9.1	9.6
10	25.5	49.3	49.1	41.1	1417.2	4.22	0.616E 09	0.03146	9.7	10.4
11	29.5	50.0	50.5	41.9	1439.2	4.15	0.633E 09	0.03645	9.4	9.8
12	33.5	49.7	50.0	42.6	1461.4	4.08	0.651E 09	0.04145	10.8	11.7
13	37.5	50.9	52.8	43.4	1484.0	4.01	0.669E 09	0.04646	9.2	9.7
14	41.5	52.4	53.4	44.2	1507.0	3.95	0.687E 09	0.05149	8.9	9.6
15	45.5	53.2	55.1	44.9	1530.2	3.88	0.705E 09	0.05653	8.4	8.8
16	49.5	52.7	53.8	45.7	1553.8	3.82	0.724E 09	0.06158	10.3	11.3
17	54.5	53.9	55.8	46.6	1583.7	3.74	0.748E 09	0.06790	9.4	10.1
18	59.5	54.0	55.5	47.6	1614.1	3.66	0.772E 09	0.07424	10.8	11.8
19	64.5	54.9	56.6	48.5	1644.9	3.59	0.796E 09	0.08058	10.7	11.8
20	69.5	57.4	58.3	49.5	1676.2	3.52	0.821E 09	0.08693	9.2	9.9
21	74.5	57.2	58.8	50.4	1702.4	3.46	0.843E 09	0.09327	10.2	11.2
22	79.5	57.3	59.2	51.3	1720.2	3.42	0.861E 09	0.09967	11.1	12.6
23	84.5	61.0	62.8	52.3	1738.6	3.38	0.879E 09	0.10608	8.0	8.6

FULLY DEVELOPED NUSSELT NUMBER= 9.7 10.5*

RUN NUMBER (11)   TUBE NUMBER 10

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 942.1   HEAT BALANCE ERROR= 5.8%

REM= 4291.9   RAM= 0.540E 09   PR= 4.55   GR= 0.921E 07

INLET BULK TEMP= 35.2 DEG C   OUTLET BULK TEMP= 40.3 DEG C

MASS FLOW RATE= 158.9 KG/HR   PRESSURE DROP= 3654.3 PA   CF=0.0042

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	39.5	39.9	35.3	4083.4	4.81	0.488E 09	0.00056	18.0	20.4
2	3.5	41.8	39.1	35.4	4093.0	4.80	0.490E 09	0.00132	15.8	16.4
3	5.5	41.5	40.4	35.6	4102.7	4.79	0.493E 09	0.00207	14.6	15.5
4	7.5	41.8	41.8	35.7	4112.3	4.77	0.495E 09	0.00282	12.8	13.2
5	10.5	42.3	40.8	35.8	4126.9	4.75	0.499E 09	0.00395	13.8	14.7
6	13.5	42.3	42.1	36.0	4141.5	4.74	0.502E 09	0.00508	12.7	13.2
7	16.5	42.2	42.2	36.2	4156.2	4.72	0.506E 09	0.00621	13.2	14.0
8	19.5	42.5	42.2	36.4	4171.0	4.70	0.510E 09	0.00734	13.2	13.9
9	22.5	42.3	41.9	36.5	4185.8	4.68	0.513E 09	0.00848	14.1	14.9
10	25.5	42.4	41.5	36.7	4200.6	4.66	0.517E 09	0.00961	15.0	16.0
11	29.5	42.5	42.5	37.0	4220.5	4.64	0.522E 09	0.01112	14.3	15.0
12	33.5	42.6	41.1	37.2	4240.5	4.61	0.527E 09	0.01264	16.9	18.3
13	37.5	43.8	43.8	37.4	4260.6	4.59	0.532E 09	0.01416	12.4	12.9
14	41.5	43.8	43.6	37.6	4280.8	4.56	0.537E 09	0.01567	13.0	11.3
15	45.5	****	45.1	37.9	4301.0	4.54	0.542E 09	0.01719	-3.6	-5.1
16	49.5	43.0	43.0	38.1	4321.4	4.52	0.547E 09	0.01871	16.0	14.8
17	54.5	44.6	44.6	38.4	4347.1	4.49	0.553E 09	0.02062	12.7	13.4
18	59.5	44.0	43.9	38.7	4372.8	4.46	0.560E 09	0.02252	14.8	16.0
19	64.5	44.0	44.0	39.0	4398.8	4.43	0.566E 09	0.02443	15.6	16.9
20	69.5	44.8	44.8	39.3	4424.9	4.40	0.572E 09	0.02634	14.1	15.2
21	74.5	45.1	45.0	39.6	4451.1	4.37	0.579E 09	0.02825	14.4	15.5
22	79.5	45.3	45.1	39.9	4477.5	4.34	0.585E 09	0.03017	14.7	16.1
23	84.5	48.1	47.7	40.2	4504.1	4.32	0.592E 09	0.03209	10.1	10.8

FULLY DEVELOPED NUSSELT NUMBER= 12.9   13.4*

RUN NUMBER (12)   TUBE NUMBER 10

INPUT POWER= 1495.0 W   HEAT GAINED BY WATER= 1423.7   HEAT BALANCE ERROR= 4.8%

REM= 4712.1   RAM= 0.757E 09   PR= 4.74   GR= 0.103E 08

INLET BULK TEMP= 32.6 DEG C   OUTLET BULK TEMP= 39.3 DEG C

MASS FLOW RATE= 181.0 KG/HR   PRESSURE DROP= 3669.2 PA   CF=0.0032

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	38.8	38.8	32.7	4411.4	5.10	0.658E 09	0.00049	19.5	20.9
2	3.5	39.0	38.6	32.8	4425.1	5.09	0.662E 09	0.00115	20.0	21.3
3	5.5	39.4	41.3	33.0	4438.9	5.07	0.667E 09	0.00180	16.3	16.9
4	7.5	40.7	43.3	33.1	4452.8	5.05	0.671E 09	0.00246	13.5	13.6
5	10.5	40.5	41.6	33.4	4473.6	5.03	0.678E 09	0.00345	15.6	16.5
6	13.5	41.6	44.0	33.6	4494.6	5.00	0.685E 09	0.00443	13.0	13.4
7	16.5	43.2	44.4	33.8	4515.6	4.97	0.692E 09	0.00542	12.0	12.3
8	19.5	41.9	43.6	34.1	4536.8	4.95	0.699E 09	0.00641	13.8	14.4
9	22.5	41.7	42.8	34.3	4558.1	4.92	0.706E 09	0.00740	15.0	15.6
10	25.5	41.7	42.3	34.5	4579.5	4.90	0.713E 09	0.00839	16.1	16.9
11	29.5	42.0	43.7	34.8	4608.2	4.86	0.723E 09	0.00972	14.9	15.3
12	33.5	39.7	41.5	35.2	4637.1	4.83	0.733E 09	0.01104	21.9	23.5
13	37.5	42.3	45.8	35.5	4666.2	4.79	0.742E 09	0.01237	13.9	14.3
14	41.5	43.5	45.4	35.8	4695.5	4.76	0.752E 09	0.01370	13.7	14.4
15	45.5	44.4	48.2	36.1	4725.0	4.73	0.762E 09	0.01503	11.7	11.9
16	49.5	42.8	43.9	36.4	4754.6	4.70	0.771E 09	0.01636	17.2	18.4
17	54.5	43.4	46.5	36.8	4792.0	4.66	0.784E 09	0.01803	14.6	15.3
18	59.5	42.3	45.9	37.2	4829.8	4.62	0.796E 09	0.01970	17.2	18.1
19	64.5	42.4	45.7	37.5	4867.8	4.58	0.809E 09	0.02137	18.2	19.4
20	69.5	45.5	47.3	37.9	4906.1	4.54	0.821E 09	0.02305	14.1	14.7
21	74.5	44.3	47.3	38.3	4944.8	4.50	0.834E 09	0.02473	15.9	16.9
22	79.5	44.7	47.0	38.7	4983.7	4.46	0.847E 09	0.02641	16.6	17.8
23	84.5	48.9	50.9	39.1	5023.0	4.42	0.860E 09	0.02810	11.0	11.6

FULLY DEVELOPED NUSSELT NUMBER= 15.5   16.3*

RUN NUMBER (13)   TUBE NUMBER 10

INPUT POWER= 1495.0 W   HEAT GAINED BY WATER= 1483.0   HEAT BALANCE ERROR= 0.8%

REM= 5701.4   RAM= 0.696E 09   PR= 5.06   GR= 0.839E 07

INLET BULK TEMP= 30.3 DEG C   OUTLET BULK TEMP= 35.8 DEG C

MASS FLOW RATE= 232.3 KG/HR   PRESSURE DROP= 3711.5 PA   CF=0.0020

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	37.1	38.3	30.4	5405.9	5.37	0.616E 09	0.00038	17.1	17.4
2	3.5	37.0	38.5	30.5	5419.5	5.36	0.619E 09	0.00089	17.4	17.2
3	5.5	37.0	38.8	30.6	5433.1	5.34	0.623E 09	0.00140	17.3	17.6
4	7.5	38.3	40.8	30.8	5446.8	5.33	0.627E 09	0.00191	14.3	13.8
5	10.5	38.8	39.0	30.9	5467.4	5.31	0.633E 09	0.00267	15.7	15.8
6	13.5	38.8	41.7	31.1	5488.0	5.28	0.638E 09	0.00344	13.8	13.6
7	16.5	40.7	42.0	31.3	5508.8	5.26	0.644E 09	0.00420	12.5	12.2
8	19.5	40.3	41.0	31.5	5529.6	5.24	0.649E 09	0.00497	13.7	13.5
9	22.5	39.9	40.2	31.7	5550.5	5.22	0.655E 09	0.00573	15.0	14.8
10	25.5	38.9	39.6	31.9	5571.5	5.20	0.661E 09	0.00650	17.0	17.0
11	29.5	39.2	41.1	32.1	5599.7	5.17	0.668E 09	0.00752	15.6	15.2
12	33.5	39.0	38.8	32.4	5628.0	5.14	0.676E 09	0.00855	19.2	19.2
13	37.5	39.3	43.1	32.6	5656.5	5.11	0.684E 09	0.00958	14.6	14.2
14	41.5	40.4	42.4	32.9	5685.1	5.08	0.692E 09	0.01060	14.7	14.6
15	45.5	41.2	45.3	33.1	5713.9	5.05	0.699E 09	0.01163	12.3	11.9
16	49.5	39.6	40.6	33.4	5742.9	5.02	0.707E 09	0.01266	18.6	18.7
17	54.5	40.1	43.3	33.7	5779.3	4.99	0.717E 09	0.01395	15.7	15.4
18	59.5	38.9	42.6	34.0	5816.0	4.95	0.727E 09	0.01524	18.6	18.3
19	64.5	38.8	42.3	34.3	5853.0	4.92	0.737E 09	0.01653	20.0	19.8
20	69.5	41.8	43.6	34.6	5890.2	4.88	0.747E 09	0.01783	15.5	15.1
21	74.5	40.5	43.6	35.0	5927.7	4.85	0.757E 09	0.01913	17.6	17.4
22	79.5	41.0	43.2	35.3	5965.4	4.82	0.767E 09	0.02042	18.2	18.1
23	84.5	45.2	47.1	35.6	6003.4	4.78	0.777E 09	0.02172	11.8	11.8

FULLY DEVELOPED NUSSELT NUMBER= 16.4   16.2*

RUN NUMBER (14) TUBE NUMBER 10

INPUT POWER= 1725.0 W HEAT GAINED BY WATER= 1675.8 HEAT BALANCE ERROR= 2.9%

REM= 4818.4 RAM= 0.514E 09 PR= 6.23 GR= 0.499E 07

INLET BULK TEMP= 21.3 DEG C OUTLET BULK TEMP= 27.4 DEG C

MASS FLOW RATE= 235.9 KG/HR PRESSURE DROP= 3719.1 PA CF=0.0019

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	29.2	30.3	21.4	4488.8	6.75	0.431E 09	0.00037	17.4	18.1
2	3.5	31.3	27.3	21.6	4504.2	6.72	0.435E 09	0.00085	18.6	19.2
3	5.5	30.4	29.8	21.7	4519.6	6.70	0.438E 09	0.00134	17.2	17.7
4	7.5	32.4	31.5	21.9	4535.1	6.67	0.442E 09	0.00183	14.3	14.0
5	10.5	31.5	30.8	22.1	4558.4	6.63	0.448E 09	0.00256	16.0	16.2
6	13.5	33.0	28.0	22.3	4581.6	6.59	0.454E 09	0.00330	17.6	18.4
7	16.5	35.8	33.7	22.5	4605.0	6.56	0.460E 09	0.00403	11.8	11.4
8	19.5	33.0	33.2	22.7	4628.4	6.52	0.466E 09	0.00477	13.9	14.2
9	22.5	33.2	32.3	22.9	4651.8	6.48	0.472E 09	0.00551	14.6	14.8
10	25.5	32.7	31.7	23.1	4675.2	6.45	0.478E 09	0.00625	15.9	16.2
11	29.5	32.6	33.4	23.4	4706.5	6.40	0.486E 09	0.00723	14.9	14.9
12	33.5	29.2	30.9	23.7	4737.9	6.35	0.494E 09	0.00822	22.5	23.5
13	37.5	32.5	34.8	24.0	4769.3	6.30	0.502E 09	0.00921	14.8	14.8
14	41.5	34.4	35.1	24.2	4800.7	6.25	0.510E 09	0.01020	13.7	13.9
15	45.5	34.6	37.6	24.5	4832.2	6.21	0.518E 09	0.01119	12.3	12.3
16	49.5	32.9	32.4	24.8	4863.7	6.16	0.526E 09	0.01219	18.2	18.9
17	54.5	33.5	35.6	25.1	4903.1	6.11	0.536E 09	0.01343	15.2	15.3
18	59.5	31.5	35.0	25.5	4942.5	6.05	0.547E 09	0.01468	18.5	18.9
19	64.5	31.4	34.7	25.8	4981.9	6.00	0.557E 09	0.01593	19.8	20.3
20	69.5	34.9	36.0	26.2	5021.3	5.94	0.567E 09	0.01719	15.5	15.6
21	74.5	33.1	36.3	26.5	5060.6	5.89	0.578E 09	0.01844	17.5	17.9
22	79.5	34.4	35.4	26.9	5099.9	5.84	0.588E 09	0.01970	17.8	18.2
23	84.5	36.9	36.6	27.2	5139.2	5.79	0.599E 09	0.02096	15.0	15.4

FULLY DEVELOPED NUSSELT NUMBER= 16.5 16.9*

RUN NUMBER (15)   TUBE NUMBER 10

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 711.2   HEAT BALANCE ERROR= 5.2%

REM= 1983.0   RAM= 0.353E 09   PR= 4.92   GR= 0.586E 07

INLET BULK TEMP= 30.4 DEG C   OUTLET BULK TEMP= 38.2 DEG C

MASS FLOW RATE= 78.8 KG/HR   PRESSURE DROP= 869.0 PA   CF=0.0040

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	33.4	33.4	30.5	1839.0	5.36	0.297E 09	0.00112	21.0	22.8
2	3.5	34.3	33.9	30.7	1845.5	5.34	0.300E 09	0.00262	17.6	18.5
3	5.5	35.2	35.1	30.9	1852.1	5.31	0.302E 09	0.00412	14.2	14.4
4	7.5	35.2	35.2	31.1	1858.7	5.29	0.305E 09	0.00563	14.4	15.3
5	10.5	36.0	35.7	31.3	1868.6	5.26	0.309E 09	0.00788	13.3	13.8
6	13.5	36.2	36.1	31.6	1878.6	5.23	0.313E 09	0.01014	13.2	13.9
7	16.5	36.6	36.6	31.9	1888.7	5.20	0.317E 09	0.01240	12.7	13.4
8	19.5	37.2	37.2	32.1	1898.8	5.17	0.320E 09	0.01466	11.7	12.2
9	22.5	37.5	37.4	32.4	1909.0	5.14	0.324E 09	0.01693	11.9	12.5
10	25.5	37.6	37.5	32.7	1919.3	5.11	0.328E 09	0.01920	12.3	13.1
11	29.5	38.0	38.0	33.0	1933.0	5.07	0.334E 09	0.02223	12.1	12.7
12	33.5	38.2	38.0	33.4	1946.9	5.03	0.339E 09	0.02527	12.7	13.5
13	37.5	38.6	38.6	33.7	1960.9	4.99	0.344E 09	0.02831	12.2	13.0
14	41.5	39.4	39.4	34.1	1975.0	4.95	0.350E 09	0.03135	11.2	11.9
15	45.5	40.1	40.1	34.4	1989.2	4.91	0.355E 09	0.03440	10.6	11.2
16	49.5	40.2	40.2	34.8	2003.5	4.87	0.360E 09	0.03745	11.0	11.8
17	54.5	40.3	40.3	35.2	2021.5	4.82	0.367E 09	0.04128	11.8	12.6
18	59.5	40.4	40.3	35.7	2039.8	4.77	0.374E 09	0.04511	12.7	13.7
19	64.5	40.6	40.6	36.1	2058.2	4.72	0.381E 09	0.04895	13.2	14.4
20	69.5	41.3	41.3	36.6	2076.7	4.68	0.388E 09	0.05280	12.5	13.5
21	74.5	41.5	41.4	37.0	2095.5	4.63	0.395E 09	0.05665	13.3	14.6
22	79.5	41.7	41.5	37.4	2114.5	4.59	0.402E 09	0.06051	14.3	16.0
23	84.5	43.3	43.0	37.9	2133.6	4.54	0.410E 09	0.06438	11.3	12.2

FULLY DEVELOPED NUSSELT NUMBER= 12.2   13.2*

RUN NUMBER (16) TUBE NUMBER 10

INPUT POWER= 500.0 W HEAT GAINED BY WATER= 478.0 HEAT BALANCE ERROR= 4.4%

REM= 620.6 RAM= 0.305E 09 PR= 4.27 GR= 0.115E 08

INLET BULK TEMP= 31.2 DEG C OUTLET BULK TEMP= 50.1 DEG C

MASS FLOW RATE= 21.7 KG/HR PRESSURE DROP= 108.2 PA CF=0.0066

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.8	34.8	31.5	515.8	5.24	0.209E 09	0.00409	12.2	14.0
2	3.5	36.2	36.0	31.9	520.3	5.19	0.213E 09	0.00956	9.6	10.0
3	5.5	37.2	37.4	32.3	524.8	5.14	0.217E 09	0.01504	8.2	8.3
4	7.5	37.8	38.0	32.8	529.4	5.09	0.221E 09	0.02052	7.8	8.4
5	10.5	39.2	39.1	33.4	536.4	5.02	0.228E 09	0.02878	7.0	7.3
6	13.5	39.8	39.9	34.1	543.5	4.95	0.234E 09	0.03706	6.9	7.3
7	16.5	40.4	40.7	34.7	550.6	4.88	0.241E 09	0.04536	6.8	7.3
8	19.5	41.4	41.7	35.4	557.9	4.81	0.248E 09	0.05368	6.5	6.8
9	22.5	42.2	42.4	36.0	565.3	4.74	0.255E 09	0.06203	6.4	6.7
10	25.5	42.6	42.7	36.7	572.8	4.67	0.262E 09	0.07041	6.6	7.2
11	29.5	43.6	44.1	37.5	582.9	4.58	0.271E 09	0.08160	6.3	6.7
12	33.5	43.9	44.2	38.4	593.2	4.49	0.280E 09	0.09284	7.0	7.7
13	37.5	45.3	45.6	39.3	603.7	4.40	0.290E 09	0.10412	6.4	6.9
14	41.5	46.6	46.8	40.1	614.5	4.32	0.300E 09	0.11544	6.0	6.5
15	45.5	47.6	48.0	41.0	625.4	4.24	0.310E 09	0.12679	5.8	6.2
16	49.5	47.8	48.5	41.9	636.4	4.15	0.320E 09	0.13817	6.3	7.0
17	54.5	49.1	49.6	42.9	650.6	4.06	0.333E 09	0.15245	6.2	6.7
18	59.5	49.8	50.1	44.0	665.0	3.96	0.346E 09	0.16676	6.7	7.5
19	64.5	51.1	51.5	45.1	679.7	3.87	0.359E 09	0.18112	6.4	7.1
20	69.5	52.8	53.0	46.2	694.7	3.78	0.373E 09	0.19551	5.8	6.4
21	74.5	53.6	53.7	47.3	710.0	3.69	0.387E 09	0.20993	6.1	6.9
22	79.5	54.6	54.7	48.3	725.5	3.60	0.401E 09	0.22436	6.2	7.1
23	84.5	57.2	56.5	49.4	741.3	3.52	0.415E 09	0.23881	5.2	5.7

FULLY DEVELOPED NUSSELT NUMBER= 6.2 6.8*

RUN NUMBER (17)   TUBE NUMBER 10

INPUT POWER= 240.0 W   HEAT GAINED BY WATER= 236.5   HEAT BALANCE ERROR= 1.5%

REM= 611.3   RAM= 0.112E 09   PR= 5.04   GR= 0.335E 07

INLET BULK TEMP= 29.2 DEG C   OUTLET BULK TEMP= 37.4 DEG C

MASS FLOW RATE= 24.8 KG/HR   PRESSURE DROP= 147.2 PA   CF=0.0069

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	30.8	30.8	29.3	564.5	5.50	0.933E 08	0.00356	13.3	15.8
2	3.5	33.0	31.3	29.5	566.7	5.48	0.941E 08	0.00832	7.5	6.6
3	5.5	32.9	31.9	29.7	568.8	5.46	0.949E 08	0.01308	7.4	8.3
4	7.5	35.0	32.2	29.9	571.0	5.43	0.958E 08	0.01784	5.4	5.0
5	10.5	35.0	32.7	30.2	574.3	5.40	0.970E 08	0.02499	5.4	5.3
6	13.5	34.0	33.1	30.4	577.5	5.37	0.984E 08	0.03215	6.5	6.6
7	16.5	34.2	33.4	30.7	580.8	5.33	0.997E 08	0.03932	6.5	6.8
8	19.5	35.6	33.8	31.0	584.1	5.30	0.101E 09	0.04649	5.3	5.3
9	22.5	37.1	34.1	31.3	587.4	5.27	0.102E 09	0.05368	4.6	4.3
10	25.5	35.9	34.3	31.6	590.7	5.23	0.104E 09	0.06088	5.6	5.7
11	29.5	34.7	35.0	31.9	595.1	5.19	0.105E 09	0.07049	6.9	6.9
12	33.5	34.8	35.0	32.3	599.6	5.15	0.107E 09	0.08012	7.6	7.8
13	37.5	35.5	35.6	32.7	604.2	5.10	0.109E 09	0.08977	6.9	6.9
14	41.5	36.1	36.2	33.1	608.7	5.06	0.111E 09	0.09943	6.5	6.5
15	45.5	36.5	36.6	33.4	613.4	5.02	0.113E 09	0.10910	6.4	6.3
16	49.5	36.7	36.9	33.8	618.0	4.98	0.115E 09	0.11880	6.7	6.8
17	54.5	37.2	37.4	34.3	623.9	4.92	0.117E 09	0.13094	6.5	6.5
18	59.5	37.5	37.6	34.8	629.8	4.87	0.119E 09	0.14311	7.1	7.1
19	64.5	37.9	38.2	35.2	635.8	4.82	0.122E 09	0.15530	7.0	7.1
20	69.5	38.7	38.8	35.7	641.8	4.77	0.124E 09	0.16751	6.4	6.4
21	74.5	39.1	39.1	36.2	648.0	4.72	0.127E 09	0.17975	6.7	6.7
22	79.5	39.6	39.6	36.6	654.1	4.67	0.129E 09	0.19202	6.7	6.7
23	84.5	40.5	40.4	37.1	660.4	4.62	0.132E 09	0.20430	5.9	6.0

FULLY DEVELOPED NUSSELT NUMBER= 6.6 6.7*

RUN NUMBER (18)   TUBE NUMBER 10

INPUT POWER= 500.0 W   HEAT GAINED BY WATER= 486.6   HEAT BALANCE ERROR= 2.7%

REM= 676.4   RAM= 0.278E 09   PR= 4.56   GR= 0.880E 07

INLET BULK TEMP= 29.4 DEG C   OUTLET BULK TEMP= 46.0 DEG C

MASS FLOW RATE= 25.1 KG/HR   PRESSURE DROP= 139.2 PA   CF=0.0064

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	32.8	32.7	29.7	575.0	5.46	0.195E 09	0.00352	13.3	14.9
2	3.5	33.9	33.8	30.0	579.5	5.42	0.198E 09	0.00823	10.8	11.2
3	5.5	35.0	35.2	30.4	583.9	5.37	0.202E 09	0.01294	8.8	8.7
4	7.5	35.5	35.7	30.8	588.4	5.32	0.206E 09	0.01767	8.5	8.9
5	10.5	36.7	36.6	31.4	595.2	5.26	0.211E 09	0.02477	7.7	7.8
6	13.5	37.3	37.4	31.9	602.0	5.19	0.217E 09	0.03188	7.6	7.7
7	16.5	37.8	38.1	32.5	609.0	5.12	0.223E 09	0.03902	7.6	7.8
8	19.5	38.7	39.0	33.1	616.0	5.06	0.228E 09	0.04618	7.1	7.2
9	22.5	39.3	39.5	33.6	623.2	4.99	0.234E 09	0.05335	7.1	7.2
10	25.5	39.7	39.8	34.2	630.4	4.93	0.240E 09	0.06054	7.4	7.7
11	29.5	40.6	41.1	35.0	640.2	4.85	0.248E 09	0.07016	7.0	7.1
12	33.5	40.8	41.1	35.7	650.1	4.76	0.256E 09	0.07981	7.8	8.2
13	37.5	42.0	42.4	36.5	660.2	4.68	0.265E 09	0.08950	7.1	7.4
14	41.5	43.3	43.5	37.3	670.5	4.60	0.273E 09	0.09921	6.6	6.8
15	45.5	44.0	44.6	38.0	680.9	4.53	0.281E 09	0.10895	6.5	6.6
16	49.5	44.3	44.9	38.8	691.6	4.45	0.290E 09	0.11873	7.0	7.3
17	54.5	45.4	45.8	39.7	705.1	4.36	0.301E 09	0.13098	6.9	7.1
18	59.5	46.1	46.3	40.7	718.8	4.26	0.312E 09	0.14328	7.4	7.7
19	64.5	47.0	47.5	41.6	732.9	4.17	0.323E 09	0.15562	7.2	7.5
20	69.5	48.6	48.8	42.6	747.2	4.09	0.335E 09	0.16799	6.6	6.9
21	74.5	49.4	49.5	43.5	761.8	4.00	0.346E 09	0.18040	6.8	7.1
22	79.5	50.3	50.4	44.5	776.6	3.92	0.358E 09	0.19284	6.8	7.2
23	84.5	52.5	52.1	45.5	791.7	3.84	0.370E 09	0.20531	5.8	6.1

FULLY DEVELOPED NUSSELT NUMBER= 6.9 7.2*

RUN NUMBER (19)   TUBE NUMBER 10

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 706.4   HEAT BALANCE ERROR= 5.8%

REM= 732.8   RAM= 0.469E 09   PR= 4.17   GR= 0.164E 08

INLET BULK TEMP= 29.5 DEG C   OUTLET BULK TEMP= 53.7 DEG C

MASS FLOW RATE= 25.1 KG/HR   PRESSURE DROP= 134.4 PA   CF=0.0061

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.6	34.6	30.0	578.6	5.42	0.287E 09	0.00353	12.9	14.9
2	3.5	36.0	36.2	30.5	585.1	5.36	0.295E 09	0.00824	10.7	11.5
3	5.5	37.6	38.1	31.1	591.6	5.29	0.303E 09	0.01296	8.8	9.0
4	7.5	38.4	39.0	31.6	598.2	5.23	0.310E 09	0.01770	8.4	9.2
5	10.5	40.2	40.3	32.4	608.3	5.13	0.322E 09	0.02483	7.6	8.1
6	13.5	41.0	41.4	33.3	618.5	5.04	0.335E 09	0.03198	7.5	8.0
7	16.5	41.8	42.4	34.1	629.0	4.94	0.347E 09	0.03917	7.4	8.1
8	19.5	43.2	43.8	34.9	639.6	4.85	0.360E 09	0.04637	6.9	7.4
9	22.5	44.0	44.5	35.8	650.4	4.76	0.372E 09	0.05361	7.0	7.5
10	25.5	44.3	44.8	36.6	661.4	4.67	0.385E 09	0.06087	7.4	8.3
11	29.5	45.9	46.9	37.7	676.4	4.56	0.403E 09	0.07059	6.8	7.3
12	33.5	46.1	46.9	38.8	691.8	4.45	0.421E 09	0.08035	7.6	8.6
13	37.5	48.0	48.7	39.9	707.5	4.34	0.440E 09	0.09016	7.0	7.7
14	41.5	49.8	50.4	41.0	723.6	4.23	0.458E 09	0.10000	6.5	7.2
15	45.5	50.9	51.8	42.1	740.0	4.13	0.478E 09	0.10988	6.3	7.0
16	49.5	51.1	52.2	43.2	756.8	4.03	0.497E 09	0.11979	6.9	7.9
17	54.5	52.6	53.5	44.6	778.3	3.91	0.522E 09	0.13222	6.9	7.8
18	59.5	53.6	54.1	46.0	800.4	3.79	0.547E 09	0.14469	7.4	8.6
19	64.5	55.1	55.9	47.4	822.9	3.68	0.573E 09	0.15719	7.1	8.3
20	69.5	57.5	57.8	48.8	846.0	3.57	0.600E 09	0.16970	6.5	7.5
21	74.5	58.3	58.8	50.1	868.8	3.47	0.627E 09	0.18217	6.9	8.1
22	79.5	59.6	59.8	51.5	882.1	3.41	0.646E 09	0.19478	7.0	8.5
23	84.5	63.1	62.4	52.9	896.0	3.36	0.667E 09	0.20744	5.8	6.5

FULLY DEVELOPED NUSSELT NUMBER= 6.9   7.8*

RUN NUMBER (20)   TUBE NUMBER 10

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 749.6   HEAT BALANCE ERROR= 0.0%

REM= 1042.8   RAM= 0.437E 09   PR= 4.51   GR= 0.107E 08

INLET BULK TEMP= 29.8 DEG C   OUTLET BULK TEMP= 46.6 DEG C

MASS FLOW RATE= 38.3 KG/HR   PRESSURE DROP= 247.5 PA   CF=0.0049

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.0	34.0	30.1	885.1	5.41	0.307E 09	0.00231	16.3	17.1
2	3.5	34.9	35.1	30.5	891.9	5.36	0.312E 09	0.00540	14.0	14.1
3	5.5	36.1	36.6	30.9	898.8	5.32	0.318E 09	0.00849	11.5	11.0
4	7.5	36.7	37.2	31.2	905.7	5.27	0.324E 09	0.01159	11.1	11.1
5	10.5	38.0	38.2	31.8	916.3	5.20	0.333E 09	0.01625	10.1	9.9
6	13.5	38.6	39.0	32.4	927.0	5.14	0.342E 09	0.02092	9.8	9.6
7	16.5	39.2	39.8	33.0	937.8	5.07	0.351E 09	0.02561	9.7	9.6
8	19.5	40.3	40.9	33.6	948.8	5.01	0.360E 09	0.03031	9.0	8.7
9	22.5	40.9	41.4	34.1	959.9	4.94	0.369E 09	0.03501	9.0	8.7
10	25.5	41.1	41.6	34.7	971.2	4.88	0.378E 09	0.03973	9.5	9.4
11	29.5	42.0	43.0	35.5	986.4	4.79	0.391E 09	0.04605	8.9	8.6
12	33.5	42.6	43.0	36.2	1001.9	4.71	0.404E 09	0.05238	9.6	9.4
13	37.5	43.4	44.1	37.0	1017.7	4.63	0.417E 09	0.05874	9.3	9.0
14	41.5	44.9	45.5	37.8	1033.7	4.55	0.430E 09	0.06511	8.5	8.2
15	45.5	45.7	46.7	38.6	1050.0	4.47	0.443E 09	0.07151	8.2	7.9
16	49.5	45.8	47.0	39.3	1066.5	4.40	0.456E 09	0.07792	8.8	8.6
17	54.5	46.6	47.5	40.3	1087.6	4.30	0.474E 09	0.08597	9.2	8.8
18	59.5	47.2	47.8	41.3	1109.1	4.21	0.491E 09	0.09404	10.0	9.6
19	64.5	48.4	49.1	42.2	1131.0	4.12	0.509E 09	0.10213	9.5	9.1
20	69.5	50.2	50.6	43.2	1153.3	4.03	0.527E 09	0.11025	8.6	8.1
21	74.5	50.5	51.1	44.1	1176.0	3.95	0.545E 09	0.11839	9.2	8.8
22	79.5	51.5	51.7	45.1	1199.1	3.87	0.564E 09	0.12655	9.5	9.1
23	84.5	54.4	53.7	46.1	1222.6	3.79	0.583E 09	0.13472	7.7	7.6

FULLY DEVELOPED NUSSELT NUMBER= 9.0 8.7*

RUN NUMBER (21) TUBE NUMBER 10

INPUT POWER= 750.0 W HEAT GAINED BY WATER= 742.1 HEAT BALANCE ERROR= 1.0%

REM= 1319.2 RAM= 0.405E 09 PR= 4.68 GR= 0.841E 07

INLET BULK TEMP= 30.2 DEG C OUTLET BULK TEMP= 42.9 DEG C

MASS FLOW RATE= 50.1 KG/HR PRESSURE DROP= 387.0 PA CF=0.0044

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	33.9	33.9	30.4	1165.3	5.37	0.308E 09	0.00177	17.9	18.8
2	3.5	34.6	34.8	30.7	1172.1	5.34	0.313E 09	0.00413	15.6	15.8
3	5.5	35.7	36.1	31.0	1178.9	5.30	0.317E 09	0.00649	12.7	12.3
4	7.5	36.0	36.5	31.3	1185.8	5.27	0.321E 09	0.00886	12.6	12.7
5	10.5	37.1	37.3	31.7	1196.3	5.22	0.328E 09	0.01242	11.5	11.3
6	13.5	37.5	37.9	32.1	1206.8	5.17	0.335E 09	0.01598	11.3	11.3
7	16.5	37.9	38.5	32.6	1217.5	5.12	0.341E 09	0.01955	11.1	11.1
8	19.5	38.9	39.5	33.0	1228.2	5.07	0.348E 09	0.02313	10.1	10.0
9	22.5	39.3	39.8	33.5	1239.1	5.02	0.355E 09	0.02672	10.2	10.1
10	25.5	39.8	40.0	33.9	1250.1	4.97	0.362E 09	0.03031	10.4	10.4
11	29.5	40.2	41.3	34.5	1264.9	4.90	0.371E 09	0.03511	9.9	9.8
12	33.5	40.4	41.1	35.1	1279.8	4.84	0.380E 09	0.03993	10.9	10.9
13	37.5	41.2	41.8	35.6	1295.0	4.78	0.390E 09	0.04475	10.6	10.5
14	41.5	42.5	43.0	36.2	1310.4	4.71	0.399E 09	0.04959	9.5	9.4
15	45.5	43.1	44.0	36.8	1326.0	4.65	0.409E 09	0.05444	9.3	9.1
16	49.5	43.1	44.2	37.4	1341.7	4.59	0.419E 09	0.05930	9.9	9.8
17	54.5	43.6	44.5	38.1	1361.7	4.52	0.431E 09	0.06540	10.4	10.3
18	59.5	43.9	44.7	38.8	1382.0	4.44	0.444E 09	0.07151	11.3	11.2
19	64.5	44.7	45.5	39.6	1402.6	4.37	0.456E 09	0.07764	11.1	11.0
20	69.5	46.3	46.6	40.3	1423.5	4.30	0.469E 09	0.08378	10.0	9.8
21	74.5	46.5	47.0	41.0	1444.7	4.23	0.482E 09	0.08994	10.8	10.6
22	79.5	47.1	47.4	41.8	1466.3	4.16	0.496E 09	0.09612	11.1	11.0
23	84.5	49.8	49.2	42.5	1488.1	4.10	0.509E 09	0.10231	8.7	8.8

FULLY DEVELOPED NUSSELT NUMBER= 10.3 10.2*

RUN NUMBER (22)   TUBE NUMBER 10

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 947.5   HEAT BALANCE ERROR= 5.3%

REM= 3254.4   RAM= 0.455E 09   PR= 5.00   GR= 0.663E 07

INLET BULK TEMP= 30.4 DEG C   OUTLET BULK TEMP= 36.7 DEG C

MASS FLOW RATE= 131.2 KG/HR   PRESSURE DROP= 1998.8 PA   CF=0.0033

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	33.9	34.0	30.6	3064.0	5.35	0.397E 09	0.00067	23.3	25.0
2	3.5	34.8	34.4	30.7	3072.7	5.34	0.400E 09	0.00158	20.6	21.7
3	5.5	35.8	35.7	30.8	3081.5	5.32	0.402E 09	0.00248	16.4	16.5
4	7.5	35.8	35.7	31.0	3090.3	5.30	0.405E 09	0.00338	16.8	17.7
5	10.5	36.5	36.1	31.2	3103.5	5.28	0.409E 09	0.00473	15.7	16.3
6	13.5	36.6	36.4	31.4	3116.7	5.25	0.413E 09	0.00609	15.8	16.6
7	16.5	37.2	37.1	31.6	3130.1	5.23	0.417E 09	0.00744	14.4	15.1
8	19.5	37.8	37.8	31.8	3143.5	5.20	0.421E 09	0.00880	13.5	14.1
9	22.5	37.9	37.9	32.0	3157.0	5.18	0.425E 09	0.01016	13.7	14.3
10	25.5	38.1	38.0	32.3	3170.5	5.15	0.430E 09	0.01152	13.8	14.7
11	29.5	38.9	40.6	32.5	3188.7	5.12	0.435E 09	0.01334	11.1	11.4
12	33.5	39.0	38.7	32.8	3206.9	5.09	0.441E 09	0.01515	13.2	14.0
13	37.5	39.2	39.0	33.1	3225.3	5.06	0.446E 09	0.01697	13.3	14.0
14	41.5	39.7	39.7	33.4	3243.8	5.02	0.452E 09	0.01880	12.8	13.4
15	45.5	39.9	39.8	33.7	3262.5	4.99	0.458E 09	0.02062	12.9	13.6
16	49.5	39.9	40.0	34.0	3281.2	4.96	0.463E 09	0.02245	13.3	14.1
17	54.5	40.0	39.9	34.3	3304.8	4.92	0.471E 09	0.02474	14.1	15.0
18	59.5	40.1	40.0	34.7	3328.6	4.88	0.478E 09	0.02703	14.9	15.9
19	64.5	40.6	40.6	35.0	3352.6	4.84	0.485E 09	0.02932	14.2	15.1
20	69.5	40.9	40.9	35.4	3376.7	4.80	0.493E 09	0.03162	14.5	15.5
21	74.5	41.0	41.0	35.7	3401.1	4.77	0.500E 09	0.03392	15.2	16.3
22	79.5	41.3	41.1	36.1	3425.6	4.73	0.507E 09	0.03623	15.6	16.9
23	84.5	42.5	42.3	36.4	3450.3	4.69	0.515E 09	0.03854	13.3	14.3

FULLY DEVELOPED NUSSELT NUMBER= 13.7   14.6*

RUN NUMBER (23)   TUBE NUMBER 10

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 951.7   HEAT BALANCE ERROR= 4.8%

REM= 6190.7   RAM= 0.854E 09   PR= 3.46   GR= 0.149E 08

INLET BULK TEMP= 48.3 DEG C   OUTLET BULK TEMP= 52.9 DEG C

MASS FLOW RATE= 177.8 KG/HR   PRESSURE DROP= 2587.6 PA   CF=0.0023

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	51.1	51.2	48.4	5952.0	3.60	0.800E 09	0.00052	28.1	30.2
2	3.5	52.2	51.5	48.5	5964.6	3.59	0.802E 09	0.00120	23.0	23.9
3	5.5	52.8	52.7	48.6	5977.1	3.59	0.805E 09	0.00189	18.7	18.8
4	7.5	52.7	52.7	48.7	5989.7	3.58	0.808E 09	0.00258	19.4	20.4
5	10.5	53.6	53.0	48.8	6008.6	3.57	0.812E 09	0.00362	17.6	18.1
6	13.5	53.5	53.2	49.0	6027.5	3.55	0.816E 09	0.00465	17.9	18.7
7	16.5	54.0	54.0	49.1	6046.5	3.54	0.820E 09	0.00568	16.2	16.8
8	19.5	54.4	54.4	49.3	6065.5	3.53	0.825E 09	0.00672	15.2	15.8
9	22.5	54.5	54.4	49.5	6084.6	3.52	0.829E 09	0.00775	15.6	16.2
10	25.5	54.5	54.3	49.6	6103.7	3.51	0.833E 09	0.00879	16.3	17.1
11	29.5	54.8	54.8	49.8	6129.3	3.49	0.838E 09	0.01017	15.7	16.3
12	33.5	54.7	54.3	50.0	6154.4	3.48	0.844E 09	0.01155	17.4	18.2
13	37.5	55.0	55.0	50.3	6168.5	3.47	0.848E 09	0.01293	16.5	17.2
14	41.5	55.1	55.1	50.5	6182.6	3.46	0.852E 09	0.01432	16.7	17.5
15	45.5	55.5	55.5	50.7	6196.9	3.45	0.856E 09	0.01570	16.2	16.9
16	49.5	55.4	55.5	50.9	6211.3	3.44	0.860E 09	0.01709	17.0	17.9
17	54.5	55.5	55.4	51.1	6229.4	3.43	0.865E 09	0.01882	18.0	19.0
18	59.5	55.6	55.4	51.4	6247.6	3.42	0.870E 09	0.02055	18.8	19.9
19	64.5	56.2	56.1	51.7	6266.0	3.41	0.876E 09	0.02229	17.4	18.4
20	69.5	56.9	56.8	51.9	6284.6	3.40	0.881E 09	0.02403	15.8	16.6
21	74.5	57.1	56.9	52.2	6303.3	3.39	0.886E 09	0.02576	16.1	17.0
22	79.5	57.2	56.8	52.5	6322.2	3.37	0.891E 09	0.02750	17.0	18.1
23	84.5	58.5	57.8	52.7	6341.2	3.36	0.896E 09	0.02925	14.3	15.1

FULLY DEVELOPED NUSSELT NUMBER= 16.6   17.5*

RUN NUMBER (24) TUBE NUMBER 10

INPUT POWER= 1500.0 W HEAT GAINED BY WATER= 1399.4 HEAT BALANCE ERROR= 6.7%

REM= 6373.4 RAM= 0.133E 10 PR= 3.34 GR= 0.286E 08

INLET BULK TEMP= 49.8 DEG C OUTLET BULK TEMP= 56.5 DEG C

MASS FLOW RATE= 177.8 KG/HR PRESSURE DROP= 2526.1 PA CF=0.0023

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	54.1	54.2	49.9	6137.4	3.49	0.124E 10	0.00052	26.9	29.5
2	3.5	55.4	54.7	50.1	6155.1	3.48	0.124E 10	0.00121	22.9	24.6
3	5.5	56.8	56.7	50.2	6165.5	3.47	0.125E 10	0.00190	17.4	17.9
4	7.5	56.9	57.0	50.4	6175.8	3.46	0.125E 10	0.00259	17.4	18.5
5	10.5	58.1	57.6	50.6	6191.5	3.45	0.126E 10	0.00362	15.8	16.6
6	13.5	58.1	57.9	50.8	6207.3	3.44	0.126E 10	0.00466	15.9	17.0
7	16.5	59.2	59.2	51.1	6223.2	3.43	0.127E 10	0.00570	14.0	14.8
8	19.5	59.8	59.8	51.3	6239.3	3.42	0.128E 10	0.00674	13.4	14.1
9	22.5	59.9	59.8	51.5	6255.4	3.41	0.128E 10	0.00777	13.7	14.6
10	25.5	59.9	59.7	51.8	6271.7	3.40	0.129E 10	0.00881	14.2	15.2
11	29.5	60.4	60.4	52.1	6293.6	3.39	0.130E 10	0.01020	13.7	14.6
12	33.5	60.3	59.9	52.4	6315.7	3.38	0.131E 10	0.01159	14.7	15.9
13	37.5	60.8	60.8	52.7	6338.0	3.36	0.132E 10	0.01298	14.1	15.1
14	41.5	61.7	61.7	53.0	6360.6	3.35	0.133E 10	0.01437	13.1	14.0
15	45.5	62.3	62.2	53.3	6383.4	3.34	0.133E 10	0.01576	12.7	13.7
16	49.5	62.1	62.2	53.6	6406.5	3.32	0.134E 10	0.01715	13.3	14.4
17	54.5	62.2	62.1	54.0	6435.6	3.31	0.135E 10	0.01890	13.9	15.1
18	59.5	62.4	62.2	54.4	6465.1	3.29	0.137E 10	0.02064	14.3	15.5
19	64.5	62.5	62.4	54.8	6495.0	3.27	0.138E 10	0.02239	14.7	16.0
20	69.5	63.5	63.4	55.2	6525.3	3.26	0.139E 10	0.02414	13.7	14.9
21	74.5	63.6	63.3	55.5	6556.0	3.24	0.140E 10	0.02589	14.4	15.7
22	79.5	63.8	63.3	55.9	6587.1	3.22	0.141E 10	0.02764	14.9	16.4
23	84.5	65.5	64.7	56.3	6618.6	3.21	0.142E 10	0.02940	12.9	14.1

FULLY DEVELOPED NUSSELT NUMBER= 13.9 15.0*

RUN NUMBER (25) TUBE NUMBER 10

INPUT POWER= 1500.0 W HEAT GAINED BY WATER= 1430.7 HEAT BALANCE ERROR= 4.6%

REM= 8281.6 RAM= 0.133E 10 PR= 3.38 GR= 0.252E 08

INLET BULK TEMP= 49.6 DEG C OUTLET BULK TEMP= 54.9 DEG C

MASS FLOW RATE= 233.5 KG/HR PRESSURE DROP= 3503.3 PA CF=0.0018

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	53.7	53.8	49.7	8028.1	3.50	0.126E 10	0.00039	29.0	30.9
2	3.5	54.8	54.1	49.8	8047.3	3.49	0.126E 10	0.00092	25.4	26.7
3	5.5	56.1	56.0	49.9	8066.5	3.48	0.127E 10	0.00144	19.3	19.3
4	7.5	56.1	56.1	50.1	8083.5	3.48	0.127E 10	0.00197	19.4	20.2
5	10.5	57.2	56.6	50.2	8099.3	3.47	0.127E 10	0.00276	17.6	18.1
6	13.5	57.2	56.9	50.4	8115.3	3.46	0.128E 10	0.00355	17.6	18.4
7	16.5	58.2	58.2	50.6	8131.4	3.45	0.129E 10	0.00434	15.4	15.8
8	19.5	58.7	58.7	50.8	8147.5	3.45	0.129E 10	0.00513	14.8	15.3
9	22.5	58.9	58.8	51.0	8163.7	3.44	0.130E 10	0.00592	14.9	15.4
10	25.5	58.8	58.6	51.2	8180.1	3.43	0.130E 10	0.00671	15.4	16.0
11	29.5	59.1	59.1	51.4	8202.0	3.42	0.131E 10	0.00776	15.1	15.6
12	33.5	59.1	58.6	51.6	8224.1	3.41	0.132E 10	0.00882	16.2	16.8
13	37.5	59.3	59.3	51.9	8246.4	3.40	0.132E 10	0.00987	15.7	16.3
14	41.5	59.5	59.5	52.1	8268.8	3.39	0.133E 10	0.01093	15.7	16.4
15	45.5	60.0	59.9	52.4	8291.5	3.38	0.134E 10	0.01199	15.3	15.9
16	49.5	60.1	60.2	52.6	8314.3	3.37	0.134E 10	0.01304	15.4	16.1
17	54.5	60.3	60.3	52.9	8343.1	3.36	0.135E 10	0.01437	15.7	16.4
18	59.5	60.7	60.5	53.2	8372.1	3.34	0.136E 10	0.01569	15.7	16.4
19	64.5	60.8	60.7	53.5	8401.5	3.33	0.137E 10	0.01702	16.0	16.7
20	69.5	61.3	61.3	53.8	8431.1	3.32	0.138E 10	0.01835	15.4	16.1
21	74.5	61.4	61.1	54.1	8461.1	3.30	0.139E 10	0.01967	16.2	17.0
22	79.5	61.4	61.0	54.4	8491.3	3.29	0.140E 10	0.02100	17.1	18.0
23	84.5	63.1	62.4	54.7	8521.9	3.28	0.141E 10	0.02233	14.4	15.1

FULLY DEVELOPED NUSSELT NUMBER= 15.7 16.4*

RUN NUMBER (26) TUBE NUMBER 10

INPUT POWER= 1000.0 W HEAT GAINED BY WATER= 999.2 HEAT BALANCE ERROR= 0.1%

REM= 4735.0 RAM= 0.401E 09 PR= 5.46 GR= 0.358E 07

INLET BULK TEMP= 27.6 DEG C OUTLET BULK TEMP= 31.7 DEG C

MASS FLOW RATE= 206.6 KG/HR PRESSURE DROP= 3024.9 PA CF=0.0020

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	30.5	30.6	27.6	4539.8	5.73	0.364E 09	0.00043	29.5	30.1
2	3.5	31.1	30.8	27.7	4549.1	5.72	0.366E 09	0.00099	26.4	26.4
3	5.5	32.0	32.0	27.8	4558.4	5.71	0.368E 09	0.00156	20.3	19.4
4	7.5	31.9	31.9	27.9	4567.7	5.69	0.369E 09	0.00213	21.3	21.1
5	10.5	32.5	32.2	28.1	4581.7	5.67	0.372E 09	0.00298	20.0	19.6
6	13.5	32.6	32.5	28.2	4595.6	5.65	0.375E 09	0.00384	19.6	19.3
7	16.5	33.2	33.2	28.3	4609.6	5.63	0.377E 09	0.00469	17.6	17.2
8	19.5	33.5	33.5	28.5	4623.5	5.61	0.380E 09	0.00554	16.9	16.5
9	22.5	33.6	33.6	28.6	4637.3	5.60	0.382E 09	0.00640	17.0	16.6
10	25.5	33.1	33.1	28.8	4651.2	5.58	0.385E 09	0.00726	19.7	19.6
11	29.5	34.4	34.4	29.0	4669.7	5.55	0.388E 09	0.00840	15.5	14.9
12	33.5	32.1	32.3	29.2	4688.0	5.53	0.392E 09	0.00954	28.1	28.1
13	37.5	32.8	34.1	29.3	4706.4	5.50	0.395E 09	0.01069	20.8	20.2
14	41.5	34.0	34.9	29.5	4724.7	5.48	0.399E 09	0.01183	17.2	16.8
15	45.5	34.2	35.7	29.7	4742.9	5.45	0.402E 09	0.01298	16.1	15.6
16	49.5	33.2	34.9	29.9	4761.1	5.43	0.406E 09	0.01413	20.3	20.0
17	54.5	33.6	34.8	30.1	4784.8	5.40	0.410E 09	0.01556	20.7	20.1
18	59.5	33.5	34.4	30.4	4807.6	5.37	0.415E 09	0.01700	23.9	23.3
19	64.5	33.6	34.8	30.6	4830.5	5.34	0.420E 09	0.01844	23.6	23.0
20	69.5	35.0	35.4	30.9	4853.5	5.32	0.425E 09	0.01988	19.4	18.8
21	74.5	34.5	35.4	31.1	4876.6	5.29	0.429E 09	0.02132	22.1	21.4
22	79.5	34.4	35.1	31.3	4899.9	5.26	0.434E 09	0.02276	24.7	24.1
23	84.5	37.9	36.6	31.6	4923.3	5.23	0.439E 09	0.02421	14.9	14.7

FULLY DEVELOPED NUSSELT NUMBER= 20.5 20.0*

RUN NUMBER (1)   TUBE NUMBER 13

INPUT POWER= 500.0 W   HEAT GAINED BY WATER= 475.4   HEAT BALANCE ERROR= 4.9%

REM= 1049.4   RAM= 0.934E 09   PR= 5.04   GR= 0.138E 08

INLET BULK TEMP= 25.1 DEG C   OUTLET BULK TEMP= 41.3 DEG C

MASS FLOW RATE= 25.1 KG/HR   PRESSURE DROP= 1276.9 PA   CF=0.0397

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	30.8	31.4	25.4	890.8	6.06	0.641E 09	0.00164	15.2	18.7
2	3.5	31.6	31.9	25.8	898.4	6.01	0.654E 09	0.00383	14.4	15.2
3	5.5	32.3	32.7	26.1	906.0	5.95	0.667E 09	0.00602	13.6	14.4
4	7.5	32.7	33.5	26.5	913.5	5.89	0.680E 09	0.00822	13.0	13.7
5	10.5	33.4	34.0	27.1	924.8	5.81	0.700E 09	0.01153	13.0	13.8
6	13.5	33.8	34.6	27.6	936.1	5.73	0.720E 09	0.01484	13.0	13.9
7	16.5	34.2	35.2	28.2	947.4	5.66	0.739E 09	0.01817	13.2	13.8
8	19.5	34.5	34.8	28.7	958.5	5.58	0.759E 09	0.02151	14.5	16.1
9	22.5	35.6	35.6	29.3	969.6	5.51	0.779E 09	0.02485	13.6	14.6
10	25.5	36.4	36.7	29.9	980.6	5.44	0.799E 09	0.02821	12.8	13.8
11	29.5	36.7	37.7	30.6	995.5	5.35	0.828E 09	0.03269	12.9	14.0
12	33.5	37.7	38.5	31.3	1010.4	5.26	0.858E 09	0.03718	12.6	13.6
13	37.5	38.0	38.9	32.1	1025.5	5.17	0.887E 09	0.04170	13.4	14.8
14	41.5	39.0	39.8	32.8	1040.9	5.09	0.918E 09	0.04622	13.0	14.1
15	45.5	39.0	40.0	33.6	1056.6	5.00	0.949E 09	0.05077	14.3	16.3
16	49.5	40.4	41.7	34.3	1072.5	4.92	0.980E 09	0.05532	12.6	13.8
17	54.5	41.2	42.1	35.2	1092.8	4.82	0.102E 10	0.06104	13.3	14.9
18	59.5	42.0	42.9	36.2	1113.5	4.72	0.106E 10	0.06678	13.4	15.0
19	64.5	42.7	43.4	37.1	1134.6	4.62	0.110E 10	0.07254	14.0	15.9
20	69.5	43.1	44.1	38.0	1156.2	4.53	0.114E 10	0.07832	15.0	17.6
21	74.5	44.7	45.4	38.9	1178.2	4.43	0.119E 10	0.08412	13.7	15.7
22	79.5	45.3	46.4	39.9	1200.6	4.34	0.123E 10	0.08995	14.0	16.4
23	84.5	46.6	48.0	40.8	1223.4	4.25	0.127E 10	0.09579	12.8	14.5

FULLY DEVELOPED NUSSELT NUMBER= 13.4   15.0*

RUN NUMBER (2)   TUBE NUMBER 13

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 711.0   HEAT BALANCE ERROR= 5.2%

REM= 1138.1   RAM= 0.170E 10   PR= 4.55   GR= 0.258E 08

INLET BULK TEMP= 25.5 DEG C   OUTLET BULK TEMP= 50.1 DEG C

MASS FLOW RATE= 24.8 KG/HR   PRESSURE DROP= 1194.4 PA   CF=0.0379

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	33.8	34.9	26.0	891.9	5.98	0.988E 09	0.00166	15.4	18.9
2	3.5	35.1	35.7	26.5	903.2	5.89	0.102E 10	0.00388	14.5	15.4
3	5.5	36.2	36.7	27.1	914.5	5.81	0.105E 10	0.00611	13.7	14.4
4	7.5	36.7	37.9	27.7	925.7	5.73	0.108E 10	0.00834	13.3	14.1
5	10.5	37.7	38.6	28.5	942.5	5.61	0.112E 10	0.01171	13.3	14.2
6	13.5	38.3	39.5	29.3	959.1	5.50	0.117E 10	0.01509	13.4	14.4
7	16.5	38.9	40.5	30.2	975.8	5.40	0.121E 10	0.01848	13.4	14.1
8	19.5	39.2	39.7	31.0	992.4	5.30	0.126E 10	0.02188	15.1	16.9
9	22.5	40.7	40.9	31.9	1009.3	5.20	0.131E 10	0.02530	14.2	15.5
10	25.5	41.8	42.5	32.7	1026.5	5.10	0.137E 10	0.02873	13.5	14.6
11	29.5	42.4	44.1	33.8	1050.0	4.97	0.144E 10	0.03332	13.5	14.8
12	33.5	44.0	45.3	34.9	1074.0	4.85	0.151E 10	0.03794	13.1	14.1
13	37.5	44.3	45.8	36.1	1098.7	4.73	0.158E 10	0.04257	14.1	15.8
14	41.5	45.8	47.1	37.2	1124.0	4.61	0.165E 10	0.04723	13.6	14.9
15	45.5	45.7	47.4	38.3	1149.9	4.50	0.173E 10	0.05191	15.3	17.7
16	49.5	47.9	50.0	39.4	1176.4	4.38	0.181E 10	0.05661	13.2	14.6
17	54.5	49.0	50.5	40.8	1210.5	4.25	0.191E 10	0.06251	14.1	16.0
18	59.5	50.2	51.6	42.2	1245.5	4.12	0.201E 10	0.06844	14.4	16.4
19	64.5	51.3	52.4	43.6	1281.4	3.99	0.211E 10	0.07439	15.2	17.6
20	69.5	51.8	53.2	45.1	1318.4	3.87	0.222E 10	0.08035	16.6	19.8
21	74.5	53.9	55.0	46.5	1356.2	3.75	0.233E 10	0.08633	15.5	18.2
22	79.5	54.8	56.6	47.9	1395.0	3.64	0.244E 10	0.09232	15.8	19.0
23	84.5	56.9	59.0	49.3	1434.6	3.53	0.255E 10	0.09831	14.3	16.3

FULLY DEVELOPED NUSSELT NUMBER= 14.4   16.4*

RUN NUMBER (3)   TUBE NUMBER 13

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 944.0   HEAT BALANCE ERROR= 5.6%

REM= 1253.9   RAM= 0.264E 10   PR= 4.14   GR= 0.471E 08

INLET BULK TEMP= 25.9 DEG C   OUTLET BULK TEMP= 58.1 DEG C

MASS FLOW RATE= 25.1 KG/HR   PRESSURE DROP= 1112.1 PA   CF=0.0344

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	37.1	38.6	26.5	912.5	5.90	0.135E 10	0.00164	15.0	18.6
2	3.5	38.8	39.6	27.2	927.5	5.79	0.140E 10	0.00384	14.2	15.2
3	5.5	40.2	41.1	27.9	942.4	5.69	0.145E 10	0.00605	13.4	14.2
4	7.5	41.0	42.7	28.7	957.2	5.59	0.150E 10	0.00827	12.9	13.7
5	10.5	42.0	43.6	29.8	979.2	5.45	0.158E 10	0.01161	13.0	14.0
6	13.5	43.0	44.8	30.9	1001.3	5.31	0.167E 10	0.01497	13.1	14.1
7	16.5	43.7	46.3	32.0	1023.8	5.18	0.176E 10	0.01834	13.0	13.7
8	19.5	44.1	44.9	33.1	1046.8	5.06	0.185E 10	0.02173	14.8	16.8
9	22.5	46.4	46.5	34.2	1070.3	4.93	0.194E 10	0.02514	13.8	15.0
10	25.5	47.6	48.9	35.3	1094.5	4.81	0.203E 10	0.02856	13.0	14.2
11	29.5	48.5	50.9	36.8	1127.7	4.66	0.216E 10	0.03316	13.0	14.4
12	33.5	50.6	52.6	38.3	1161.9	4.50	0.229E 10	0.03777	12.5	13.6
13	37.5	51.0	53.1	39.7	1197.2	4.36	0.243E 10	0.04242	13.5	15.3
14	41.5	52.9	55.0	41.2	1233.6	4.22	0.257E 10	0.04708	13.0	14.3
15	45.5	52.9	55.2	42.7	1271.0	4.08	0.271E 10	0.05177	14.6	17.0
16	49.5	55.8	58.9	44.1	1309.6	3.95	0.286E 10	0.05647	12.5	14.0
17	54.5	57.2	59.3	46.0	1359.2	3.79	0.304E 10	0.06237	13.5	15.4
18	59.5	58.8	61.1	47.8	1410.5	3.64	0.324E 10	0.06829	13.5	15.5
19	64.5	60.2	62.2	49.7	1463.3	3.50	0.343E 10	0.07421	14.2	16.5
20	69.5	61.1	63.2	51.5	1498.1	3.42	0.359E 10	0.08014	15.4	18.5
21	74.5	64.1	65.6	53.3	1529.8	3.34	0.374E 10	0.08613	14.1	16.7
22	79.5	65.3	67.8	55.2	1563.6	3.26	0.390E 10	0.09215	14.3	17.2
23	84.5	68.2	71.2	57.0	1599.6	3.17	0.405E 10	0.09821	12.8	14.7

FULLY DEVELOPED NUSSELT NUMBER= 13.6   15.5*

RUN NUMBER (4)   TUBE NUMBER 13

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 729.8   HEAT BALANCE ERROR= 2.7%

REM= 1458.3   RAM= 0.131E 10   PR= 5.27   GR= 0.154E 08

INLET BULK TEMP= 22.6 DEG C   OUTLET BULK TEMP= 39.8 DEG C

MASS FLOW RATE= 36.3 KG/HR   PRESSURE DROP= 2192.5 PA   CF=0.0326

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	30.0	31.0	22.9	1215.2	6.48	0.854E 09	0.00112	17.6	20.4
2	3.5	31.2	31.4	23.3	1226.7	6.41	0.875E 09	0.00262	16.7	17.0
3	5.5	31.9	32.1	23.7	1238.3	6.34	0.895E 09	0.00413	16.0	16.4
4	7.5	32.5	33.2	24.1	1249.9	6.28	0.916E 09	0.00564	15.1	15.2
5	10.5	32.7	33.5	24.7	1267.3	6.18	0.947E 09	0.00791	15.7	16.2
6	13.5	33.3	34.2	25.3	1284.8	6.08	0.978E 09	0.01019	15.7	16.2
7	16.5	34.2	35.4	25.9	1302.2	5.99	0.101E 10	0.01247	14.8	14.6
8	19.5	34.1	34.2	26.5	1319.7	5.90	0.104E 10	0.01477	17.2	18.4
9	22.5	35.8	35.0	27.0	1337.1	5.82	0.107E 10	0.01707	15.8	16.2
10	25.5	36.7	36.1	27.6	1354.4	5.73	0.111E 10	0.01938	15.0	15.3
11	29.5	36.5	37.5	28.4	1377.4	5.62	0.115E 10	0.02247	15.4	16.0
12	33.5	38.3	38.5	29.2	1400.2	5.52	0.119E 10	0.02558	14.3	14.4
13	37.5	37.5	38.5	30.0	1423.1	5.42	0.124E 10	0.02868	16.4	17.3
14	41.5	39.1	39.6	30.8	1445.6	5.33	0.128E 10	0.03180	15.3	15.5
15	45.5	38.6	39.6	31.6	1468.7	5.23	0.133E 10	0.03493	17.5	18.8
16	49.5	41.5	41.9	32.4	1492.1	5.14	0.138E 10	0.03807	14.0	14.1
17	54.5	41.6	41.8	33.3	1521.9	5.03	0.144E 10	0.04202	15.7	16.4
18	59.5	41.8	42.9	34.3	1552.5	4.92	0.151E 10	0.04597	16.3	16.9
19	64.5	42.5	43.3	35.3	1583.7	4.81	0.157E 10	0.04995	17.2	17.9
20	69.5	43.0	43.8	36.3	1615.6	4.71	0.164E 10	0.05394	18.4	19.4
21	74.5	44.8	45.0	37.3	1648.2	4.60	0.171E 10	0.05795	17.1	17.8
22	79.5	45.2	46.1	38.3	1681.5	4.50	0.177E 10	0.06197	17.5	18.6
23	84.5	47.1	48.3	39.3	1715.4	4.40	0.184E 10	0.06601	15.3	16.2

FULLY DEVELOPED NUSSELT NUMBER= 16.1   16.8*

RUN NUMBER (5)   TUBE NUMBER 13

INPUT POWER= 750.0 W   HEAT GAINED BY WATER= 741.1   HEAT BALANCE ERROR= 1.2%

REM= 1978.5   RAM= 0.139E 10   PR= 5.16   GR= 0.137E 08

INLET BULK TEMP= 25.6 DEG C   OUTLET BULK TEMP= 38.8 DEG C

MASS FLOW RATE= 48.3 KG/HR   PRESSURE DROP= 3343.6 PA   CF=0.0280

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	32.0	32.9	25.8	1731.8	6.00	0.102E 10	0.00085	20.3	22.6
2	3.5	32.9	33.0	26.1	1743.6	5.95	0.104E 10	0.00199	19.7	19.8
3	5.5	33.4	33.6	26.4	1755.5	5.91	0.106E 10	0.00313	19.0	19.2
4	7.5	33.9	34.4	26.7	1767.3	5.86	0.107E 10	0.00427	18.0	17.8
5	10.5	33.9	34.7	27.2	1784.9	5.80	0.110E 10	0.00599	18.8	18.9
6	13.5	34.3	35.4	27.6	1802.5	5.73	0.112E 10	0.00771	18.6	18.8
7	16.5	35.2	36.3	28.1	1820.1	5.67	0.115E 10	0.00943	17.5	16.9
8	19.5	34.8	35.0	28.5	1837.6	5.61	0.117E 10	0.01116	20.9	21.7
9	22.5	36.3	35.6	29.0	1855.0	5.55	0.120E 10	0.01290	19.1	19.0
10	25.5	37.0	36.5	29.4	1872.3	5.49	0.123E 10	0.01463	18.2	18.1
11	29.5	36.6	37.7	30.0	1895.6	5.42	0.126E 10	0.01695	18.8	19.0
12	33.5	38.2	38.5	30.6	1918.5	5.34	0.130E 10	0.01928	17.2	16.9
13	37.5	37.3	38.3	31.2	1941.7	5.27	0.133E 10	0.02161	20.2	20.6
14	41.5	38.7	39.2	31.8	1965.3	5.20	0.137E 10	0.02395	18.7	18.3
15	45.5	38.1	39.0	32.4	1989.2	5.13	0.141E 10	0.02629	21.8	22.5
16	49.5	40.7	41.2	33.0	2013.4	5.06	0.145E 10	0.02864	16.8	16.4
17	54.5	40.6	40.9	33.8	2044.2	4.98	0.150E 10	0.03159	19.1	19.1
18	59.5	40.6	41.8	34.5	2075.4	4.90	0.155E 10	0.03455	19.9	19.9
19	64.5	41.1	42.0	35.3	2107.2	4.81	0.160E 10	0.03752	21.2	21.1
20	69.5	41.4	42.2	36.0	2139.5	4.73	0.165E 10	0.04049	23.0	23.1
21	74.5	42.9	43.1	36.8	2172.4	4.65	0.170E 10	0.04348	21.3	21.2
22	79.5	43.2	44.1	37.5	2205.8	4.58	0.175E 10	0.04648	21.5	21.6
23	84.5	44.8	46.0	38.3	2239.7	4.50	0.181E 10	0.04948	18.6	19.0

FULLY DEVELOPED NUSSELT NUMBER= 19.7   19.8*

RUN NUMBER (6) TUBE NUMBER 13

INPUT POWER= 750.0 W HEAT GAINED BY WATER= 594.8 HEAT BALANCE ERROR=20.7%

REM= 1931.6 RAM= 0.106E 10 PR= 5.30 GR= 0.157E 08

INLET BULK TEMP= 25.7 DEG C OUTLET BULK TEMP= 36.2 DEG C

MASS FLOW RATE= 48.3 KG/HR PRESSURE DROP= 3639.4 PA CF=0.0305

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	32.0	33.0	25.9	1734.4	5.99	0.824E 09	0.00085	16.3	22.8
2	3.5	32.8	33.0	26.1	1743.9	5.95	0.834E 09	0.00199	15.9	20.3
3	5.5	33.4	33.6	26.4	1753.4	5.92	0.845E 09	0.00313	15.1	19.7
4	7.5	34.0	34.7	26.6	1762.8	5.88	0.856E 09	0.00427	13.9	17.5
5	10.5	34.1	34.9	27.0	1777.0	5.83	0.872E 09	0.00598	14.3	18.7
6	13.5	34.5	35.6	27.3	1791.1	5.77	0.888E 09	0.00770	13.9	18.4
7	16.5	35.4	36.5	27.7	1805.3	5.72	0.904E 09	0.00942	13.0	16.6
8	19.5	35.0	35.2	28.1	1819.3	5.67	0.920E 09	0.01115	15.2	21.6
9	22.5	36.5	35.9	28.4	1833.4	5.62	0.936E 09	0.01288	13.8	18.8
10	25.5	37.3	36.7	28.8	1847.3	5.58	0.953E 09	0.01461	13.1	17.9
11	29.5	36.8	37.9	29.3	1865.9	5.51	0.974E 09	0.01692	13.3	18.7
12	33.5	38.5	38.7	29.7	1884.3	5.45	0.996E 09	0.01924	12.1	16.6
13	37.5	37.5	38.6	30.2	1902.9	5.39	0.102E 10	0.02156	13.7	20.4
14	41.5	39.0	39.5	30.7	1921.4	5.34	0.104E 10	0.02388	12.5	17.8
15	45.5	38.2	39.2	31.2	1940.0	5.28	0.107E 10	0.02622	14.2	22.3
16	49.5	40.9	41.4	31.7	1958.9	5.22	0.109E 10	0.02855	11.3	16.2
17	54.5	40.7	41.0	32.3	1982.7	5.15	0.112E 10	0.03148	12.4	19.1
18	59.5	40.7	41.9	32.9	2006.9	5.08	0.115E 10	0.03442	12.6	19.8
19	64.5	41.2	42.2	33.5	2031.4	5.01	0.118E 10	0.03736	12.9	20.9
20	69.5	41.6	42.3	34.1	2056.2	4.95	0.122E 10	0.04031	13.4	22.7
21	74.5	43.1	43.3	34.7	2081.4	4.88	0.125E 10	0.04327	12.4	20.7
22	79.5	43.4	44.3	35.3	2106.9	4.81	0.128E 10	0.04624	12.4	21.3
23	84.5	44.9	46.2	35.9	2132.8	4.75	0.131E 10	0.04922	10.9	15.9

FULLY DEVELOPED NUSSELT NUMBER= 12.7 19.3*

RUN NUMBER (7)   TUBE NUMBER 13

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 987.9   HEAT BALANCE ERROR= 1.2%

REM= 7912.9   RAM= 0.117E 10   PR= 6.45   GR= 0.442E 07

INLET BULK TEMP= 21.3 DEG C   OUTLET BULK TEMP= 24.9 DEG C

MASS FLOW RATE= 235.2 KG/HR   PRESSURE DROP= 3934.4 PA   CF=0.0014

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	25.8	27.6	21.3	7584.8	6.77	0.105E 10	0.00017	33.8	34.1
2	3.5	25.1	26.3	21.4	7600.2	6.75	0.106E 10	0.00040	42.5	44.4
3	5.5	25.7	26.4	21.5	7615.6	6.74	0.106E 10	0.00063	40.0	39.9
4	7.5	25.5	27.4	21.6	7631.1	6.72	0.107E 10	0.00086	37.5	36.7
5	10.5	25.3	26.8	21.7	7654.2	6.70	0.108E 10	0.00121	41.7	42.1
6	13.5	25.8	27.4	21.8	7677.4	6.68	0.109E 10	0.00155	37.8	37.7
7	16.5	25.7	28.9	22.0	7700.7	6.65	0.109E 10	0.00190	33.9	32.7
8	19.5	25.7	26.2	22.1	7724.0	6.63	0.110E 10	0.00225	46.6	47.7
9	22.5	27.1	26.2	22.2	7747.2	6.61	0.111E 10	0.00259	41.2	40.8
10	25.5	26.3	27.6	22.3	7770.6	6.59	0.112E 10	0.00294	39.2	38.9
11	29.5	26.0	28.1	22.5	7801.7	6.56	0.113E 10	0.00340	39.8	39.9
12	33.5	27.1	28.9	22.7	7832.9	6.53	0.114E 10	0.00387	34.0	33.2
13	37.5	25.9	27.9	22.8	7864.1	6.50	0.115E 10	0.00433	44.4	44.9
14	41.5	26.6	28.7	23.0	7895.3	6.47	0.117E 10	0.00479	38.9	38.3
15	45.5	26.5	28.0	23.2	7926.6	6.44	0.118E 10	0.00526	44.1	44.6
16	49.5	27.6	30.2	23.3	7957.9	6.41	0.119E 10	0.00572	32.4	31.6
17	54.5	27.2	28.6	23.5	7997.1	6.37	0.120E 10	0.00631	41.4	41.4
18	59.5	26.8	29.2	23.7	8036.3	6.34	0.122E 10	0.00689	41.9	41.6
19	64.5	27.5	28.8	23.9	8075.6	6.30	0.123E 10	0.00747	42.6	42.2
20	69.5	27.2	28.2	24.1	8114.9	6.27	0.125E 10	0.00806	50.8	50.5
21	74.5	27.2	28.4	24.3	8154.3	6.24	0.126E 10	0.00864	52.3	52.1
22	79.5	27.9	29.6	24.6	8193.6	6.20	0.128E 10	0.00923	43.0	42.9
23	84.5	29.8	31.4	24.8	8233.0	6.17	0.129E 10	0.00982	31.0	31.2

FULLY DEVELOPED NUSSELT NUMBER= 41.1 40.9*

RUN NUMBER (8)   TUBE NUMBER 13

INPUT POWER= 1900.0 W   HEAT GAINED BY WATER= 1727.6   HEAT BALANCE ERROR= 9.1%

REM= 4802.7   RAM= 0.438E 10   PR= 4.40   GR= 0.373E 08

INLET BULK TEMP= 32.0 DEG C   OUTLET BULK TEMP= 46.6 DEG C

MASS FLOW RATE= 101.5 KG/HR   PRESSURE DROP= 7.7 PA   CF=0.0000

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA
									(AVERAGE)	
1	1.5	43.1	45.9	32.2	4163.9	5.16	0.326E 10	0.00041	25.2	29.0
2	3.5	43.8	45.1	32.6	4191.9	5.12	0.331E 10	0.00096	26.1	28.9
3	5.5	44.5	46.0	32.9	4220.2	5.08	0.336E 10	0.00151	25.1	28.2
4	7.5	45.6	49.6	33.2	4248.6	5.04	0.341E 10	0.00207	21.6	22.4
5	10.5	44.1	47.7	33.7	4291.8	4.99	0.348E 10	0.00290	25.5	28.7
6	13.5	45.1	49.3	34.2	4335.4	4.93	0.356E 10	0.00373	23.9	26.5
7	16.5	46.5	52.4	34.7	4379.5	4.87	0.364E 10	0.00456	21.0	21.9
8	19.5	45.1	46.3	35.2	4424.0	4.82	0.372E 10	0.00540	29.5	34.4
9	22.5	48.3	46.7	35.7	4469.1	4.77	0.380E 10	0.00623	26.2	29.0
10	25.5	48.3	48.5	36.2	4514.7	4.71	0.388E 10	0.00707	25.3	28.2
11	29.5	46.6	51.1	36.9	4576.2	4.64	0.398E 10	0.00819	25.8	29.3
12	33.5	51.0	53.2	37.6	4638.7	4.57	0.409E 10	0.00932	21.1	22.9
13	37.5	47.1	50.7	38.2	4702.0	4.50	0.420E 10	0.01044	28.7	33.6
14	41.5	50.2	53.2	38.9	4766.2	4.44	0.431E 10	0.01158	23.9	26.5
15	45.5	47.9	51.1	39.6	4831.4	4.37	0.443E 10	0.01271	30.8	37.1
16	49.5	54.0	57.4	40.2	4897.4	4.31	0.454E 10	0.01385	19.8	21.6
17	54.5	51.9	53.2	41.1	4981.2	4.23	0.469E 10	0.01527	26.6	31.2
18	59.5	50.7	55.4	41.9	5066.4	4.15	0.484E 10	0.01670	27.4	32.0
19	64.5	51.5	55.0	42.7	5153.0	4.07	0.498E 10	0.01813	29.0	34.2
20	69.5	51.7	53.7	43.6	5241.0	4.00	0.514E 10	0.01957	33.4	40.7
21	74.5	53.4	55.0	44.4	5330.4	3.93	0.529E 10	0.02101	30.9	37.4
22	79.5	54.2	56.7	45.2	5421.1	3.85	0.545E 10	0.02245	29.7	36.5
23	84.5	58.1	62.1	46.1	5513.3	3.78	0.560E 10	0.02389	21.6	24.8

FULLY DEVELOPED NUSSELT NUMBER= 26.7   31.1*

RUN NUMBER (9) TUBE NUMBER 13

INPUT POWER= 750.0 W HEAT GAINED BY WATER= 733.2 HEAT BALANCE ERROR= 2.2%

REM= 4076.4 RAM= 0.132E 10 PR= 5.28 GR= 0.799E 07

INLET BULK TEMP= 28.1 DEG C OUTLET BULK TEMP= 34.3 DEG C

MASS FLOW RATE= 101.5 KG/HR PRESSURE DROP= 2574.0 PA CF=0.0049

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	32.5	33.5	28.2	3834.1	5.66	0.114E 10	0.00041	27.5	29.4
2	3.5	32.8	33.1	28.3	3845.7	5.64	0.115E 10	0.00095	28.5	29.0
3	5.5	33.0	33.3	28.5	3857.2	5.62	0.116E 10	0.00150	28.3	29.4
4	7.5	33.5	34.4	28.6	3868.7	5.60	0.117E 10	0.00204	24.8	24.0
5	10.5	33.1	33.8	28.8	3886.0	5.57	0.118E 10	0.00286	28.8	29.6
6	13.5	33.3	34.3	29.0	3903.2	5.54	0.119E 10	0.00368	27.8	28.3
7	16.5	34.1	35.1	29.2	3920.3	5.52	0.120E 10	0.00450	24.7	24.0
8	19.5	33.5	33.6	29.4	3937.5	5.49	0.122E 10	0.00532	32.6	34.1
9	22.5	34.6	33.9	29.7	3954.5	5.46	0.123E 10	0.00615	29.1	29.2
10	25.5	34.9	34.3	29.9	3971.5	5.44	0.124E 10	0.00697	28.1	28.4
11	29.5	34.2	35.2	30.2	3994.9	5.40	0.126E 10	0.00807	29.1	29.7
12	33.5	35.6	35.6	30.4	4017.6	5.37	0.127E 10	0.00917	25.7	25.4
13	37.5	34.2	35.1	30.7	4040.5	5.33	0.129E 10	0.01027	33.4	34.6
14	41.5	35.5	36.0	31.0	4063.5	5.30	0.131E 10	0.01137	28.1	27.9
15	45.5	34.6	35.4	31.3	4086.6	5.27	0.132E 10	0.01247	35.7	37.4
16	49.5	36.9	37.2	31.6	4109.9	5.23	0.134E 10	0.01358	24.2	23.9
17	54.5	36.4	36.4	31.9	4139.2	5.19	0.136E 10	0.01496	29.6	30.1
18	59.5	36.0	36.9	32.3	4168.8	5.15	0.139E 10	0.01635	31.7	32.1
19	64.5	36.1	36.9	32.6	4198.6	5.11	0.141E 10	0.01774	34.1	34.6
20	69.5	36.1	36.6	33.0	4228.7	5.07	0.143E 10	0.01913	39.1	40.1
21	74.5	37.0	37.1	33.3	4259.0	5.03	0.145E 10	0.02052	35.4	36.0
22	79.5	37.1	37.7	33.7	4289.5	4.99	0.148E 10	0.02192	35.2	36.2
23	84.5	38.5	39.2	34.1	4320.3	4.95	0.150E 10	0.02332	27.6	28.4

FULLY DEVELOPED NUSSELT NUMBER= 31.2 31.8*

RUN NUMBER (10) TUBE NUMBER 13

INPUT POWER= 980.0 W HEAT GAINED BY WATER= 934.5 HEAT BALANCE ERROR= 4.6%

REM= 4701.6 RAM= 0.151E 10 PR= 5.57 GR= 0.857E 07

INLET BULK TEMP= 25.6 DEG C OUTLET BULK TEMP= 32.1 DEG C

MASS FLOW RATE= 122.8 KG/HR PRESSURE DROP= 620.6 PA CF=0.0008

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	31.2	32.6	25.7	4388.5	6.02	0.128E 10	0.00033	27.5	29.7
2	3.5	31.3	31.7	25.8	4403.4	6.00	0.129E 10	0.00078	29.9	31.6
3	5.5	31.6	31.9	26.0	4418.4	5.98	0.130E 10	0.00123	29.4	31.0
4	7.5	31.9	32.9	26.1	4433.3	5.95	0.131E 10	0.00168	27.0	27.3
5	10.5	31.3	32.5	26.4	4455.7	5.92	0.133E 10	0.00235	30.6	32.3
6	13 5	31.8	33.1	26.6	4478.0	5.88	0.135E 10	0.00302	28.9	30.3
7	16.5	32.6	34.4	26.8	4500.4	5.85	0.136E 10	0.00370	25.3	25.1
8	19.5	31.9	32.0	27.0	4522.7	5.82	0.138E 10	0.00437	34.2	37.0
9	22.5	33.4	32.3	27.2	4545.0	5.79	0.139E 10	0.00505	30.2	31.3
10	25.5	33.6	33.0	27.5	4567.2	5.75	0.141E 10	0.00572	29.2	30.4
11	29.5	32.6	34.2	27.8	4596.8	5.71	0.143E 10	0.00663	30.3	32.0
12	33.5	34.5	35.0	28.1	4626.4	5.67	0.145E 10	0.00753	25.4	25.8
13	37.5	32.6	34.0	28.4	4655.9	5.63	0.147E 10	0.00844	34.2	36.8
14	41.5	34.1	34.9	28.7	4685.2	5.59	0.149E 10	0.00935	29.0	29.8
15	45.5	33.1	34.2	29.0	4714.5	5.55	0.151E 10	0.01026	36.2	39.5
16	49.5	36.0	36.6	29.3	4743.6	5.51	0.154E 10	0.01117	24.1	24.6
17	54.5	35.2	35.2	29.6	4779.9	5.46	0.156E 10	0.01231	30.5	32.4
18	59.5	34.4	36.1	30.0	4816.9	5.42	0.159E 10	0.01345	32.1	34.1
19	64.5	34.8	36.0	30.4	4853.0	5.37	0.162E 10	0.01459	33.6	35.7
20	69.5	34.9	35.3	30.8	4889.4	5.33	0.165E 10	0.01574	38.7	41.8
21	74.5	35.7	35.9	31.1	4926.1	5.28	0.168E 10	0.01688	36.2	38.8
22	79.5	35.7	36.8	31.5	4963.1	5.24	0.171E 10	0.01803	35.5	38.5
23	84.5	37.5	38.8	31.9	5000.5	5.20	0.174E 10	0.01918	26.7	28.5

FULLY DEVELOPED NUSSELT NUMBER= 31.5 33.5*

RUN NUMBER (11)   TUBE NUMBER 13

INPUT POWER= 1940.0 W   HEAT GAINED BY WATER= 1827.5   HEAT BALANCE ERROR= 5.8%

REM= 8087.4   RAM= 0.544E 10   PR= 4.00   GR= 0.431E 08

INLET BULK TEMP= 38.6 DEG C   OUTLET BULK TEMP= 48.6 DEG C

MASS FLOW RATE= 156.6 KG/HR   PRESSURE DROP= 1960.2 PA   CF=0.0016

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	48.2	51.4	38.7	7330.1	4.45	0.454E 10	0.00027	29.4	32.0
2	3.5	48.6	49.9	39.0	7364.3	4.43	0.458E 10	0.00063	31.7	33.9
3	5.5	48.9	50.7	39.2	7398.7	4.41	0.462E 10	0.00099	30.5	33.0
4	7.5	49.9	54.3	39.4	7433.2	4.39	0.466E 10	0.00136	25.6	25.4
5	10.5	48.1	52.1	39.8	7485.3	4.35	0.472E 10	0.00190	31.2	33.7
6	13.5	49.1	53.7	40.1	7537.7	4.32	0.479E 10	0.00245	28.8	30.5
7	16.5	50.3	56.9	40.5	7590.6	4.29	0.485E 10	0.00299	24.6	24.5
8	19.5	48.8	50.3	40.8	7643.8	4.25	0.491E 10	0.00354	37.0	40.9
9	22.5	51.9	50.4	41.1	7697.3	4.22	0.498E 10	0.00409	32.4	34.0
10	25.5	51.7	52.2	41.5	7751.3	4.19	0.504E 10	0.00463	30.8	32.5
11	29.5	50.1	54.7	42.0	7823.7	4.15	0.513E 10	0.00537	30.9	33.2
12	33.5	54.3	57.1	42.4	7896.9	4.10	0.521E 10	0.00610	24.3	24.9
13	37.5	50.5	54.2	42.9	7970.6	4.06	0.530E 10	0.00683	34.0	37.3
14	41.5	53.4	56.7	43.3	8045.1	4.02	0.539E 10	0.00757	27.4	28.5
15	45.5	50.7	54.2	43.8	8120.2	3.98	0.548E 10	0.00831	37.1	41.4
16	49.5	56.4	60.5	44.2	8195.9	3.94	0.557E 10	0.00904	22.6	23.2
17	54.5	54.3	55.7	44.8	8291.4	3.89	0.568E 10	0.00997	31.5	34.2
18	59.5	52.5	57.9	45.4	8388.0	3.84	0.579E 10	0.01089	32.6	35.1
19	64.5	53.3	57.3	46.0	8485.5	3.79	0.591E 10	0.01182	34.4	37.2
20	69.5	53.3	55.7	46.5	8584.0	3.75	0.602E 10	0.01275	40.1	44.0
21	74.5	55.0	56.6	47.1	8683.4	3.70	0.614E 10	0.01367	36.9	40.3
22	79.5	55.3	58.3	47.7	8783.8	3.66	0.626E 10	0.01461	34.9	38.5
23	84.5	59.3	63.6	48.2	8885.1	3.61	0.638E 10	0.01554	24.2	26.1

FULLY DEVELOPED NUSSELT NUMBER= 31.5   34.0*

RUN NUMBER (12)   TUBE NUMBER 13

INPUT POWER= 980.0 W   HEAT GAINED BY WATER= 990.7   HEAT BALANCE ERROR=-1.1%

REM= 1912.9   RAM= 0.284E 10   PR= 4.08   GR= 0.367E 08

INLET BULK TEMP= 31.4 DEG C   OUTLET BULK TEMP= 53.9 DEG C

MASS FLOW RATE= 37.8 KG/HR   PRESSURE DROP= 366.0 PA   CF=0.0050

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	38.2	38.5	31.8	1535.7	5.21	0.183E 10	0.00111	27.2	31.2
2	3.5	40.5	40.2	32.3	1551.6	5.15	0.187E 10	0.00259	22.1	20.9
3	5.5	40.8	41.6	32.8	1567.7	5.09	0.192E 10	0.00407	21.2	20.8
4	7.5	41.9	42.2	33.3	1584.0	5.03	0.196E 10	0.00555	20.3	20.1
5	10.5	43.7	43.5	34.1	1608.9	4.94	0.203E 10	0.00779	18.6	17.9
6	13.5	43.5	44.4	34.9	1634.1	4.86	0.210E 10	0.01003	19.5	19.1
7	16.5	44.7	44.6	35.7	1659.8	4.77	0.217E 10	0.01228	19.7	19.1
8	19.5	45.2	45.4	36.4	1685.9	4.69	0.224E 10	0.01454	19.8	19.3
9	22.5	46.0	46.7	37.2	1712.5	4.61	0.231E 10	0.01681	19.3	18.4
10	25.5	46.4	46.8	38.0	1739.5	4.53	0.238E 10	0.01908	20.3	19.9
11	29.5	47.4	47.8	39.0	1776.2	4.43	0.248E 10	0.02212	20.4	19.7
12	33.5	48.6	48.9	40.0	1813.7	4.33	0.258E 10	0.02518	20.1	19.3
13	37.5	49.5	50.3	41.0	1852.0	4.23	0.268E 10	0.02824	19.7	19.1
14	41.5	51.7	52.2	42.1	1891.1	4.13	0.279E 10	0.03132	17.7	16.6
15	45.5	51.6	52.7	43.1	1931.0	4.04	0.289E 10	0.03441	19.3	18.5
16	49.5	52.7	53.4	44.1	1971.6	3.95	0.300E 10	0.03750	19.5	18.6
17	54.5	53.7	54.2	45.4	2023.6	3.84	0.314E 10	0.04138	20.4	19.4
18	59.5	55.5	56.1	46.7	2076.7	3.73	0.328E 10	0.04527	19.0	17.8
19	64.5	56.7	57.4	48.0	2130.9	3.63	0.342E 10	0.04917	19.1	18.0
20	69.5	58.4	59.2	49.3	2186.3	3.53	0.357E 10	0.05307	18.1	16.9
21	74.5	59.6	60.4	50.6	2232.4	3.46	0.370E 10	0.05697	18.2	17.1
22	79.5	61.0	61.5	51.8	2264.5	3.40	0.380E 10	0.06090	18.2	17.2
23	84.5	63.8	63.8	53.1	2297.9	3.35	0.391E 10	0.06485	16.1	15.7

FULLY DEVELOPED NUSSELT NUMBER= 19.0 18.1*

RUN NUMBER (13)   TUBE NUMBER 13

INPUT POWER= 990.0 W   HEAT GAINED BY WATER= 983.6   HEAT BALANCE ERROR= 0.7%

REM= 2368.7   RAM= 0.253E 10   PR= 4.37   GR= 0.253E 08

INLET BULK TEMP= 31.2 DEG C   OUTLET BULK TEMP= 48.1 DEG C

MASS FLOW RATE= 49.7 KG/HR   PRESSURE DROP= 589.0 PA   CF=0.0046

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	37.1	37.3	31.5	2007.2	5.25	0.179E 10	0.00084	30.7	34.9
2	3.5	39.0	38.7	31.8	2022.9	5.20	0.182E 10	0.00196	25.3	24.3
3	5.5	39.0	39.9	32.2	2038.7	5.16	0.185E 10	0.00309	24.6	24.6
4	7.5	39.9	40.3	32.6	2054.7	5.11	0.189E 10	0.00421	23.6	23.7
5	10.5	41.2	41.1	33.2	2078.9	5.05	0.194E 10	0.00591	22.2	22.0
6	13.5	41.5	42.0	33.8	2103.4	4.98	0.199E 10	0.00760	22.0	21.7
7	16.5	41.9	41.9	34.4	2128.3	4.92	0.204E 10	0.00931	23.3	23.3
8	19.5	42.4	42.5	34.9	2153.5	4.85	0.209E 10	0.01101	23.5	23.4
9	22.5	42.9	43.5	35.5	2179.0	4.79	0.214E 10	0.01272	22.8	22.3
10	25.5	43.1	43.6	36.1	2204.8	4.73	0.219E 10	0.01444	24.3	24.4
11	29.5	43.7	44.2	36.9	2239.8	4.64	0.226E 10	0.01673	24.7	24.6
12	33.5	44.7	44.9	37.7	2275.3	4.56	0.234E 10	0.01903	24.4	24.2
13	37.5	45.4	46.0	38.4	2311.5	4.48	0.241E 10	0.02134	24.0	24.0
14	41.5	47.3	47.9	39.2	2348.2	4.41	0.248E 10	0.02366	20.8	20.2
15	45.5	46.9	48.0	40.0	2385.5	4.33	0.256E 10	0.02598	23.2	23.1
16	49.5	47.9	48.6	40.8	2423.4	4.26	0.264E 10	0.02831	23.2	23.0
17	54.5	48.5	49.1	41.7	2471.7	4.17	0.273E 10	0.03123	24.6	24.4
18	59.5	50.0	50.6	42.7	2520.9	4.08	0.283E 10	0.03416	22.8	22.4
19	64.5	50.8	51.6	43.7	2571.0	3.99	0.293E 10	0.03710	23.0	22.6
20	69.5	52.1	52.9	44.6	2622.0	3.91	0.303E 10	0.04004	21.9	21.5
21	74.5	53.1	53.9	45.6	2673.9	3.82	0.314E 10	0.04299	21.9	21.5
22	79.5	54.0	54.6	46.6	2726.7	3.74	0.324E 10	0.04595	22.2	21.9
23	84.5	56.5	56.4	47.6	2780.3	3.67	0.335E 10	0.04891	19.4	19.6

FULLY DEVELOPED NUSSELT NUMBER= 22.9   22.7*

RUN NUMBER (14)   TUBE NUMBER 13

INPUT POWER= 980.0 W   HEAT GAINED BY WATER= 939.1   HEAT BALANCE ERROR= 4.2%

REM= 3396.8   RAM= 0.211E 10   PR= 4.70   GR= 0.153E 08

INLET BULK TEMP= 31.0 DEG C   OUTLET BULK TEMP= 41.6 DEG C

MASS FLOW RATE= 76.3 KG/HR   PRESSURE DROP= 1320.4 PA   CF=0.0044

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	35.7	35.9	31.2	3065.1	5.28	0.169E 10	0.00055	36.7	42.3
2	3.5	37.0	36.6	31.5	3080.0	5.25	0.171E 10	0.00128	31.4	32.0
3	5.5	37.3	37.4	31.7	3094.9	5.22	0.173E 10	0.00201	29.7	30.6
4	7.5	37.7	37.7	31.9	3110.0	5.19	0.175E 10	0.00274	29.2	30.4
5	10.5	38.2	38.2	32.3	3132.7	5.15	0.178E 10	0.00384	28.7	29.9
6	13.5	38.6	38.9	32.7	3155.6	5.11	0.181E 10	0.00494	27.6	28.3
7	16.5	38.6	38.6	33.0	3178.7	5.07	0.183E 10	0.00605	30.1	31.5
8	19.5	38.9	38.9	33.4	3202.0	5.02	0.186E 10	0.00715	30.6	32.1
9	22.5	39.1	39.7	33.7	3225.5	4.98	0.189E 10	0.00826	29.6	30.7
10	25.5	39.0	39.7	34.1	3249.1	4.94	0.192E 10	0.00937	32.0	34.0
11	29.5	39.4	40.0	34.6	3281.0	4.89	0.197E 10	0.01085	32.9	34.7
12	33.5	40.2	40.4	35.1	3313.2	4.84	0.201E 10	0.01233	32.1	33.9
13	37.5	40.5	41.3	35.6	3345.7	4.78	0.205E 10	0.01382	31.5	33.6
14	41.5	42.2	42.9	36.0	3378.6	4.73	0.209E 10	0.01531	25.9	26.8
15	45.5	42.0	42.9	36.5	3411.8	4.68	0.213E 10	0.01681	28.3	30.0
16	49.5	42.3	43.1	37.0	3445.4	4.63	0.217E 10	0.01830	29.5	31.5
17	54.5	42.5	43.4	37.6	3487.9	4.57	0.223E 10	0.02018	31.5	33.8
18	59.5	43.7	44.3	38.2	3530.9	4.51	0.228E 10	0.02206	28.9	30.8
19	64.5	44.1	44.9	38.8	3574.5	4.45	0.234E 10	0.02394	29.3	31.4
20	69.5	44.9	45.7	39.4	3618.6	4.39	0.239E 10	0.02583	28.3	30.3
21	74.5	45.5	46.3	40.0	3663.3	4.33	0.245E 10	0.02772	28.3	30.4
22	79.5	46.1	46.7	40.6	3708.5	4.27	0.251E 10	0.02962	28.7	31.3
23	84.5	48.2	48.3	41.2	3754.3	4.21	0.256E 10	0.03152	23.8	25.4

FULLY DEVELOPED NUSSELT NUMBER= 29.3   31.3*

RUN NUMBER (15)   TUBE NUMBER 13

INPUT POWER= 980.0 W   HEAT GAINED BY WATER= 935.8   HEAT BALANCE ERROR= 4.5%

REM= 5409.5   RAM= 0.198E 10   PR= 4.86   GR= 0.940E 07

INLET BULK TEMP= 31.6 DEG C   OUTLET BULK TEMP= 38.0 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 3329.8 PA   CF=0.0042

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	35.1	35.2	31.7	5081.8	5.21	0.173E 10	0.00033	49.2	53.8
2	3.5	35.4	35.5	31.9	5096.8	5.20	0.174E 10	0.00078	47.1	48.7
3	5.5	35.3	36.2	32.0	5111.9	5.18	0.175E 10	0.00123	45.1	46.6
4	7.5	35.7	36.2	32.2	5127.0	5.16	0.176E 10	0.00167	44.2	46.0
5	10.5	36.2	36.5	32.4	5149.7	5.14	0.178E 10	0.00234	42.9	44.5
6	13.5	36.2	37.1	32.6	5172.6	5.11	0.180E 10	0.00301	41.3	42.7
7	16.5	36.4	37.0	32.8	5195.6	5.09	0.182E 10	0.00368	43.6	45.5
8	19.5	36.6	37.2	33.1	5218.7	5.06	0.183E 10	0.00436	43.5	45.4
9	22.5	36.7	37.5	33.3	5241.9	5.04	0.185E 10	0.00503	43.4	45.2
10	25.5	36.7	37.5	33.5	5265.2	5.01	0.187E 10	0.00570	45.9	48.5
11	29.5	37.2	37.7	33.8	5296.5	4.98	0.189E 10	0.00660	46.1	48.4
12	33.5	37.5	37.7	34.1	5328.0	4.95	0.192E 10	0.00750	47.6	50.3
13	37.5	37.8	38.2	34.4	5359.7	4.91	0.194E 10	0.00840	46.3	49.0
14	41.5	38.9	38.6	34.7	5391.6	4.88	0.197E 10	0.00930	41.4	43.5
15	45.5	38.8	38.9	35.0	5423.8	4.85	0.199E 10	0.01021	43.1	45.7
16	49.5	39.1	39.1	35.3	5456.1	4.82	0.202E 10	0.01111	43.8	46.8
17	54.5	39.3	39.3	35.6	5496.8	4.78	0.205E 10	0.01224	45.5	48.7
18	59.5	39.8	40.3	36.0	5537.8	4.74	0.208E 10	0.01338	41.4	43.9
19	64.5	39.9	40.4	36.4	5579.2	4.70	0.211E 10	0.01451	44.1	47.3
20	69.5	40.3	41.0	36.7	5620.9	4.66	0.214E 10	0.01565	42.1	45.1
21	74.5	40.7	41.4	37.1	5662.9	4.62	0.218E 10	0.01679	42.2	45.4
22	79.5	41.1	41.6	37.5	5705.2	4.58	0.221E 10	0.01793	43.3	47.0
23	84.5	42.7	42.7	37.8	5747.9	4.55	0.224E 10	0.01908	34.2	36.4

FULLY DEVELOPED NUSSELT NUMBER= 43.4   46.1*

RUN NUMBER (16) TUBE NUMBER 13

INPUT POWER= 1450.0 W HEAT GAINED BY WATER= 1403.7 HEAT BALANCE ERROR= 3.2%

REM= 6670.6 RAM= 0.292E 10 PR= 4.91 GR= 0.122E 08

INLET BULK TEMP= 30.6 DEG C OUTLET BULK TEMP= 38.3 DEG C

MASS FLOW RATE= 155.5 KG/HR PRESSURE DROP= 2478.3 PA CF=0.0020

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.9	35.3	30.7	6186.6	5.34	0.247E 10	0.00027	57.6	61.6
2	3.5	35.5	35.5	30.9	6208.6	5.31	0.249E 10	0.00063	54.6	55.7
3	5.5	35.6	36.5	31.1	6230.7	5.29	0.251E 10	0.00098	51.1	51.8
4	7.5	36.0	36.7	31.2	6252.9	5.27	0.253E 10	0.00134	49.7	50.7
5	10.5	36.3	37.0	31.5	6286.3	5.24	0.256E 10	0.00188	49.3	50.4
6	13.5	36.3	38.1	31.8	6319.9	5.21	0.260E 10	0.00242	46.7	47.5
7	16.5	36.6	37.9	32.0	6353.8	5.18	0.263E 10	0.00296	48.3	49.4
8	19.5	36.8	38.0	32.3	6387.8	5.15	0.266E 10	0.00350	49.5	50.7
9	22.5	37.0	38.3	32.6	6422.1	5.12	0.269E 10	0.00404	49.6	50.4
10	25.5	36.9	37.8	32.8	6456.6	5.09	0.272E 10	0.00458	55.8	57.8
11	29.5	37.1	38.2	33.2	6502.9	5.05	0.277E 10	0.00530	56.3	57.9
12	33.5	37.8	38.6	33.5	6549.5	5.01	0.281E 10	0.00603	53.7	55.2
13	37.5	38.3	39.1	33.9	6596.5	4.97	0.285E 10	0.00675	52.6	54.1
14	41.5	38.8	39.6	34.2	6643.9	4.93	0.290E 10	0.00748	50.5	51.9
15	45.5	38.9	40.2	34.6	6691.7	4.89	0.294E 10	0.00821	50.8	52.4
16	49.5	39.6	40.7	35.0	6739.9	4.85	0.299E 10	0.00893	48.4	50.0
17	54.5	39.9	41.0	35.4	6800.6	4.80	0.305E 10	0.00985	49.9	51.6
18	59.5	40.6	41.9	35.8	6861.9	4.75	0.310E 10	0.01076	46.2	47.6
19	64.5	41.4	42.3	36.3	6923.8	4.71	0.316E 10	0.01168	45.1	46.5
20	69.5	41.6	42.7	36.7	6986.3	4.66	0.322E 10	0.01259	46.1	47.7
21	74.5	42.0	43.3	37.2	7049.4	4.61	0.328E 10	0.01351	45.8	47.4
22	79.5	42.3	43.3	37.6	7113.1	4.57	0.334E 10	0.01443	48.3	50.6
23	84.5	44.9	45.1	38.1	7177.4	4.52	0.340E 10	0.01536	36.1	37.5

FULLY DEVELOPED NUSSELT NUMBER= 49.0 50.6*

RUN NUMBER (17) TUBE NUMBER 13

INPUT POWER= 1450.0 W HEAT GAINED BY WATER= 1392.5 HEAT BALANCE ERROR= 4.0%

REM= 7435.4 RAM= 0.282E 10 PR= 4.98 GR= 0.112E 08

INLET BULK TEMP= 30.4 DEG C OUTLET BULK TEMP= 37.2 DEG C

MASS FLOW RATE= 175.6 KG/HR PRESSURE DROP= 2478.9 PA CF=0.0016

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.6	34.8	30.5	6959.7	5.36	0.243E 10	0.00024	60.0	64.2
2	3.5	34.8	35.0	30.7	6981.4	5.34	0.245E 10	0.00055	59.6	61.7
3	5.5	34.8	36.0	30.8	7003.2	5.32	0.246E 10	0.00087	55.1	56.2
4	7.5	35.1	36.1	31.0	7025.1	5.30	0.248E 10	0.00119	54.2	55.8
5	10.5	35.2	36.4	31.2	7058.1	5.27	0.251E 10	0.00166	54.7	56.7
6	13.5	35.8	37.4	31.4	7091.2	5.25	0.254E 10	0.00214	48.7	49.7
7	16.5	36.0	37.2	31.7	7124.6	5.22	0.257E 10	0.00262	51.0	52.6
8	19.5	36.1	37.3	31.9	7158.1	5.19	0.259E 10	0.00310	52.5	54.4
9	22.5	36.3	37.7	32.2	7191.8	5.17	0.262E 10	0.00357	51.7	53.2
10	25.5	36.3	37.7	32.4	7225.6	5.14	0.265E 10	0.00405	54.5	56.8
11	29.5	36.6	37.8	32.7	7271.1	5.10	0.269E 10	0.00469	55.2	57.3
12	33.5	37.0	38.1	33.0	7316.8	5.07	0.272E 10	0.00533	55.2	57.3
13	37.5	37.4	38.6	33.3	7362.9	5.03	0.276E 10	0.00597	53.5	55.8
14	41.5	38.6	39.2	33.6	7409.3	5.00	0.280E 10	0.00661	47.6	49.2
15	45.5	38.5	39.2	33.9	7456.0	4.96	0.284E 10	0.00726	50.9	53.2
16	49.5	38.6	39.6	34.3	7503.1	4.93	0.288E 10	0.00790	51.2	53.6
17	54.5	38.8	39.9	34.6	7562.4	4.88	0.293E 10	0.00871	53.0	55.6
18	59.5	39.8	40.7	35.0	7622.2	4.84	0.298E 10	0.00951	48.0	50.1
19	64.5	39.9	41.0	35.4	7682.5	4.80	0.303E 10	0.01032	49.7	52.2
20	69.5	40.2	41.4	35.8	7743.3	4.76	0.307E 10	0.01113	49.9	52.5
21	74.5	40.7	41.9	36.2	7804.7	4.72	0.313E 10	0.01194	48.8	51.2
22	79.5	40.9	41.8	36.6	7866.6	4.67	0.318E 10	0.01275	52.3	55.7
23	84.5	43.4	43.5	37.0	7928.9	4.63	0.323E 10	0.01357	38.3	40.1

FULLY DEVELOPED NUSSELT NUMBER= 50.6 52.9*

RUN NUMBER (18)   TUBE NUMBER 13

INPUT POWER= 1450.0 W   HEAT GAINED BY WATER= 1407.4   HEAT BALANCE ERROR= 2.9%

REM= 9642.2   RAM= 0.267E 10   PR= 5.15   GR= 0.874E 07

INLET BULK TEMP= 29.7 DEG C   OUTLET BULK TEMP= 34.9 DEG C

MASS FLOW RATE= 234.7 KG/HR   PRESSURE DROP= 2480.1 PA   CF=0.0009

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	33.3	33.6	29.8	9171.1	5.44	0.238E 10	0.00018	69.4	73.1
2	3.5	33.8	33.7	29.9	9192.8	5.43	0.239E 10	0.00041	66.8	67.4
3	5.5	33.7	34.0	30.1	9216.4	5.41	0.240E 10	0.00065	66.9	68.1
4	7.5	33.9	34.3	30.2	9238.1	5.40	0.242E 10	0.00089	65.0	66.1
5	10.5	34.1	34.5	30.3	9270.8	5.38	0.244E 10	0.00124	64.4	65.3
6	13.5	34.2	34.8	30.5	9303.7	5.36	0.246E 10	0.00160	64.3	65.2
7	16.5	34.3	34.7	30.7	9336.6	5.34	0.248E 10	0.00195	66.2	67.3
8	19.5	34.6	34.9	30.9	9369.7	5.31	0.250E 10	0.00231	66.3	67.5
9	22.5	34.7	35.3	31.1	9403.0	5.29	0.252E 10	0.00267	64.6	65.5
10	25.5	34.6	35.3	31.2	9436.4	5.27	0.254E 10	0.00302	67.8	69.4
11	29.5	34.9	35.6	31.5	9481.1	5.25	0.257E 10	0.00350	67.1	68.5
12	33.5	35.5	36.0	31.7	9526.0	5.22	0.260E 10	0.00398	62.9	64.0
13	37.5	35.8	36.3	31.9	9571.2	5.19	0.262E 10	0.00445	61.7	62.9
14	41.5	36.1	36.5	32.2	9616.6	5.16	0.265E 10	0.00493	60.8	61.9
15	45.5	36.1	36.6	32.4	9662.3	5.14	0.268E 10	0.00541	64.7	66.3
16	49.5	36.4	37.4	32.6	9708.2	5.11	0.271E 10	0.00589	59.6	60.9
17	54.5	36.6	37.9	32.9	9766.0	5.07	0.275E 10	0.00649	58.9	60.2
18	59.5	37.0	38.3	33.2	9824.1	5.04	0.278E 10	0.00709	57.0	58.3
19	64.5	37.2	38.5	33.5	9882.6	5.01	0.282E 10	0.00769	58.7	60.2
20	69.5	37.7	38.8	33.8	9941.5	4.97	0.286E 10	0.00829	57.4	58.8
21	74.5	38.0	39.2	34.1	10000.8	4.94	0.289E 10	0.00889	56.4	57.8
22	79.5	38.7	39.5	34.4	10060.5	4.91	0.293E 10	0.00950	53.8	55.3
23	84.5	40.4	40.5	34.7	10120.6	4.88	0.297E 10	0.01010	43.8	45.1

FULLY DEVELOPED NUSSELT NUMBER= 59.3 60.7*

RUN NUMBER (1)   TUBE NUMBER 14

INPUT POWER= 500.0 W   HEAT GAINED BY WATER= 477.8   HEAT BALANCE ERROR= 4.4%

REM= 2311.8   RAM= 0.177E 11   PR= 4.84   GR= 0.196E 09

INLET BULK TEMP= 33.0 DEG C   OUTLET BULK TEMP= 37.0 DEG C

MASS FLOW RATE= 101.5 KG/HR   PRESSURE DROP= 130.1 PA   CF=0.0124

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	36.0	36.3	33.1	2223.0	5.06	0.163E 11	0.00033	35.0	44.4
2	3.5	37.1	37.1	33.2	2227.1	5.05	0.164E 11	0.00076	27.3	27.1
3	5.5	37.6	37.6	33.3	2231.2	5.04	0.164E 11	0.00120	24.7	25.2
4	7.5	37.9	38.0	33.4	2235.4	5.03	0.165E 11	0.00164	23.3	24.3
5	10.5	38.3	38.6	33.5	2241.6	5.01	0.166E 11	0.00229	21.7	22.3
6	13.5	38.7	38.7	33.6	2247.8	5.00	0.167E 11	0.00295	21.2	22.2
7	16.5	39.0	39.2	33.8	2254.1	4.98	0.168E 11	0.00361	20.3	20.8
8	19.5	39.2	39.0	33.9	2260.4	4.96	0.169E 11	0.00426	20.6	21.6
9	22.5	39.4	39.1	34.1	2266.7	4.95	0.170E 11	0.00492	20.5	21.6
10	25.5	39.6	39.6	34.2	2273.0	4.93	0.171E 11	0.00558	19.9	20.9
11	29.5	40.2	39.8	34.4	2281.5	4.91	0.172E 11	0.00646	19.0	19.7
12	33.5	40.2	40.1	34.6	2290.0	4.89	0.174E 11	0.00734	19.1	20.0
13	37.5	40.4	40.4	34.7	2298.5	4.87	0.175E 11	0.00822	18.9	19.8
14	41.5	40.5	40.7	34.9	2307.1	4.85	0.177E 11	0.00910	18.9	19.8
15	45.5	40.8	40.9	35.1	2315.7	4.83	0.178E 11	0.00998	18.5	19.3
16	49.5	40.9	41.0	35.3	2324.3	4.81	0.179E 11	0.01086	18.9	20.1
17	54.5	41.5	41.7	35.5	2335.1	4.79	0.181E 11	0.01196	17.6	18.4
18	59.5	41.6	41.6	35.8	2346.0	4.76	0.183E 11	0.01307	18.2	19.1
19	64.5	41.6	41.6	36.0	2357.0	4.74	0.185E 11	0.01417	19.0	20.2
20	69.5	41.9	42.0	36.2	2368.0	4.71	0.186E 11	0.01528	18.6	19.7
21	74.5	42.4	42.5	36.4	2379.0	4.69	0.188E 11	0.01638	17.8	18.6
22	79.5	42.3	42.2	36.7	2390.2	4.67	0.190E 11	0.01749	19.1	20.5
23	84.5	42.6	42.9	36.9	2401.3	4.64	0.192E 11	0.01860	18.2	20.0

FULLY DEVELOPED NUSSELT NUMBER= 18.7   19.7*

RUN NUMBER (2)   TUBE NUMBER 14

INPUT POWER= 990.0 W   HEAT GAINED BY WATER= 950.8   HEAT BALANCE ERROR= 4.0%

REM= 2549.6   RAM= 0.411E 11   PR= 4.46   GR= 0.466E 09

INLET BULK TEMP= 34.8 DEG C   OUTLET BULK TEMP= 42.6 DEG C

MASS FLOW RATE= 103.9 KG/HR   PRESSURE DROP= 123.7 PA   CF=0.0113

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	40.5	40.8	34.9	2361.6	4.85	0.352E 11	0.00032	37.4	46.8
2	3.5	42.5	42.4	35.1	2370.1	4.83	0.355E 11	0.00075	29.0	28.6
3	5.5	43.4	43.4	35.3	2378.7	4.81	0.357E 11	0.00118	26.3	26.9
4	7.5	44.0	44.2	35.5	2387.4	4.79	0.360E 11	0.00161	24.7	25.6
5	10.5	44.8	45.4	35.7	2400.4	4.76	0.364E 11	0.00225	22.7	23.1
6	13.5	45.5	45.4	36.0	2413.5	4.74	0.368E 11	0.00290	22.5	23.6
7	16.5	46.2	46.3	36.3	2426.6	4.71	0.372E 11	0.00355	21.3	21.7
8	19.5	46.5	46.2	36.6	2439.9	4.68	0.376E 11	0.00419	21.6	22.4
9	22.5	47.0	46.3	36.8	2453.2	4.65	0.381E 11	0.00484	21.7	22.7
10	25.5	47.5	47.2	37.1	2466.6	4.62	0.385E 11	0.00549	20.7	21.5
11	29.5	48.5	47.8	37.4	2484.6	4.59	0.390E 11	0.00635	19.8	20.4
12	33.5	48.5	48.3	37.8	2502.7	4.55	0.396E 11	0.00722	20.0	20.8
13	37.5	48.8	48.6	38.2	2521.0	4.51	0.402E 11	0.00809	20.0	20.9
14	41.5	49.2	49.3	38.5	2539.3	4.48	0.407E 11	0.00896	19.8	20.6
15	45.5	49.6	49.8	38.9	2557.9	4.44	0.413E 11	0.00983	19.6	20.3
16	49.5	49.8	49.7	39.2	2576.6	4.40	0.419E 11	0.01070	20.1	21.3
17	54.5	50.9	51.1	39.7	2600.1	4.36	0.426E 11	0.01180	18.6	19.2
18	59.5	51.1	51.1	40.1	2623.9	4.32	0.434E 11	0.01289	19.2	20.1
19	64.5	51.2	51.0	40.6	2647.8	4.27	0.441E 11	0.01399	20.1	21.1
20	69.5	51.6	51.0	41.0	2672.0	4.23	0.449E 11	0.01508	20.5	21.7
21	74.5	52.6	52.5	41.5	2696.4	4.19	0.456E 11	0.01618	19.1	19.7
22	79.5	52.4	52.2	41.9	2721.1	4.15	0.464E 11	0.01729	20.3	21.6
23	84.5	53.2	53.5	42.4	2745.9	4.11	0.471E 11	0.01839	19.2	20.8

FULLY DEVELOPED NUSSELT NUMBER= 19.8   20.7*

RUN NUMBER (3)   TUBE NUMBER 14

INPUT POWER= 1250.0 W   HEAT GAINED BY WATER= 1191.0   HEAT BALANCE ERROR= 4.7%

REM= 2565.9   RAM= 0.544E 11   PR= 4.31   GR= 0.639E 09

INLET BULK TEMP= 35.2 DEG C   OUTLET BULK TEMP= 45.2 DEG C

MASS FLOW RATE= 101.5 KG/HR   PRESSURE DROP= 123.7 PA   CF=0.0118

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	42.3	42.7	35.3	2325.7	4.81	0.448E 11	0.00033	37.2	47.1
2	3.5	45.0	44.9	35.6	2336.6	4.79	0.452E 11	0.00077	28.5	28.0
3	5.5	46.0	46.1	35.8	2347.4	4.76	0.457E 11	0.00121	26.0	26.9
4	7.5	46.8	47.1	36.0	2358.4	4.74	0.461E 11	0.00165	24.3	25.4
5	10.5	47.8	48.6	36.4	2374.9	4.70	0.468E 11	0.00231	22.4	23.0
6	13.5	48.7	48.5	36.7	2391.5	4.66	0.474E 11	0.00297	22.4	23.7
7	16.5	49.5	49.7	37.0	2408.2	4.63	0.481E 11	0.00363	21.2	21.8
8	19.5	50.0	49.5	37.4	2425.1	4.59	0.488E 11	0.00430	21.5	22.6
9	22.5	50.5	49.6	37.7	2442.1	4.56	0.495E 11	0.00496	21.6	22.9
10	25.5	51.2	50.8	38.1	2459.2	4.52	0.501E 11	0.00563	20.6	21.5
11	29.5	52.4	51.4	38.5	2482.3	4.47	0.511E 11	0.00652	19.8	20.6
12	33.5	52.5	52.0	39.0	2505.5	4.43	0.520E 11	0.00741	20.0	21.0
13	37.5	53.0	52.5	39.5	2529.0	4.38	0.529E 11	0.00830	19.9	20.9
14	41.5	53.4	53.2	39.9	2552.7	4.34	0.539E 11	0.00920	19.7	20.8
15	45.5	53.9	53.8	40.4	2576.6	4.29	0.548E 11	0.01009	19.6	20.5
16	49.5	54.2	53.9	40.8	2600.7	4.25	0.558E 11	0.01099	20.0	21.3
17	54.5	55.4	55.7	41.4	2631.2	4.20	0.570E 11	0.01211	18.7	19.5
18	59.5	55.6	55.6	42.0	2662.1	4.14	0.582E 11	0.01324	19.3	20.4
19	64.5	55.7	55.3	42.6	2693.3	4.09	0.594E 11	0.01437	20.3	21.7
20	69.5	56.3	56.3	43.1	2724.8	4.04	0.607E 11	0.01550	20.0	21.3
21	74.5	57.8	57.4	43.7	2756.7	3.99	0.619E 11	0.01663	18.9	19.8
22	79.5	57.3	57.0	44.3	2788.9	3.94	0.632E 11	0.01777	20.4	22.0
23	84.5	58.3	58.7	44.8	2821.4	3.89	0.645E 11	0.01890	19.2	21.1

FULLY DEVELOPED NUSSELT NUMBER= 19.7 20.9*

RUN NUMBER (4) TUBE NUMBER 14

INPUT POWER= 500.0 W HEAT GAINED BY WATER= 484.0 HEAT BALANCE ERROR= 3.2%

REM= 2791.0 RAM= 0.172E 11 PR= 4.96 GR= 0.155E 09

INLET BULK TEMP= 32.3 DEG C OUTLET BULK TEMP= 35.7 DEG C

MASS FLOW RATE= 125.1 KG/HR PRESSURE DROP= 189.0 PA CF=0.0119

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	35.0	35.2	32.4	2702.6	5.14	0.160E 11	0.00027	39.9	48.7
2	3.5	36.0	35.9	32.5	2706.7	5.13	0.161E 11	0.00062	31.4	30.7
3	5.5	36.3	36.4	32.6	2710.8	5.12	0.161E 11	0.00097	28.7	29.4
4	7.5	36.7	36.8	32.6	2714.9	5.11	0.162E 11	0.00133	26.7	27.2
5	10.5	36.9	37.3	32.7	2721.1	5.10	0.163E 11	0.00186	24.9	25.2
6	13.5	37.2	37.2	32.9	2727.4	5.08	0.164E 11	0.00239	25.1	26.0
7	16.5	37.4	37.6	33.0	2733.6	5.07	0.164E 11	0.00292	24.0	24.3
8	19.5	37.6	37.6	33.1	2739.9	5.06	0.165E 11	0.00345	24.3	24.9
9	22.5	37.7	37.5	33.2	2746.1	5.05	0.166E 11	0.00399	24.6	25.5
10	25.5	37.9	37.9	33.3	2752.4	5.03	0.167E 11	0.00452	23.7	24.4
11	29.5	38.5	38.2	33.5	2760.8	5.02	0.168E 11	0.00523	22.4	22.8
12	33.5	38.4	38.4	33.6	2769.3	5.00	0.169E 11	0.00594	22.7	23.3
13	37.5	38.6	38.6	33.8	2777.7	4.98	0.170E 11	0.00665	22.6	23.2
14	41.5	38.7	38.8	33.9	2786.2	4.96	0.171E 11	0.00736	22.5	23.2
15	45.5	38.9	39.0	34.1	2794.8	4.95	0.173E 11	0.00807	22.1	22.6
16	49.5	39.0	39.0	34.2	2803.3	4.93	0.174E 11	0.00879	22.6	23.5
17	54.5	39.5	39.7	34.4	2814.0	4.91	0.175E 11	0.00968	21.0	21.4
18	59.5	39.6	39.7	34.6	2824.8	4.89	0.177E 11	0.01057	21.6	22.2
19	64.5	39.5	39.6	34.8	2835.6	4.87	0.178E 11	0.01147	22.8	23.7
20	69.5	39.7	39.8	35.0	2846.5	4.85	0.179E 11	0.01236	22.8	23.6
21	74.5	40.2	40.3	35.2	2857.4	4.83	0.181E 11	0.01325	21.4	21.8
22	79.5	40.0	40.0	35.4	2868.4	4.81	0.182E 11	0.01415	23.4	24.5
23	84.5	40.4	40.6	35.5	2879.4	4.79	0.184E 11	0.01505	21.8	23.3

FULLY DEVELOPED NUSSELT NUMBER= 22.4 23.1*

RUN NUMBER (5)   TUBE NUMBER 14

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 911.5   HEAT BALANCE ERROR= 8.9%

REM= 2980.8   RAM= 0.371E 11   PR= 4.61   GR= 0.362E 09

INLET BULK TEMP= 34.1 DEG C   OUTLET BULK TEMP= 40.4 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 176.4 PA   CF=0.0111

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	39.1	39.3	34.2	2804.6	4.93	0.327E 11	0.00027	41.3	53.1
2	3.5	40.8	40.8	34.4	2812.7	4.91	0.329E 11	0.00062	31.9	33.0
3	5.5	41.4	41.5	34.5	2820.8	4.90	0.332E 11	0.00098	29.4	32.1
4	7.5	42.0	42.2	34.7	2828.9	4.88	0.334E 11	0.00133	27.6	30.2
5	10.5	42.6	43.2	34.9	2841.2	4.86	0.337E 11	0.00187	25.4	27.4
6	13.5	43.2	43.1	35.1	2853.5	4.83	0.340E 11	0.00240	25.4	28.2
7	16.5	43.7	44.0	35.3	2865.8	4.81	0.343E 11	0.00294	23.9	25.8
8	19.5	43.9	43.8	35.5	2878.3	4.79	0.346E 11	0.00347	24.5	27.1
9	22.5	44.3	43.8	35.7	2890.8	4.77	0.349E 11	0.00401	24.6	27.4
10	25.5	44.7	44.5	36.0	2903.3	4.74	0.352E 11	0.00454	23.6	26.0
11	29.5	45.6	45.0	36.2	2920.1	4.71	0.356E 11	0.00526	22.5	24.7
12	33.5	45.6	45.5	36.5	2937.0	4.68	0.361E 11	0.00598	22.6	25.0
13	37.5	45.8	45.7	36.8	2954.1	4.65	0.365E 11	0.00670	22.7	25.3
14	41.5	46.0	46.2	37.1	2971.2	4.62	0.369E 11	0.00742	22.5	25.1
15	45.5	46.4	46.6	37.4	2988.4	4.59	0.373E 11	0.00814	22.3	24.9
16	49.5	46.6	46.7	37.7	3005.8	4.56	0.378E 11	0.00886	22.7	25.7
17	54.5	47.6	47.9	38.0	3027.6	4.53	0.383E 11	0.00976	20.9	23.2
18	59.5	47.6	47.8	38.4	3049.6	4.49	0.388E 11	0.01066	21.8	24.6
19	64.5	47.6	47.6	38.7	3071.7	4.46	0.394E 11	0.01157	22.9	26.1
20	69.5	48.0	48.2	39.1	3094.0	4.42	0.399E 11	0.01247	22.4	25.6
21	74.5	49.0	49.1	39.4	3116.5	4.38	0.405E 11	0.01338	21.1	23.7
22	79.5	48.7	48.6	39.8	3139.2	4.35	0.411E 11	0.01429	22.8	26.4
23	84.5	49.5	49.9	40.2	3162.0	4.31	0.416E 11	0.01520	21.2	24.5

FULLY DEVELOPED NUSSELT NUMBER= 22.3 25.1*

RUN NUMBER (6)   TUBE NUMBER 14

INPUT POWER= 1240.0 W   HEAT GAINED BY WATER= 1137.4   HEAT BALANCE ERROR= 8.3%

REM= 2964.0   RAM= 0.458E 11   PR= 4.63   GR= 0.444E 09

INLET BULK TEMP= 33.1 DEG C   OUTLET BULK TEMP= 40.9 DEG C

MASS FLOW RATE= 125.1 KG/HR   PRESSURE DROP= 179.5 PA   CF=0.0113

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	39.2	39.7	33.2	2747.3	5.04	0.391E 11	0.00027	41.0	52.6
2	3.5	41.5	41.4	33.4	2757.2	5.02	0.394E 11	0.00062	31.7	32.8
3	5.5	42.3	42.4	33.6	2767.1	5.00	0.397E 11	0.00097	29.1	31.3
4	7.5	42.9	43.2	33.8	2777.0	4.98	0.400E 11	0.00133	27.5	30.0
5	10.5	43.7	44.6	34.0	2792.0	4.95	0.405E 11	0.00186	25.2	26.9
6	13.5	44.2	44.3	34.3	2807.1	4.92	0.409E 11	0.00240	25.5	28.1
7	16.5	45.0	45.3	34.6	2822.2	4.89	0.414E 11	0.00293	24.1	25.9
8	19.5	45.4	45.1	34.8	2837.5	4.86	0.419E 11	0.00347	24.5	26.8
9	22.5	45.8	45.1	35.1	2852.8	4.84	0.424E 11	0.00400	24.5	27.1
10	25.5	46.3	46.2	35.4	2868.3	4.81	0.428E 11	0.00454	23.4	25.7
11	29.5	47.4	46.7	35.7	2889.0	4.77	0.435E 11	0.00525	22.4	24.5
12	33.5	47.4	47.2	36.1	2909.9	4.73	0.441E 11	0.00597	22.6	24.8
13	37.5	47.6	47.5	36.4	2930.9	4.69	0.448E 11	0.00669	22.8	25.2
14	41.5	48.0	48.2	36.8	2952.2	4.66	0.455E 11	0.00741	22.4	24.8
15	45.5	48.5	48.8	37.1	2973.5	4.62	0.461E 11	0.00813	22.1	24.3
16	49.5	48.7	48.7	37.5	2995.1	4.58	0.468E 11	0.00885	22.6	25.4
17	54.5	49.8	50.4	37.9	3022.2	4.54	0.476E 11	0.00976	20.8	22.9
18	59.5	49.9	50.2	38.4	3049.6	4.49	0.485E 11	0.01066	21.7	24.2
19	64.5	49.9	49.8	38.8	3077.3	4.45	0.493E 11	0.01157	23.0	26.0
20	69.5	50.4	50.6	39.3	3105.2	4.40	0.502E 11	0.01248	22.5	25.3
21	74.5	51.7	51.7	39.7	3133.4	4.36	0.511E 11	0.01339	21.1	23.5
22	79.5	51.2	51.1	40.2	3161.9	4.32	0.519E 11	0.01430	22.9	26.2
23	84.5	52.1	52.8	40.6	3190.6	4.27	0.528E 11	0.01521	21.3	24.4

FULLY DEVELOPED NUSSELT NUMBER= 22.3 24.8*

RUN NUMBER (7)   TUBE NUMBER 14

INPUT POWER= 500.0 W   HEAT GAINED BY WATER= 501.4   HEAT BALANCE ERROR=-0.3%

REM= 3411.0   RAM= 0.172E 11   PR= 5.05   GR= 0.130E 09

INLET BULK TEMP= 31.8 DEG C   OUTLET BULK TEMP= 34.5 DEG C

MASS FLOW RATE= 155.5 KG/HR   PRESSURE DROP= 247.9 PA   CF=0.0101

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	34.2	34.5	31.8	3320.8	5.20	0.162E 11	0.00021	45.0	52.1
2	3.5	35.1	35.0	31.9	3325.0	5.19	0.162E 11	0.00050	35.9	33.9
3	5.5	35.3	35.4	32.0	3329.2	5.19	0.163E 11	0.00078	33.3	33.0
4	7.5	35.6	35.7	32.0	3333.4	5.18	0.163E 11	0.00107	30.9	30.2
5	10.5	35.9	36.2	32.1	3339.8	5.17	0.164E 11	0.00149	29.0	28.1
6	13.5	36.0	36.1	32.2	3346.1	5.16	0.165E 11	0.00192	29.4	29.3
7	16.5	36.3	36.5	32.3	3352.5	5.15	0.165E 11	0.00235	27.6	26.7
8	19.5	36.4	36.4	32.4	3358.9	5.14	0.166E 11	0.00277	28.4	28.0
9	22.5	36.5	36.3	32.5	3365.3	5.13	0.167E 11	0.00320	28.7	28.5
10	25.5	36.7	36.7	32.6	3371.7	5.11	0.168E 11	0.00363	27.6	27.1
11	29.5	37.2	36.8	32.7	3380.3	5.10	0.169E 11	0.00420	26.4	25.8
12	33.5	37.1	37.1	32.8	3388.9	5.09	0.170E 11	0.00477	26.6	26.2
13	37.5	37.2	37.2	33.0	3397.5	5.07	0.170E 11	0.00534	26.5	26.1
14	41.5	37.3	37.4	33.1	3406.1	5.06	0.171E 11	0.00591	26.3	25.8
15	45.5	37.5	37.6	33.2	3414.8	5.04	0.172E 11	0.00648	26.0	25.4
16	49.5	37.6	37.6	33.3	3423.5	5.03	0.173E 11	0.00706	26.6	26.4
17	54.5	38.0	38.3	33.5	3434.4	5.01	0.175E 11	0.00777	24.4	23.6
18	59.5	38.1	38.2	33.7	3445.4	4.99	0.176E 11	0.00849	25.1	24.5
19	64.5	38.0	38.1	33.8	3456.3	4.98	0.177E 11	0.00920	26.9	26.4
20	69.5	38.2	38.3	34.0	3467.4	4.96	0.178E 11	0.00992	26.4	25.9
21	74.5	38.6	38.7	34.1	3478.4	4.94	0.179E 11	0.01064	24.7	23.8
22	79.5	38.4	38.5	34.3	3489.5	4.92	0.181E 11	0.01136	27.2	26.8
23	84.5	38.8	39.0	34.5	3500.7	4.90	0.182E 11	0.01208	25.2	25.6

FULLY DEVELOPED NUSSELT NUMBER= 26.1   25.7*

RUN NUMBER (8)   TUBE NUMBER 14

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 972.5   HEAT BALANCE ERROR= 2.7%

REM= 3549.5   RAM= 0.363E 11   PR= 4.83   GR= 0.285E 09

INLET BULK TEMP= 32.5 DEG C   OUTLET BULK TEMP= 37.8 DEG C

MASS FLOW RATE= 155.5 KG/HR   PRESSURE DROP= 241.6 PA   CF=0.0098

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	37.1	37.4	32.6	3369.2	5.12	0.325E 11	0.00021	46.6	55.7
2	3.5	38.7	38.7	32.7	3377.5	5.10	0.326E 11	0.00050	36.4	35.5
3	5.5	39.2	39.4	32.8	3385.8	5.09	0.328E 11	0.00078	33.7	34.2
4	7.5	39.7	39.9	32.9	3394.2	5.08	0.330E 11	0.00107	31.8	32.4
5	10.5	40.2	40.9	33.1	3406.7	5.06	0.333E 11	0.00150	29.4	29.5
6	13.5	40.6	40.7	33.3	3419.4	5.04	0.335E 11	0.00192	29.7	30.6
7	16.5	41.0	41.4	33.5	3432.0	5.01	0.338E 11	0.00235	28.3	28.4
8	19.5	41.2	41.1	33.7	3444.8	4.99	0.341E 11	0.00278	29.2	29.9
9	22.5	41.4	41.1	33.8	3457.6	4.97	0.344E 11	0.00321	29.6	30.5
10	25.5	41.8	41.8	34.0	3470.4	4.95	0.346E 11	0.00364	28.1	28.6
11	29.5	42.7	42.2	34.3	3487.6	4.93	0.350E 11	0.00421	26.7	27.0
12	33.5	42.6	42.6	34.5	3504.9	4.90	0.354E 11	0.00479	27.1	27.6
13	37.5	42.8	42.8	34.8	3522.3	4.87	0.358E 11	0.00536	27.3	27.9
14	41.5	43.0	43.3	35.0	3539.8	4.84	0.361E 11	0.00594	26.7	27.2
15	45.5	43.3	43.7	35.2	3557.3	4.82	0.365E 11	0.00651	26.4	26.8
16	49.5	43.4	43.6	35.5	3575.0	4.79	0.369E 11	0.00709	27.1	28.0
17	54.5	44.3	44.9	35.8	3597.2	4.76	0.374E 11	0.00781	24.7	25.0
18	59.5	44.5	44.8	36.1	3619.6	4.73	0.378E 11	0.00854	25.4	25.9
19	64.5	44.4	44.5	36.4	3642.1	4.69	0.383E 11	0.00926	27.1	27.9
20	69.5	44.8	45.1	36.7	3664.8	4.66	0.388E 11	0.00998	26.4	27.1
21	74.5	45.7	45.9	37.0	3687.6	4.63	0.393E 11	0.01071	24.7	25.0
22	79.5	45.4	45.4	37.3	3710.6	4.60	0.398E 11	0.01144	26.9	27.9
23	84.5	46.0	46.6	37.6	3733.7	4.57	0.403E 11	0.01216	25.0	26.4

FULLY DEVELOPED NUSSELT NUMBER= 26.4   27.0*

RUN NUMBER (9)   TUBE NUMBER 14

INPUT POWER= 1240.0 W   HEAT GAINED BY WATER= 1221.1   HEAT BALANCE ERROR= 1.5%

REM= 3574.6   RAM= 0.473E 11   PR= 4.74   GR= 0.376E 09

INLET BULK TEMP= 32.6 DEG C   OUTLET BULK TEMP= 39.4 DEG C

MASS FLOW RATE= 154.0 KG/HR   PRESSURE DROP= 232.2 PA   CF=0.0096

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	38.5	38.8	32.7	3345.6	5.10	0.410E 11	0.00022	46.3	54.3
2	3.5	40.4	40.3	32.8	3356.1	5.08	0.413E 11	0.00050	36.7	35.3
3	5.5	41.0	41.2	33.0	3366.6	5.07	0.416E 11	0.00079	34.1	34.1
4	7.5	41.6	41.9	33.2	3377.2	5.05	0.419E 11	0.00108	32.1	32.3
5	10.5	42.2	43.2	33.4	3393.0	5.02	0.423E 11	0.00151	29.6	29.2
6	13.5	42.7	42.8	33.6	3409.0	5.00	0.427E 11	0.00194	30.1	30.6
7	16.5	43.3	43.7	33.9	3425.1	4.97	0.432E 11	0.00238	28.5	28.2
8	19.5	43.6	43.4	34.1	3441.2	4.95	0.436E 11	0.00281	29.1	29.3
9	22.5	43.9	43.4	34.3	3457.4	4.92	0.441E 11	0.00325	29.4	29.8
10	25.5	44.5	44.3	34.6	3473.7	4.89	0.445E 11	0.00368	27.8	27.9
11	29.5	45.5	44.8	34.9	3495.6	4.86	0.451E 11	0.00426	26.5	26.5
12	33.5	45.4	45.3	35.2	3517.6	4.83	0.457E 11	0.00484	26.8	27.0
13	37.5	45.7	45.6	35.5	3539.8	4.79	0.463E 11	0.00543	26.9	27.1
14	41.5	45.9	46.2	35.8	3562.1	4.76	0.469E 11	0.00601	26.7	26.9
15	45.5	46.3	46.7	36.1	3584.6	4.73	0.475E 11	0.00659	26.3	26.2
16	49.5	46.4	46.6	36.4	3607.2	4.69	0.481E 11	0.00718	27.1	27.6
17	54.5	47.5	48.1	36.8	3635.8	4.65	0.489E 11	0.00791	24.8	24.6
18	59.5	47.6	47.9	37.2	3664.5	4.61	0.497E 11	0.00864	25.9	25.9
19	64.5	47.6	47.5	37.6	3693.5	4.57	0.505E 11	0.00937	27.4	27.6
20	69.5	47.9	48.2	38.0	3722.7	4.53	0.513E 11	0.01011	26.9	27.1
21	74.5	49.1	49.3	38.4	3752.2	4.49	0.521E 11	0.01085	25.1	24.9
22	79.5	48.7	48.7	38.7	3781.9	4.45	0.529E 11	0.01158	27.3	27.8
23	84.5	49.5	50.3	39.1	3811.8	4.41	0.537E 11	0.01232	25.2	26.1

FULLY DEVELOPED NUSSELT NUMBER= 26.5   26.7*

RUN NUMBER (10) TUBE NUMBER 14

INPUT POWER= 1250.0 W HEAT GAINED BY WATER= 1214.6 HEAT BALANCE ERROR= 2.8%

REM= 4072.3 RAM= 0.449E 11 PR= 4.86 GR= 0.325E 09

INLET BULK TEMP= 32.0 DEG C OUTLET BULK TEMP= 37.8 DEG C

MASS FLOW RATE= 179.4 KG/HR PRESSURE DROP= 294.3 PA CF=0.0090

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	37.3	37.7	32.1	3848.8	5.18	0.397E 11	0.00018	50.1	58.9
2	3.5	39.1	39.1	32.2	3859.1	5.16	0.399E 11	0.00043	39.6	38.8
3	5.5	39.7	39.9	32.3	3869.4	5.14	0.401E 11	0.00068	36.8	37.3
4	7.5	40.2	40.5	32.5	3879.7	5.13	0.404E 11	0.00092	34.8	35.6
5	10.5	40.7	41.7	32.7	3895.3	5.11	0.407E 11	0.00130	31.9	31.9
6	13.5	41.2	41.3	32.9	3910.9	5.08	0.411E 11	0.00167	32.6	33.7
7	16.5	41.7	42.2	33.1	3926.6	5.06	0.415E 11	0.00204	30.7	30.8
8	19.5	41.9	41.8	33.3	3942.4	5.04	0.418E 11	0.00241	31.7	32.5
9	22.5	42.4	41.8	33.5	3958.2	5.02	0.422E 11	0.00278	31.6	32.5
10	25.5	42.7	42.7	33.7	3974.1	4.99	0.426E 11	0.00315	30.2	30.8
11	29.5	43.8	43.1	33.9	3995.4	4.96	0.431E 11	0.00365	28.6	29.0
12	33.5	43.7	43.6	34.2	4016.9	4.93	0.436E 11	0.00415	28.8	29.4
13	37.5	43.8	43.9	34.4	4038.4	4.91	0.441E 11	0.00465	29.0	29.6
14	41.5	44.0	44.4	34.7	4060.1	4.88	0.446E 11	0.00514	28.7	29.3
15	45.5	44.3	44.9	35.0	4082.0	4.85	0.451E 11	0.00564	28.3	28.8
16	49.5	44.5	44.7	35.2	4103.9	4.82	0.456E 11	0.00614	29.2	30.2
17	54.5	45.4	46.2	35.6	4131.5	4.78	0.462E 11	0.00677	26.6	26.9
18	59.5	45.6	45.9	35.9	4159.4	4.75	0.469E 11	0.00739	27.6	28.2
19	64.5	45.5	45.5	36.2	4187.4	4.71	0.475E 11	0.00802	29.4	30.3
20	69.5	45.8	46.1	36.6	4215.6	4.68	0.482E 11	0.00865	28.9	29.7
21	74.5	47.0	47.2	36.9	4244.0	4.64	0.489E 11	0.00928	26.7	27.0
22	79.5	46.4	46.4	37.2	4272.7	4.61	0.495E 11	0.00991	29.6	30.7
23	84.5	47.3	48.1	37.6	4301.5	4.57	0.502E 11	0.01054	26.7	28.1

FULLY DEVELOPED NUSSELT NUMBER= 28.4 29.1*

RUN NUMBER (11)   TUBE NUMBER 14

INPUT POWER= 1250.0 W   HEAT GAINED BY WATER= 1217.1   HEAT BALANCE ERROR= 2.6%

REM= 4741.9   RAM= 0.446E 11   PR= 4.88   GR= 0.293E 09

INLET BULK TEMP= 32.2 DEG C   OUTLET BULK TEMP= 37.2 DEG C

MASS FLOW RATE= 209.8 KG/HR   PRESSURE DROP= 374.8 PA   CF=0.0084

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	37.2	37.6	32.3	4517.9	5.15	0.401E 11	0.00016	53.9	62.4
2	3.5	38.8	38.8	32.4	4528.3	5.14	0.403E 11	0.00037	42.7	41.7
3	5.5	39.2	39.5	32.5	4538.6	5.13	0.405E 11	0.00058	40.1	40.5
4	7.5	39.7	40.0	32.6	4549.0	5.11	0.407E 11	0.00079	38.0	38.7
5	10.5	40.1	41.2	32.8	4564.6	5.09	0.411E 11	0.00111	34.8	34.7
6	13.5	40.5	40.7	32.9	4580.3	5.07	0.414E 11	0.00143	35.8	36.7
7	16.5	41.0	41.5	33.1	4596.1	5.05	0.417E 11	0.00174	33.7	33.8
8	19.5	41.2	41.2	33.3	4611.9	5.03	0.420E 11	0.00206	34.5	35.2
9	22.5	41.6	41.1	33.5	4627.8	5.02	0.423E 11	0.00238	34.7	35.6
10	25.5	41.9	42.0	33.6	4643.8	5.00	0.426E 11	0.00270	33.0	33.6
11	29.5	42.8	42.3	33.9	4665.1	4.97	0.431E 11	0.00312	31.4	31.8
12	33.5	42.6	42.7	34.1	4686.6	4.95	0.435E 11	0.00355	31.8	32.3
13	37.5	42.8	42.9	34.3	4708.1	4.92	0.439E 11	0.00397	32.0	32.6
14	41.5	43.1	43.4	34.5	4729.8	4.90	0.444E 11	0.00440	31.4	31.9
15	45.5	43.3	43.9	34.8	4751.6	4.87	0.448E 11	0.00482	30.9	31.2
16	49.5	43.4	43.7	35.0	4773.5	4.85	0.452E 11	0.00525	31.8	32.7
17	54.5	44.3	45.1	35.3	4801.0	4.81	0.458E 11	0.00579	28.9	29.2
18	59.5	44.4	44.9	35.6	4828.7	4.78	0.463E 11	0.00632	30.1	30.6
19	64.5	44.3	44.3	35.8	4856.6	4.75	0.469E 11	0.00686	32.2	33.0
20	69.5	44.5	45.0	36.1	4884.6	4.72	0.475E 11	0.00739	31.6	32.4
21	74.5	45.7	45.9	36.4	4912.9	4.69	0.480E 11	0.00793	29.1	29.3
22	79.5	45.0	45.1	36.7	4941.2	4.66	0.486E 11	0.00847	32.5	33.5
23	84.5	45.8	46.7	37.0	4969.8	4.63	0.491E 11	0.00901	29.4	30.8

FULLY DEVELOPED NUSSELT NUMBER= 31.2   31.8*

RUN NUMBER (12)   TUBE NUMBER 14

INPUT POWER= 1240.0 W   HEAT GAINED BY WATER= 1236.9   HEAT BALANCE ERROR= 0.3%

REM= 5129.5   RAM= 0.436E 11   PR= 4.98   GR= 0.257E 09

INLET BULK TEMP= 31.5 DEG C   OUTLET BULK TEMP= 36.0 DEG C

MASS FLOW RATE= 231.1 KG/HR   PRESSURE DROP= 436.9 PA   CF=0.0081

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	36.2	36.6	31.5	4905.9	5.24	0.394E 11	0.00014	57.4	64.5
2	3.5	37.7	37.7	31.6	4916.3	5.22	0.396E 11	0.00033	46.1	44.0
3	5.5	38.1	38.3	31.7	4926.6	5.21	0.398E 11	0.00053	43.4	42.9
4	7.5	38.5	38.8	31.9	4937.0	5.20	0.400E 11	0.00072	41.0	40.5
5	10.5	38.8	39.9	32.0	4952.6	5.18	0.403E 11	0.00100	38.1	37.1
6	13.5	39.3	39.4	32.2	4968.3	5.16	0.406E 11	0.00129	39.0	39.0
7	16.5	39.7	40.1	32.3	4984.1	5.15	0.409E 11	0.00158	36.8	35.8
8	19.5	39.9	39.8	32.5	4999.8	5.13	0.412E 11	0.00187	37.9	37.6
9	22.5	40.2	39.8	32.6	5015.7	5.11	0.415E 11	0.00215	38.0	37.8
10	25.5	40.6	40.5	32.8	5031.6	5.09	0.418E 11	0.00244	35.8	35.3
11	29.5	41.5	40.9	33.0	5052.9	5.07	0.422E 11	0.00283	34.1	33.5
12	33.5	41.3	41.3	33.2	5074.3	5.04	0.426E 11	0.00321	34.5	34.0
13	37.5	41.4	41.5	33.4	5095.8	5.02	0.430E 11	0.00360	34.6	34.2
14	41.5	41.6	42.0	33.6	5117.4	5.00	0.434E 11	0.00398	34.2	33.7
15	45.5	41.8	42.4	33.8	5139.1	4.97	0.438E 11	0.00437	33.8	33.2
16	49.5	41.9	42.2	34.1	5160.9	4.95	0.442E 11	0.00476	34.9	34.7
17	54.5	42.7	43.5	34.3	5188.3	4.92	0.447E 11	0.00524	31.7	30.9
18	59.5	42.8	43.2	34.6	5215.8	4.89	0.452E 11	0.00572	32.9	32.3
19	64.5	42.6	42.7	34.8	5243.6	4.86	0.457E 11	0.00621	35.4	35.0
20	69.5	42.9	43.3	35.1	5271.4	4.83	0.462E 11	0.00669	34.7	34.2
21	74.5	44.0	44.2	35.4	5299.5	4.81	0.467E 11	0.00718	31.7	30.8
22	79.5	43.4	43.5	35.6	5327.7	4.78	0.472E 11	0.00767	35.5	35.3
23	84.5	44.2	45.0	35.9	5356.0	4.75	0.478E 11	0.00815	31.8	32.3

FULLY DEVELOPED NUSSELT NUMBER= 34.0   33.5*

RUN NUMBER (13) TUBE NUMBER 14

INPUT POWER= 1250.0 W HEAT GAINED BY WATER= 1204.9 HEAT BALANCE ERROR= 3.6%

REM= 7620.7 RAM= 0.485E 11 PR= 4.64 GR= 0.238E 09

INLET BULK TEMP= 35.3 DEG C OUTLET BULK TEMP= 38.5 DEG C

MASS FLOW RATE= 322.3 KG/HR PRESSURE DROP= 781.6 PA CF=0.0074

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	39.0	39.4	35.3	7385.3	4.81	0.455E 11	0.00010	70.2	79.0
2	3.5	40.0	40.0	35.4	7396.2	4.80	0.456E 11	0.00024	58.5	58.6
3	5.5	40.3	40.5	35.5	7407.2	4.79	0.458E 11	0.00038	55.1	56.3
4	7.5	40.5	40.8	35.6	7418.2	4.78	0.459E 11	0.00052	52.8	54.2
5	10.5	40.7	41.7	35.7	7434.8	4.77	0.461E 11	0.00073	48.9	49.4
6	13.5	41.0	41.2	35.8	7451.4	4.76	0.463E 11	0.00093	50.8	52.7
7	16.5	41.4	41.9	35.9	7468.0	4.75	0.466E 11	0.00114	47.0	47.5
8	19.5	41.5	41.5	36.0	7484.6	4.74	0.468E 11	0.00135	49.3	50.8
9	22.5	41.8	41.3	36.1	7501.4	4.73	0.470E 11	0.00156	49.4	51.1
10	25.5	42.1	42.1	36.2	7518.1	4.71	0.472E 11	0.00177	46.0	47.2
11	29.5	42.9	42.3	36.4	7540.5	4.70	0.475E 11	0.00204	43.4	44.3
12	33.5	42.5	42.7	36.5	7562.9	4.68	0.478E 11	0.00232	44.3	45.5
13	37.5	42.7	42.7	36.7	7585.5	4.67	0.481E 11	0.00260	44.8	46.1
14	41.5	42.7	43.1	36.8	7608.1	4.65	0.484E 11	0.00288	44.4	45.6
15	45.5	42.8	43.4	37.0	7630.8	4.64	0.486E 11	0.00316	43.8	44.9
16	49.5	42.9	43.1	37.1	7653.5	4.62	0.489E 11	0.00343	45.8	47.6
17	54.5	43.7	44.4	37.3	7682.0	4.60	0.493E 11	0.00378	39.9	40.7
18	59.5	43.7	44.1	37.5	7710.7	4.58	0.497E 11	0.00413	42.1	43.3
19	64.5	43.4	43.5	37.7	7739.4	4.56	0.500E 11	0.00448	46.5	48.2
20	69.5	43.5	44.0	37.8	7768.3	4.55	0.504E 11	0.00483	45.5	47.1
21	74.5	44.5	44.8	38.0	7797.3	4.53	0.508E 11	0.00518	40.6	41.4
22	79.5	44.0	44.1	38.2	7826.4	4.51	0.511E 11	0.00553	46.3	48.4
23	84.5	44.6	45.5	38.4	7855.6	4.49	0.515E 11	0.00588	40.3	42.3

FULLY DEVELOPED NUSSELT NUMBER= 43.9 45.2*

RUN NUMBER (14)   TUBE NUMBER 14

INPUT POWER= 1250.0 W   HEAT GAINED BY WATER= 1205.6   HEAT BALANCE ERROR= 3.6%

REM= 10785.4   RAM= 0.462E 11   PR= 4.77   GR= 0.164E 09

INLET BULK TEMP= 34.6 DEG C   OUTLET BULK TEMP= 36.8 DEG C

MASS FLOW RATE= 467.5 KG/HR   PRESSURE DROP= 1545.2 PA   CF=0.0070

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	37.6	38.0	34.6	10554.6	4.89	0.441E 11	0.00007	84.3	92.5
2	3.5	38.4	38.3	34.6	10565.4	4.88	0.442E 11	0.00017	73.9	74.4
3	5.5	38.4	38.6	34.7	10576.2	4.88	0.443E 11	0.00026	70.9	72.6
4	7.5	38.6	38.9	34.7	10587.1	4.87	0.444E 11	0.00036	67.2	68.7
5	10.5	38.6	39.6	34.8	10603.3	4.86	0.446E 11	0.00050	62.8	63.4
6	13.5	38.8	39.0	34.9	10619.6	4.86	0.447E 11	0.00064	67.5	69.8
7	16.5	39.1	39.6	35.0	10635.9	4.85	0.449E 11	0.00079	62.0	62.6
8	19.5	39.1	39.1	35.1	10652.3	4.84	0.450E 11	0.00093	67.3	69.3
9	22.5	39.4	39.0	35.1	10668.7	4.83	0.452E 11	0.00107	66.3	68.2
10	25.5	39.6	39.6	35.2	10685.1	4.82	0.453E 11	0.00121	62.1	63.6
11	29.5	40.3	39.7	35.3	10707.0	4.81	0.455E 11	0.00141	57.8	58.9
12	33.5	40.0	40.0	35.4	10729.0	4.80	0.457E 11	0.00160	59.4	60.8
13	37.5	39.9	40.0	35.5	10751.0	4.79	0.459E 11	0.00179	60.4	62.0
14	41.5	40.0	40.3	35.6	10773.0	4.78	0.461E 11	0.00198	59.8	61.3
15	45.5	40.1	40.6	35.7	10795.2	4.77	0.463E 11	0.00217	58.6	59.8
16	49.5	40.0	40.2	35.8	10817.3	4.76	0.465E 11	0.00236	62.7	65.0
17	54.5	40.7	41.4	35.9	10845.1	4.74	0.467E 11	0.00260	53.0	54.0
18	59.5	40.7	41.1	36.1	10872.9	4.73	0.470E 11	0.00284	56.3	57.7
19	64.5	40.5	40.5	36.2	10900.9	4.72	0.472E 11	0.00308	62.8	64.8
20	69.5	40.5	41.0	36.3	10928.9	4.70	0.475E 11	0.00332	60.9	62.8
21	74.5	41.4	41.6	36.4	10956.9	4.69	0.477E 11	0.00356	53.4	54.4
22	79.5	40.7	40.9	36.6	10985.1	4.68	0.480E 11	0.00380	63.7	66.4
23	84.5	41.3	42.2	36.7	11013.3	4.66	0.482E 11	0.00404	53.0	55.2

FULLY DEVELOPED NUSSELT NUMBER= 58.9   60.5*

RUN NUMBER (1) TUBE NUMBER 20

INPUT POWER= 1000.0 W HEAT GAINED BY WATER= 966.7 HEAT BALANCE ERROR= 3.3%

REM= 744.5 RAM= 0.405E 10 PR= 3.75 GR= 0.183E 09

INLET BULK TEMP= 30.2 DEG C OUTLET BULK TEMP= 63.0 DEG C

MASS FLOW RATE= 25.1 KG/HR PRESSURE DROP= 46.2 PA CF=0.0093

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	46.3	46.0	30.8	541.8	5.33	0.217E 10	0.00247	7.6	12.9
2	3.5	53.5	52.8	31.5	549.9	5.24	0.225E 10	0.00577	5.4	5.3
3	5.5	60.0	57.6	32.3	558.3	5.15	0.233E 10	0.00909	4.4	4.0
4	7.5	62.8	61.2	33.0	566.7	5.06	0.241E 10	0.01242	4.0	3.9
5	10.5	66.3	62.6	34.2	579.7	4.94	0.253E 10	0.01743	3.8	3.9
6	13.5	68.4	64.6	35.3	593.0	4.81	0.266E 10	0.02246	3.7	3.7
7	16.5	69.2	65.6	36.4	606.7	4.69	0.278E 10	0.02752	3.7	3.9
8	19.5	70.9	66.2	37.5	620.6	4.58	0.291E 10	0.03261	3.7	3.8
9	22.5	71.2	66.1	38.6	635.0	4.46	0.305E 10	0.03772	3.8	3.8
10	25.5	70.7	62.8	39.8	649.6	4.35	0.318E 10	0.04285	4.2	4.3
11	29.5	67.0	57.6	41.3	669.7	4.21	0.337E 10	0.04972	5.4	5.9
12	33.5	63.7	56.1	42.8	690.3	4.07	0.356E 10	0.05663	6.6	7.5
13	37.5	64.6	59.2	44.3	711.6	3.94	0.375E 10	0.06357	6.4	6.9
14	41.5	66.2	62.6	45.8	733.5	3.81	0.395E 10	0.07053	6.1	6.6
15	45.5	69.5	67.5	47.3	755.9	3.69	0.416E 10	0.07751	5.3	5.4
16	49.5	70.4	67.4	48.8	778.9	3.57	0.437E 10	0.08450	5.6	6.0
17	54.5	72.3	67.5	50.6	804.2	3.45	0.461E 10	0.09323	5.8	6.3
18	59.5	73.5	69.3	52.5	821.2	3.37	0.481E 10	0.10206	5.9	6.3
19	64.5	73.0	70.0	54.4	839.3	3.29	0.501E 10	0.11093	6.5	7.2
20	69.5	75.7	71.3	56.2	858.6	3.21	0.522E 10	0.11985	6.4	7.0
21	74.5	77.1	74.5	58.1	879.1	3.13	0.543E 10	0.12882	6.2	6.8
22	79.5	79.0	75.6	60.0	901.1	3.04	0.565E 10	0.13783	6.3	7.0
23	84.5	81.4	77.8	61.9	924.6	2.96	0.588E 10	0.14690	6.2	6.9

FULLY DEVELOPED NUSSELT NUMBER= 5.9 6.4*

RUN NUMBER (2)   TUBE NUMBER 20

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 1020.8   HEAT BALANCE ERROR=-2.1%

REM= 1020.6   RAM= 0.357E 10   PR= 4.21   GR= 0.112E 09

INLET BULK TEMP= 29.9 DEG C   OUTLET BULK TEMP= 52.6 DEG C

MASS FLOW RATE= 38.3 KG/HR   PRESSURE DROP= 77.3 PA   CF=0.0067

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	39.6	39.7	30.3	817.6	5.39	0.225E 10	0.00162	13.1	17.5
2	3.5	43.1	43.4	30.8	826.2	5.33	0.230E 10	0.00378	9.9	9.3
3	5.5	46.4	45.5	31.3	834.8	5.27	0.236E 10	0.00594	8.4	7.7
4	7.5	47.1	47.7	31.8	843.6	5.20	0.242E 10	0.00812	7.9	7.6
5	10.5	49.5	48.4	32.6	856.9	5.11	0.251E 10	0.01138	7.5	7.3
6	13.5	50.7	50.4	33.4	870.5	5.02	0.260E 10	0.01466	7.1	6.8
7	16.5	51.6	50.8	34.2	884.4	4.94	0.269E 10	0.01795	7.2	7.0
8	19.5	52.6	51.9	34.9	898.4	4.85	0.278E 10	0.02125	7.1	6.7
9	22.5	53.0	51.9	35.7	912.7	4.77	0.287E 10	0.02457	7.3	7.1
10	25.5	54.4	52.4	36.5	927.3	4.68	0.297E 10	0.02789	7.2	7.0
11	29.5	55.7	53.7	37.5	947.1	4.58	0.309E 10	0.03234	7.1	6.8
12	33.5	55.9	54.6	38.6	967.3	4.47	0.322E 10	0.03681	7.3	7.1
13	37.5	57.3	55.7	39.6	988.0	4.37	0.336E 10	0.04130	7.2	6.8
14	41.5	57.4	56.1	40.7	1009.1	4.27	0.349E 10	0.04580	7.5	7.4
15	45.5	59.1	59.0	41.7	1030.7	4.17	0.363E 10	0.05032	7.0	6.5
16	49.5	59.2	58.2	42.8	1052.7	4.07	0.377E 10	0.05485	7.6	7.3
17	54.5	60.7	58.8	44.1	1080.9	3.96	0.395E 10	0.06054	7.6	7.3
18	59.5	62.5	61.1	45.4	1109.7	3.85	0.414E 10	0.06624	7.3	6.8
19	64.5	61.9	60.9	46.7	1139.2	3.74	0.432E 10	0.07196	8.1	7.8
20	69.5	63.9	61.6	48.0	1169.4	3.63	0.452E 10	0.07769	8.0	7.6
21	74.5	64.7	63.7	49.3	1200.2	3.53	0.471E 10	0.08342	8.0	7.5
22	79.5	65.8	64.1	50.6	1225.9	3.46	0.489E 10	0.08914	8.2	7.8
23	84.5	68.2	66.0	51.9	1243.7	3.40	0.503E 10	0.09493	7.8	7.7

FULLY DEVELOPED NUSSELT NUMBER= 7.6   7.2*

RUN NUMBER (3)   TUBE NUMBER 20

INPUT POWER= 1450.0 W   HEAT GAINED BY WATER= 1397.2   HEAT BALANCE ERROR= 3.6%

REM= 3939.4   RAM= 0.356E 10   PR= 5.03   GR= 0.295E 08

INLET BULK TEMP= 29.9 DEG C   OUTLET BULK TEMP= 36.8 DEG C

MASS FLOW RATE= 173.4 KG/HR   PRESSURE DROP= 1179.2 PA   CF=0.0050

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	35.0	35.2	30.0	3683.6	5.42	0.305E 10	0.00036	33.1	37.6
2	3.5	36.0	36.5	30.1	3696.0	5.40	0.308E 10	0.00083	27.7	28.5
3	5.5	37.8	37.1	30.3	3707.7	5.39	0.310E 10	0.00131	23.8	23.5
4	7.5	36.9	38.1	30.4	3719.4	5.37	0.312E 10	0.00178	23.9	24.5
5	10.5	37.7	37.3	30.7	3737.1	5.34	0.316E 10	0.00250	24.7	25.7
6	13.5	38.1	38.4	30.9	3754.9	5.31	0.319E 10	0.00322	23.1	23.4
7	16.5	37.7	38.2	31.2	3772.8	5.28	0.323E 10	0.00393	24.9	25.9
8	19.5	38.1	38.7	31.4	3790.8	5.25	0.327E 10	0.00465	24.2	24.7
9	22.5	38.3	38.4	31.6	3808.8	5.23	0.330E 10	0.00537	25.1	26.1
10	25.5	39.1	38.7	31.9	3827.0	5.20	0.334E 10	0.00609	23.9	24.6
11	29.5	39.4	39.0	32.2	3851.4	5.16	0.339E 10	0.00705	24.0	24.6
12	33.5	38.9	39.6	32.5	3876.0	5.13	0.344E 10	0.00801	24.9	25.9
13	37.5	40.3	40.0	32.8	3900.7	5.09	0.349E 10	0.00897	23.0	23.5
14	41.5	39.1	40.2	33.1	3925.6	5.05	0.354E 10	0.00994	25.7	27.2
15	45.5	40.5	43.0	33.4	3950.7	5.02	0.358E 10	0.01091	20.3	20.4
16	49.5	39.8	41.0	33.8	3976.0	4.98	0.364E 10	0.01187	25.4	26.7
17	54.5	40.9	40.8	34.2	4007.8	4.94	0.370E 10	0.01308	25.2	26.4
18	59.5	42.6	43.1	34.6	4040.0	4.89	0.376E 10	0.01430	20.2	20.5
19	64.5	40.9	41.8	34.9	4072.4	4.85	0.383E 10	0.01551	26.3	27.7
20	69.5	41.7	42.0	35.3	4105.1	4.81	0.389E 10	0.01673	25.8	27.0
21	74.5	42.4	43.6	35.7	4138.1	4.76	0.396E 10	0.01795	23.1	23.9
22	79.5	42.6	43.2	36.1	4171.3	4.72	0.402E 10	0.01917	24.9	26.1
23	84.5	44.1	43.8	36.5	4204.9	4.68	0.409E 10	0.02039	22.6	23.7

FULLY DEVELOPED NUSSELT NUMBER= 24.0 24.9*

RUN NUMBER (4)   TUBE NUMBER 20

INPUT POWER= 1450.0 W   HEAT GAINED BY WATER= 1438.1   HEAT BALANCE ERROR= 0.8%

REM= 5125.1   RAM= 0.343E 10   PR= 5.20   GR= 0.231E 08

INLET BULK TEMP= 29.2 DEG C   OUTLET BULK TEMP= 34.5 DEG C

MASS FLOW RATE= 232.3 KG/HR   PRESSURE DROP= 1844.8 PA   CF=0.0044

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU	NUA (AVERAGE)
1	1.5	33.7	33.9	29.3	4866.6	5.51	0.305E 10	0.00027	38.4	41.8
2	3.5	34.5	35.2	29.4	4878.8	5.50	0.306E 10	0.00062	32.2	32.0
3	5.5	36.3	35.5	29.5	4890.9	5.48	0.308E 10	0.00097	27.4	26.2
4	7.5	35.3	36.5	29.6	4903.0	5.47	0.310E 10	0.00133	27.9	27.7
5	10.5	36.0	35.6	29.8	4921.0	5.44	0.312E 10	0.00186	29.1	29.2
6	13.5	36.3	36.6	30.0	4939.1	5.42	0.315E 10	0.00240	27.2	26.5
7	16.5	35.8	36.3	30.2	4958.1	5.40	0.318E 10	0.00293	29.9	30.0
8	19.5	36.2	36.8	30.4	4976.2	5.38	0.320E 10	0.00346	28.4	27.9
9	22.5	36.3	36.5	30.5	4994.4	5.35	0.323E 10	0.00400	29.9	29.9
10	25.5	37.1	36.6	30.7	5012.6	5.33	0.326E 10	0.00453	28.5	28.2
11	29.5	37.3	36.9	31.0	5037.1	5.30	0.330E 10	0.00525	28.5	28.2
12	33.5	36.7	37.4	31.2	5061.7	5.28	0.334E 10	0.00596	29.8	29.7
13	37.5	38.0	37.7	31.5	5086.4	5.25	0.337E 10	0.00668	27.2	26.6
14	41.5	36.8	37.8	31.7	5111.2	5.22	0.341E 10	0.00739	31.0	31.3
15	45.5	38.0	40.5	31.9	5136.2	5.19	0.345E 10	0.00811	23.9	23.0
16	49.5	37.3	38.5	32.2	5161.4	5.16	0.349E 10	0.00883	30.4	30.5
17	54.5	38.3	38.1	32.5	5193.0	5.13	0.354E 10	0.00973	30.3	30.3
18	59.5	39.9	40.5	32.8	5224.8	5.09	0.359E 10	0.01063	23.4	22.7
19	64.5	38.2	39.1	33.1	5256.9	5.06	0.364E 10	0.01153	31.3	31.3
20	69.5	38.9	39.1	33.4	5289.2	5.02	0.368E 10	0.01243	30.9	30.6
21	74.5	39.4	40.6	33.7	5321.7	4.99	0.373E 10	0.01333	27.5	27.0
22	79.5	39.5	40.1	34.0	5354.4	4.95	0.378E 10	0.01424	29.9	29.7
23	84.5	41.0	40.6	34.3	5387.3	4.92	0.383E 10	0.01514	26.8	27.0

FULLY DEVELOPED NUSSELT NUMBER= 28.5 28.3*

RUN NUMBER (5)   TUBE NUMBER 20

INPUT POWER= 1420.0 W   HEAT GAINED BY WATER= 1342.1   HEAT BALANCE ERROR= 5.5%

REM= 1941.6   RAM= 0.431E 10   PR= 4.44   GR= 0.723E 08

INLET BULK TEMP= 31.4 DEG C   OUTLET BULK TEMP= 46.5 DEG C

MASS FLOW RATE= 76.3 KG/HR   PRESSURE DROP= 287.6 PA   CF=0.0063

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	38.8	38.8	31.6	1676.2	5.22	0.317E 10	0.00081	22.7	28.5
2	3.5	41.0	41.6	32.0	1687.9	5.18	0.322E 10	0.00190	17.4	18.0
3	5.5	43.4	43.0	32.3	1699.6	5.14	0.327E 10	0.00299	14.9	15.1
4	7.5	43.2	44.8	32.7	1711.4	5.10	0.332E 10	0.00408	14.3	14.9
5	10.5	44.3	44.4	33.2	1729.3	5.05	0.340E 10	0.00572	14.5	15.5
6	13.5	45.3	45.7	33.7	1747.4	4.99	0.348E 10	0.00736	13.7	14.3
7	16.5	45.6	46.2	34.2	1765.8	4.93	0.356E 10	0.00901	13.9	14.8
8	19.5	46.1	47.0	34.8	1784.3	4.87	0.364E 10	0.01066	13.6	14.4
9	22.5	46.7	47.0	35.3	1803.0	4.82	0.372E 10	0.01231	13.9	14.9
10	25.5	47.9	48.0	35.8	1822.0	4.76	0.380E 10	0.01397	13.2	14.0
11	29.5	48.6	48.3	36.5	1847.6	4.69	0.391E 10	0.01618	13.4	14.4
12	33.5	48.6	49.2	37.2	1873.6	4.61	0.402E 10	0.01841	13.6	14.7
13	37.5	50.1	50.2	37.9	1900.0	4.54	0.413E 10	0.02063	13.0	13.8
14	41.5	49.4	50.5	38.5	1926.8	4.47	0.425E 10	0.02287	14.0	15.5
15	45.5	51.2	54.1	39.2	1954.0	4.41	0.436E 10	0.02511	11.9	12.3
16	49.5	51.0	51.9	39.9	1981.5	4.34	0.448E 10	0.02736	13.9	15.3
17	54.5	52.6	52.0	40.8	2016.5	4.26	0.463E 10	0.03017	13.8	15.1
18	59.5	54.7	55.0	41.6	2052.1	4.17	0.478E 10	0.03300	12.1	12.8
19	64.5	53.2	54.2	42.5	2088.3	4.09	0.493E 10	0.03583	14.2	15.7
20	69.5	55.5	54.3	43.4	2125.2	4.02	0.509E 10	0.03867	13.8	15.1
21	74.5	55.7	56.4	44.2	2162.6	3.94	0.525E 10	0.04152	13.4	14.6
22	79.5	55.9	56.0	45.1	2200.6	3.87	0.541E 10	0.04437	14.5	16.2
23	84.5	57.9	57.4	45.9	2239.2	3.80	0.557E 10	0.04723	13.5	14.9

FULLY DEVELOPED NUSSELT NUMBER= 13.4   14.6*

RUN NUMBER (6)   TUBE NUMBER 20

INPUT POWER= 1450.0 W   HEAT GAINED BY WATER= 1393.0   HEAT BALANCE ERROR= 3.9%

REM= 2880.3   RAM= 0.380E 10   PR= 4.86   GR= 0.423E 08

INLET BULK TEMP= 30.0 DEG C   OUTLET BULK TEMP= 39.8 DEG C

MASS FLOW RATE= 122.8 KG/HR   PRESSURE DROP= 686.1 PA   CF=0.0058

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	36.1	36.1	30.2	2620.9	5.40	0.307E 10	0.00050	28.5	33.7
2	3.5	37.4	38.2	30.4	2632.6	5.37	0.311E 10	0.00118	22.8	23.3
3	5.5	39.3	39.1	30.6	2644.3	5.34	0.314E 10	0.00185	19.7	19.7
4	7.5	38.8	40.5	30.9	2656.1	5.32	0.317E 10	0.00252	19.2	19.5
5	10.5	39.4	39.7	31.2	2673.9	5.28	0.322E 10	0.00354	20.1	21.1
6	13.5	40.1	40.7	31.5	2691.9	5.24	0.327E 10	0.00455	18.9	19.3
7	16.5	40.2	41.0	31.9	2710.0	5.20	0.332E 10	0.00556	19.3	20.1
8	19.5	40.5	41.5	32.2	2728.2	5.16	0.338E 10	0.00658	19.2	19.8
9	22.5	40.9	41.3	32.5	2746.6	5.12	0.343E 10	0.00760	19.7	20.7
10	25.5	42.0	42.3	32.9	2765.1	5.08	0.348E 10	0.00862	18.2	18.7
11	29.5	42.4	42.0	33.3	2789.9	5.03	0.355E 10	0.00998	18.9	19.6
12	33.5	42.0	42.6	33.8	2815.1	4.98	0.362E 10	0.01135	19.6	20.5
13	37.5	43.4	43.5	34.2	2840.5	4.93	0.369E 10	0.01271	18.1	18.6
14	41.5	42.5	43.8	34.6	2866.1	4.88	0.376E 10	0.01408	19.8	21.1
15	45.5	44.0	47.2	35.1	2892.0	4.84	0.383E 10	0.01546	15.9	16.0
16	49.5	43.6	44.7	35.5	2918.1	4.79	0.391E 10	0.01683	19.4	20.6
17	54.5	45.0	44.7	36.1	2951.2	4.73	0.400E 10	0.01856	19.0	20.1
18	59.5	46.9	47.5	36.6	2984.6	4.67	0.409E 10	0.02028	15.8	16.1
19	64.5	45.0	46.3	37.2	3018.5	4.61	0.418E 10	0.02202	19.8	21.1
20	69.5	47.3	46.1	37.8	3052.7	4.55	0.428E 10	0.02375	18.5	19.5
21	74.5	47.3	48.1	38.3	3087.4	4.50	0.438E 10	0.02549	17.8	18.6
22	79.5	47.1	47.3	38.9	3122.5	4.44	0.447E 10	0.02723	19.9	21.3
23	84.5	48.7	48.4	39.4	3158.0	4.39	0.457E 10	0.02898	18.2	19.4

FULLY DEVELOPED NUSSELT NUMBER= 18.5   19.4*

RUN NUMBER (7)   TUBE NUMBER 20

INPUT POWER= 1000.0 W   HEAT GAINED BY WATER= 1022.0   HEAT BALANCE ERROR=-2.2%

REM= 1256.8   RAM= 0.323E 10   PR= 4.47   GR= 0.759E 08

INLET BULK TEMP= 29.8 DEG C   OUTLET BULK TEMP= 47.4 DEG C

MASS FLOW RATE= 49.7 KG/HR   PRESSURE DROP= 125.3 PA   CF=0.0064

STATION NO	X CM	TW(TOP) DEG C	TW(BOTTOM) DEGC	TBULK DEG C	RE	PR	RA	X+	NU (AVERAGE)	NUA
1	1.5	37.4	37.3	30.1	1059.3	5.41	0.224E 10	0.00124	17.1	21.2
2	3.5	39.8	40.0	30.5	1067.8	5.36	0.228E 10	0.00291	13.2	12.5
3	5.5	42.2	41.6	30.9	1076.4	5.31	0.233E 10	0.00457	11.2	10.4
4	7.5	42.5	43.3	31.3	1085.1	5.26	0.237E 10	0.00624	10.7	10.3
5	10.5	44.0	43.6	31.9	1098.3	5.19	0.244E 10	0.00875	10.4	10.1
6	13.5	44.9	45.0	32.5	1111.7	5.12	0.251E 10	0.01126	9.9	9.5
7	16.5	45.6	45.8	33.1	1125.3	5.05	0.257E 10	0.01378	9.8	9.5
8	19.5	46.4	46.4	33.7	1139.0	4.99	0.264E 10	0.01631	9.7	9.3
9	22.5	47.1	46.9	34.3	1153.0	4.92	0.271E 10	0.01885	9.7	9.4
10	25.5	48.4	47.7	34.9	1167.1	4.85	0.279E 10	0.02139	9.3	8.9
11	29.5	49.3	48.7	35.7	1186.3	4.77	0.288E 10	0.02479	9.2	8.8
12	33.5	49.9	49.4	36.5	1205.7	4.68	0.298E 10	0.02820	9.3	9.0
13	37.5	50.8	50.3	37.3	1225.6	4.60	0.308E 10	0.03163	9.2	8.7
14	41.5	50.6	50.9	38.1	1245.7	4.51	0.318E 10	0.03506	9.7	9.4
15	45.5	51.9	53.4	39.0	1266.2	4.43	0.328E 10	0.03851	8.8	8.2
16	49.5	52.0	52.5	39.8	1287.1	4.35	0.339E 10	0.04197	9.7	9.4
17	54.5	53.5	52.9	40.8	1313.6	4.26	0.352E 10	0.04630	9.7	9.3
18	59.5	55.2	55.1	41.8	1340.7	4.16	0.365E 10	0.05065	9.0	8.4
19	64.5	54.8	54.9	42.8	1368.4	4.07	0.379E 10	0.05501	10.0	9.5
20	69.5	56.8	55.4	43.8	1396.5	3.98	0.393E 10	0.05939	9.8	9.2
21	74.5	57.2	57.1	44.8	1425.2	3.89	0.407E 10	0.06377	9.7	9.1
22	79.5	57.7	57.3	45.8	1454.5	3.81	0.421E 10	0.06817	10.2	9.6
23	84.5	59.6	58.7	46.8	1484.2	3.73	0.436E 10	0.07257	9.7	9.6

FULLY DEVELOPED NUSSELT NUMBER= 9.5 9.1*