Experimental Investigation of Prandtl Number Effects On Laminar Forced and Free Convection In A Horizontal Semicircular Duct

by

Han Jiang

A Thesis Presented to
The University of Manitoba
in Partial Fulfillment of the Requirements for the Degree of
Master of Science
in Mechanical Engineering

Winnipeg, Manitoba, Canada 1993

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ISBN 0-315-86136-3

EXPERIMENTAL INVESTIGATION OF PRANDTL NUMBER EFFECTS ON LAMINAR FORCED AND FREE CONVECTION IN A HORIZONTAL SEMICIRCULAR DUCT

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Abstract

An experimental investigation was conducted on laminar free and forced convective flows of highly viscous fluids (ethylene glycol-water mixtures) through a horizontal semicircular duct with uniform heat input axially and with fully developed velocity profiles at the onset of heating. Pressure drop measurements and local measurements of temperature were made to determine friction factors and Nusselt numbers for fluids with Pr=100 and 20. Mass flow rates and heating rates were varied to cover a range of Reynolds numbers from 150 to 250 over a range of modified Rayleigh numbers from 3.5×10^6 to 4.3×10^7. For Ra=4.3×10^7 (for example), test results showed that fully developed Nusselt numbers for Pr=100 were about 15% greater than for Pr=20 (for the same Re). Meanwhile, pressure drops for Pr=100 decreased by about 2% relative to those for Pr=20.

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Acknowledgements

I wish to record my sincere thanks to Prof.A.C.Trupp for his continued guidance and encouragement during my study. I owe the greatest debt to him for his extremely patient support with hardly audible complains through all these years.

I also would like to express my gratitude towards the staff of the department who helped me in many ways. In particular , I wish to thank Mr.M.Kapitolar for his crucially important contribution to setting up the experimental facility.

Last but not least, I would also like to express my thanks to my parents for all the supports they gave to me during these years.

Nomenclature

A	= cross-sectional area of circular sector duct, ϕR_0^2
A_{fl}	= cross-sectional fluid area
A_{iw}	= inside heated wall area
c_p	= specific heat at constant pressure
$d\bar{P}/dX$	= axial pressure gradient
D_h	= hydraulic diameter, $2\phi R_0/(1+\phi)$
$D_i,\ D_0$	= inside and outside diameters of the duct
f	= Fanning friction factor, $D_h(-d\bar{P}/dX)/(2\rho\bar{W}^2)$
g	= gravity
Gr	= Grashof number, $Gr = \beta g \rho^2 D_h^4 Q_f/\mu^2 k A_{iw}$
$H1$	= uniform axial heat flux with uniform peripheral temperature
$H2$	= uniform axial and peripheral heat flux
$\overline{h}$	= convection coefficient
k	= thermal conductivity of fluid
L	= total heated length
$\dot{m}$	= mass flow rate
Nu	= peripherally averaged Nusselt number, $Nu = \bar{h}D_h/k$
$\overline{Nu_{x,t}}$	= local, but peripherally averaged, Nusselt numbers
$\overline{Nu_{x,th}}$	= $(\overline{Nu_{x,t}} + \overline{Nu_{x,h}})/2$

P	=	total thermodynamic pressure
ΔP	=	pressure drop across the heated section
Pr	=	Prandtl number, $\mu c_p/k$
Q_f	=	heat gain by the fluid
Q_e	=	electric power input
R_0	=	radius of the duct
Ra	=	Rayleigh number, $Ra = GrPr$
Re	=	Reynolds number, $Re = \rho\bar{W}D_h/\mu$
$\overline{W}$	=	cross-sectional mean axial velocity
β	=	thermal expansion coefficient
ρ	=	density
μ	=	dynamic viscosity
ϕ	=	half the apex angle of a circular sector duct

Chapter 1

Introduction

The rapid developments within the body of scientific knowledge called heat transfer represent a phenomena encountered throughout science and technology. Heat transfer has reached widely to many fields and brought interests to some areas due to the fast-developing technology. One of these areas is the study on noncircular duct heat transfer, and it has interested a growing number of investigators for some time. One reason for this is certainly the wide range of engineering applications from nuclear power plants to automobile radiators. Another reason is connected with the fact that at first glance one is tempted to consider noncircular duct flow and heat transfer processes as simple extensions of the classical round tube problem. Closer analysis, however, indicates that the situation is the other way around: the round tube is actually a very special case of the more general noncircular duct problem and any attempts to proceed from the circular to the noncircular shape is historically correct but fraught with many difficulties and pitfalls.

In this study, efforts were made to investigate the Prandtl number effects on laminar combined free and forced convection in a horizontal semicircular duct for the following reasons:

1. Free convection effects, which are induced by buoyancy forces due to temperature difference, can cause the heat transfer mechanism to be significantly different from its pure forced convection condition. The study of the combined results of both forced and free convection is an attempt to approach reality since free convection always exists as soon as temperature gradients appear.

2. Free convection effects are perceived much stronger in laminar flow than in turbulent flow relative to pure forced convection for the reason that turbulent diffusion will decrease temperature gradients and hence reduce buoyancy effects. For the purpose of observing free-convection effects, laminar flow was chosen in this investigation.

3. The last but not least important reason is the fact that high Prandtl number effects on free-forced laminar combined flow for a semicircular duct, so far, has not been studied by other investigators. It is believed that this study would facilitate the process of further understanding of the problem. As well, some fluids with high Prandtl number are actually used in industry such as in the manufacturing and nuclear power generation areas, either as products or working fluids. A broader knowledge of their thermodynamic effects could benefit dealing with these fluids in the design and research areas.

In conclusion, it is believed that the results of the present investigation will contribute to our understanding of combined laminar convection heat transfer in semicircular ducts in particular and non-circular ducts in general.

Chapter 2

Literature Review

Since the present study is concerned with information on flow and heat transfer of combined laminar free and forced convection for a semicircular duct with high Prandtl number fluid, a brief review of the research efforts done in this area is conducted here. However, due to the relatively small size of the literature on this topic, the review also surveys some previous works that are, to some extents, relevant to the current study.

The review is focused on the following two aspects:

1. Laminar free and forced flow through a horizontal semicircular and circular ducts.

2. The impacts of highly viscous fluids, or high Prandtl number fluids, on the characteristics of flow and heat transfer mechanism.

2.1 Combined free-forced flow

2.1.1 Thermally and hydrodynamically fully developed flow in horizontal circular tubes

For circular tubes, it has been realized that heat transfer in combined convection can be significantly different from its values in both pure free and pure forced convection. Temperature variations in the fluid lead to the possibility of counterrotating transverse vortices that are superimposed on the streamwise main flow, which is secondary flow and it can increase the heat transfer significantly, because increased free convection effects near a heat transfer wall cause more cold fluid to be drawn to the wall, thereby increasing the heat transfer[1]. Also, free convection can cause the change of thermal development length. It has been noticed that peripheral variation of heat transfer can also result from secondary flows which are frequently present in combined convection in horizontal tubes. For a horizontal circular tube at uniform wall temperature, the circumferential Nusselt number can differ by as much as a factor of 4, with the maximum occuring at the lowest point and minimum at the highest point on the circumference of the tube. This problem has been discuss by Yousef and Tarasuk [2] for uniform wall temperature and by Bergles and Simonds [3] for uniform heat flux. Some experimental works of uniform heat flux of different fluids were recorded concerning air [4, 5], water [3, 6, 7, 8], and ethylene glycol [9, 10]. For ethylene glycol, the studies in the range of Re=6 to 300, Gr=0 to 22400, Pr=26 to 500, and Gz=3 to 4800 show that the Nusselt number and pressure gradient are functions only of the Graetz number and the wall-to-bulk viscosity ratio for both the hydrodynamically and thermally developing and fully developed flow regions [9]. With water in fully developed flow, it was shown that the heat transfer coefficients can be 3 to 4 times the pure forced flow values [10]. Large variation in the peripheral temperatures are present with gas flows when the tubes are uniformly heated, and heat transfer is higher than the pure forced flow value when Reynolds number is large [11]. For uniform heat flux, Morcos and Bergles [12] obtained empirical correlations for the Nusselt number by using the correlation technique recommended by Churchill and Usagi [13]. Their experimental study was conducted using electrically heated glass and stainless-steel tubes, with distilled water and ethylene glycol as working fluids. It is found [12] that circumferentially averaged Nusselt number, which is independent of axial distance,depends on the thermal boundary condition imposed and hence on the type of tube employed.

2.1.2 Thermally developing flow in horizontal circular tubes

Ou and Cheng [14] solved the problem of combined free and forced convection in the thermal entrance region of horizontal ducts theoretically by using a modified stream function. Their results indicated that, for axially uniform heat flux, the secondary flow first grows and then decays. Near the tube entrance, the isotherms are nearly concentric circles, but further downstream, the isotherms near the bottom of the tube become distorted as the local heat transfer deteriorates in the lower region.

Some empirical correlations were obtained for thermally developing combined convection with hydrodynamically fully developed flow at entrance in horizontal heated tubes. For uniform wall temperature and using water, ethyl alcohol and a mixture of glycerol and water, Depew and August [15] generalized the correlations of Oliver [16] and Brown and Thomas [17] for locally averaged Nusselt numbers.

2.1.3 Combined semicircular duct flow

Previous studies by Lei and Trupp [18, 19, 20] on laminar combined free-forced flow in a horizontal semi-circular duct has been conducted experimentally and analytically. Numerical predictions were carried out using the modified SIMPLER algorithm for fully-developed laminar combined convection in a horizontal semi-circular duct. As well, combined convection flow and heat transfer were experimentally investigated in the thermal entrance region of the horizontal semi-circular duct with uniform heat flux axially. It was shown in the experimental data that considerable circumferential variations occurred in wall temperatures, which would otherwise be uniform without free convection effects in the same running conditions, a factor of more than two for friction factor increase, and a factor of more than five was observed for heat transfer enhancement. Furthermore, the onset of thermal instability was discovered to advance with increasing Grashof number and with decreasing Reynold number. A conclusion was inferred that increasing Grashof number augments flow resistance and greatly enhances heat transfer. In these previous experimental results, distilled water with Prandtl number ranging from 5-9 was used as the working fluid. Therefore, these results have not provided much information on the impact of highly viscous fluid on the flow and heat transfer inside a semicircular duct.

2.2 Effects of Viscous Fluid

For most liquids, the specific heat, thermal conductivity and density are nearly independent of temperature, but the viscosity decreases markedly with increasing temperature. The Prandtl number of liquids varies with temperature in much the same manner as the viscosity. The impacts of highly viscous fluids on combined free and forced flow in ducts of different geometries have been studied by some investigators [21, 22, 23]. So far, to the knowledge of the writer, there is no information available for the semicircular duct. Since similar features to the circular duct are expected for the semicircular duct, it is believed that a brief review of the behaviour of highly viscous fluids for circular duct could serve as a guide for understanding the semicircular duct.

The pioneering work on viscosity effects dates back to the experimental work of McAdams [24]. Deissler [25] carried out a numerical analysis for laminar flow through a circular duct at constant heat flux boundary condition for liquid viscosity variation with temperature, and it has been widely used to correlate experimental data for laminar flow. Yang [26] obtained the solution for both constant wall heat flux and constant wall temperature boundary condition, and he concluded that the effect of thermal boundary condition is small and the influence on the friction coefficient is very substantial. He also found that the correction for variable properties is the same for developing and developed regions. Shannon and Depew [27] and Joshi and Bergles [28] carried out similar analyses for the constant heat flux boundary condition, and produced similar correlation to that of Deissler [25], but their predictions differ from Yang's, particular in the entrance region. A simpler empirical correlation has been proposed by Sieder and Tate [29] to predict the mean Nusselt number in a circular duct at constant wall temperature. Some other investigators have proposed alternative correlations for specific fluids. Oskay and Kakac [30] performed experimental studies with mineral oil in laminar flow through a circular duct under constant wall heat flux boundary condition. Kuznetsova [31] made experiments with transformer oil and fuel oil. Test [32] conducted an analytical and experimental study of heat transfer and fluid flow behavior for laminar flow in a circular duct for liquid with viscosity varying with temperature.

The publications dealing with viscosity effects generally have not treated the influence of buoyant forces and vice versa. Among the papers on free convection effects in forced flow, only a few have examined the problem in a horizontal tube with uniform flux. When a uniform wall-temperature boundary condition is imposed, the heat flux is the dependent variable and responds to the free-convection circulation by increasing. The higher heat flux brings the bulk of the fluid to the wall temperature more quickly, and the free-convection contribution is self-eliminating. This situation is contrary to the imposed wall flux case where the wall temperature is reduced by free convection but must be maintained at some level above the fluid temperature providing a driving force for circulation consequently, the free-convection contribution is maintained.

It is hoped that some key features about free convection in circular ducts and high viscosity effects have been highlighted through this brief review. In the remainders of this thesis, the impact of these two factors is investigated in a semicircular duct.

Chapter 3

Experimental Facility and Procedures

The objective of the experiments was to investigate Prandtl effect on combined laminar convection for a semicircular duct. Specifically, experiments were run to determine the heat transfer and pressure drop characteristics, which are expressed by both local and fully developed Nusselt number and by friction factor. The experimental facility was previously designed for exploring buoyancy effect on laminar water flow and heat transfer in the thermally developing and fully developed regions of a horizontal semicircular duct. In the current investigation as in previous investigations, uniform heat input axially was chosen as the thermal boundary condition. No special attention was put on the verification of the phenomenon of flow bifurcation due to limitations of the experimental apparatus.

The single symmetric orientation of the duct with the flat surface up and circular surface down, was chosen for the experiments. This should provide an indication of Prandtl effect for any orientation. In any case, the effect of Prandtl number for other orientations of the duct are left to future investigations.

For the experiments of low Prandtl number fluid, distilled water was selected as the working fluid. For all those experiments, Prandtl number averaged about 5. For the experiments of high Prandtl number, solutions of ethylene glycol were chosen as the working fluids. Under the temperature range of the experiments, concentrations of the solutions were decided upon which gave the required values of Prandtl number of 20 and 100.

Thus, throughout the whole experiments , only the orientation with flat surface up and circular surface down and Prandtl numbers of 5, 20 and 100 were studied .

In summary, power input, temperature (both wall and fluid bulk) and pressure drop measurements were made so as to deduce the following main characteristics:

a) Local circumferential temperature variations of the duct wall at a cross-section, which indicate the significance of buoyancy effects for different Prandtl numbers.

b) Fully developed friction factors for the working fluids with different Prandtl numbers under different rates of heating.

c) Axial variations of the local average Nusselt number along the heated section and fully developed Nusselt numbers at different Reynolds and Rayleigh number for the fluids with different Prandtl numbers.

d) Comparison of the experimental results to the previous numerical predictions by Lei [20] whenever possible.

All dimensions for the semi-circular duct used in the test section are listed in Table.1.

Table 3.1: Detailed dimensions of test section

Inside diameter D_i (mm)	49.76
Outside diameter D_o (mm)	53.98
Hydraulic diameter D_h (mm)	30.40
Cross-section fluid area A_{fl} (cm^2)	9.7229
Inside heated wall area A_{iw} (m^2)	0.5997
Cross-section solid area A_s (cm^2)	3.4311

3.1 Preparation of working fluids with high Prandtl number

3.1.1 Range of Prandtl number

A main objective of the investigation was to study the effect of Prandtl number on pressure drop and heat transfer. Previous experimental work [20] was conducted using distilled water, which had Prandtl numbers ranging from 4.0 to 6.5 under the earlier experimental conditions. As a result, working fluids with Prandtl numbers other than this range have to be tested under similar experimental conditions in order to observe the impact of Prandtl number on pressure drop and heat transfer. After due consideration, working fluids with Prandtl numbers of 20 and 100 were selected. In this way, a reasonably wide range of Prandtl number from 5 to 100 with 20 in between would be covered in the experiments and the effects of Prandtl number could be observed.

3.1.2 Selection of working fluids

In the process of choosing appropriate working fluids, the top priority was to use some fluids with high and stable values of viscosity under test conditions. Much attention had been put on hydrocarbons and their solutions. As a result, it was found that ethylene glycol and its aqueous solutions would reasonably well meet the requirements. Details and considerations were as follows:

a) High Prandtl number. 90% ethylene glycol and 10% distilled water by weight, has the value of Prandtl number around 100 at a temperature about 40°C, while the solution of 70% ethylene glycol and 30% distilled water by weight, has the value of Prandtl number around 20 at the same temperature. The experiments were run in the vicinity of the noted temperature.

b) Ethylene glycols have been major products for many years, and their physical properties have been extensively studied. Especially, since ethylene glycols are generally encountered diluted in water the properties of its aqueous solutions are available in many literature references. This greatly facilitates the process of data reduction for the tests.

c) Ethylene glycol is one of the basic products of chemical industry and widely used in other fields. Most of ethylene glycol products go into antifreeze, as well as into plasticizers and solvents.

3.1.3 Viscosity measurement of ethylene glycol solution

Although values of property for ethylene glycol and it solutions are available from the literature, it was still necessary to have first-hand information about values of viscosity for solutions of different concentration for the following reasons:

a) 90 % and 70 % ethylene glycol were produced in the lab by mixing (by weight) 90% ethylene glycol with 10 % distilled water and 70 % ethylene glycol with 30 % distilled water, respectively. Due to the uncertainties of both human performance and equipments during the operation of mixing, percentage errors of solutions were assumed unavoidable. As a matter of fact, the percentage errors were found to be within 3% for both solutions. Fig.3.1, Fig.3.2 and Fig.3.3 show the changes of Prandtl number versus temperature and various concentration of different solutions .

b) After checking the property table of ethylene glycol and its solutions, it showed that most properties, such as density, specific heat and thermal conductivity, do not vary significantly within a 3% error band with concentration at fixed temperature. Hence their values at any required temperature could be interpolated from published values without losing much accuracy. On the other hand, viscosity was found to be extremely sensitive to both temperature and percentage concentration. Even a small percentage error of concentration would cause significant deviation for the values of viscosity. Accordingly, accurate measurement of viscosity for the solutions was crucial, since viscosity values would have a direct effect on Prandtl number values.

Measurements of viscosity values for 90% and 70% ethylene glycol were conducted by using a viscometer (FISHER 13-616E), strictly following the procedures suggested by the manufacturer. Measurement were made at the temperature range that aqueous solutions would go through during the experiments. For both 90% and 70% ethylene glycol solutions, it was found that measured values of viscosity were within about 7% of those viscosity values provided by Gallant [33]. All the measured values of viscosity became property input of the computer program for data reduction, and they are listed in Appendix A.

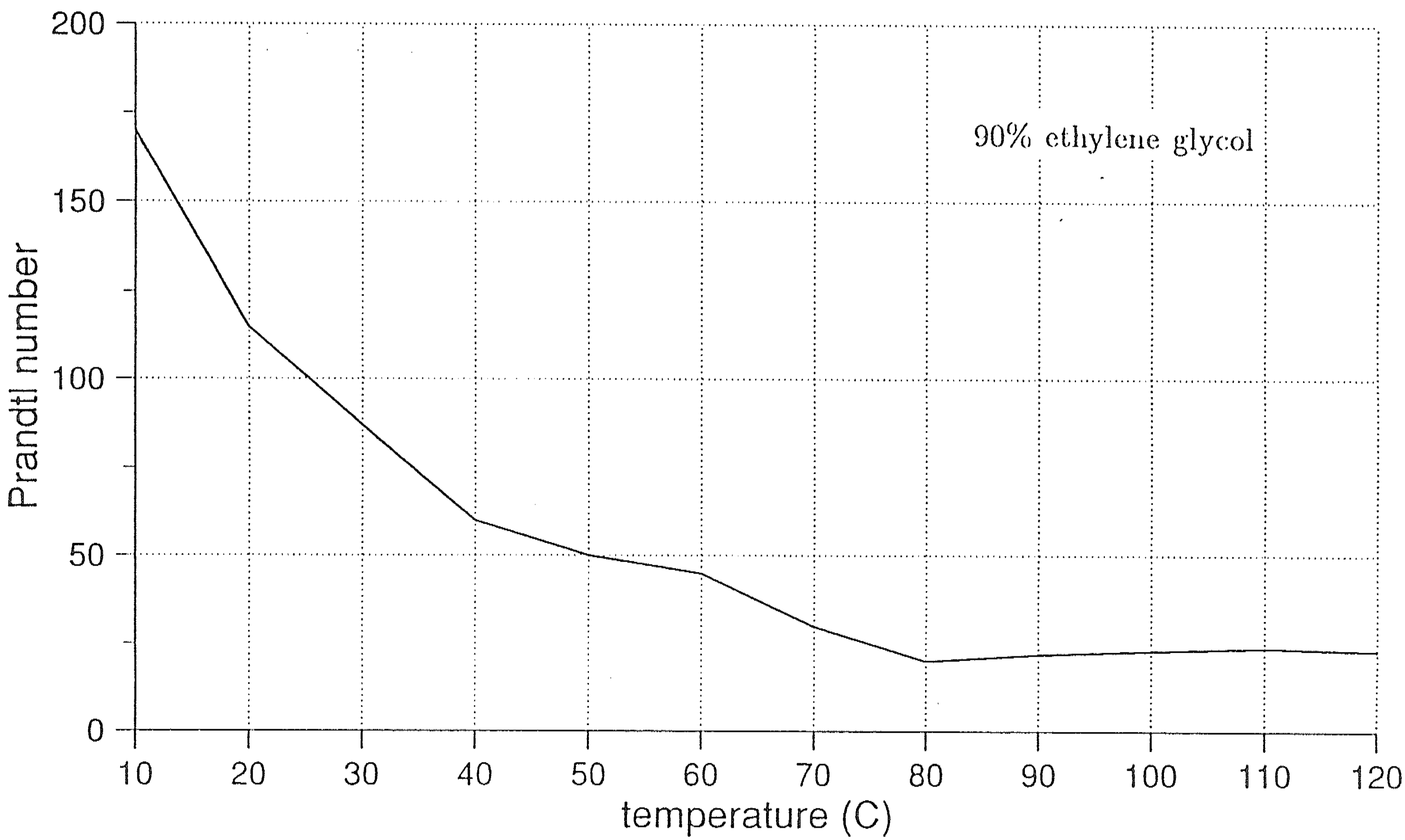


Figure 3.1: **Pr vs T** for 90% ethylene glycol

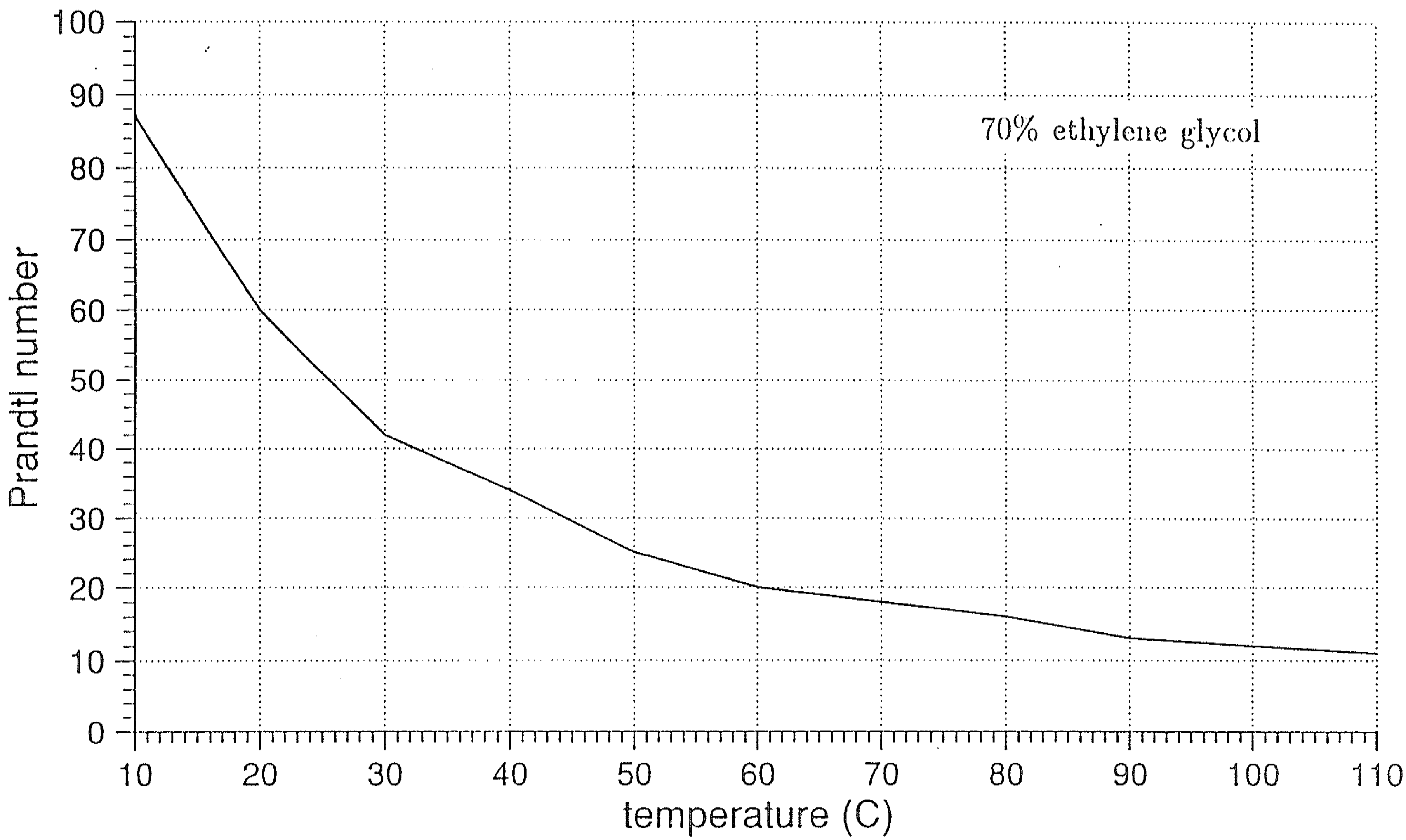


Figure 3.2: Pr vs T for 80% ethylene glycol

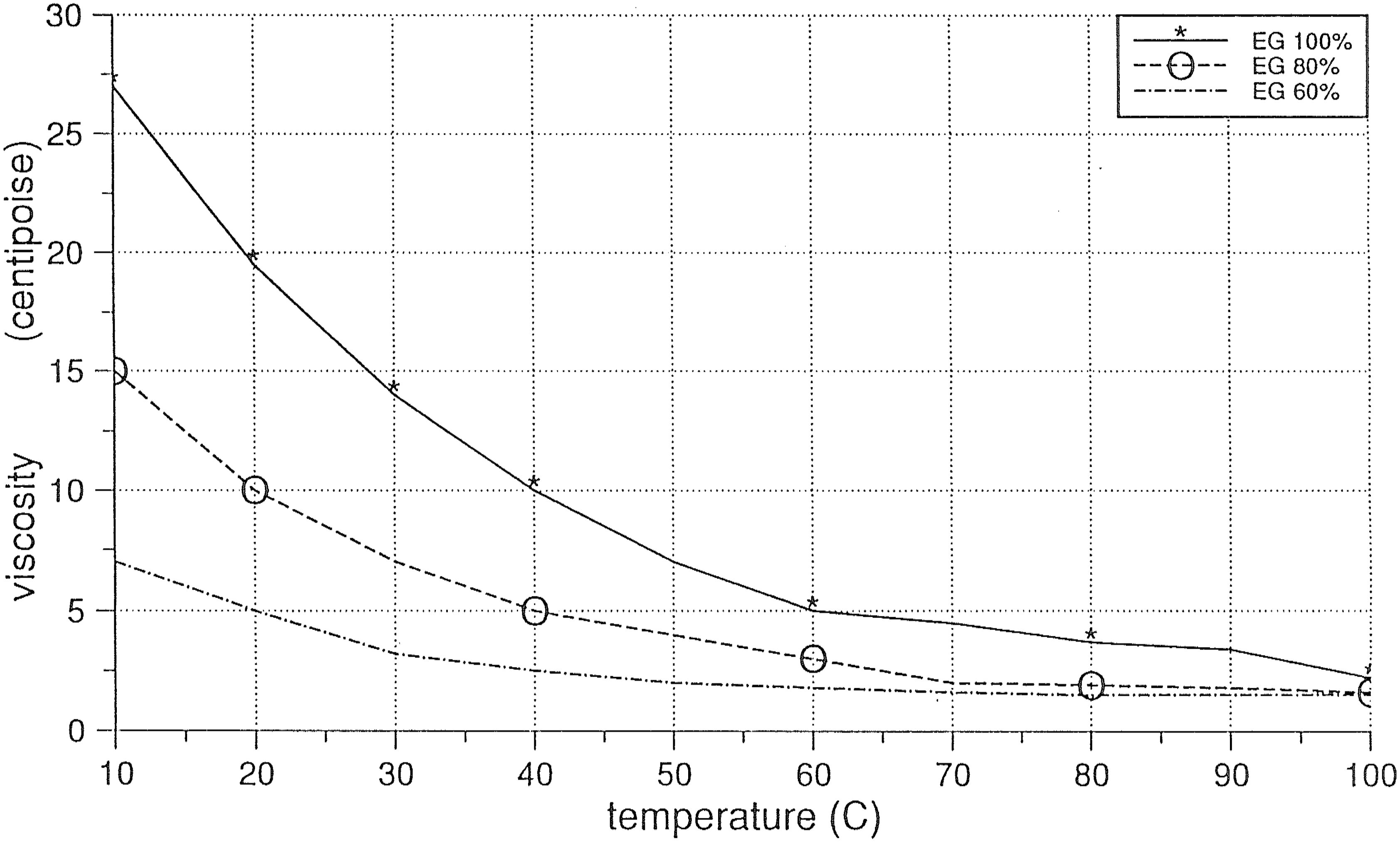


Figure 3.3: Viscosity vs T for different concentration

3.2 General description of the experimental set-up

A schematic diagram of the experimental set-up is shown in Fig.3.4. A tank of 200-liter capacity was used for collecting the test fluid. The tank was insulated by a 25-mm layer of fiberglass. A 2-horsepower centrifugal pump was used to circulate the working fluid in the system. The working fluid was pumped from the tank and passed through a filter preventing any solid impurities from being circulated into the system. A by-pass line controlled by two valves was constructed to adjust flow rate and pressure level in the system.

For the system, the test section consisted of a hydrodynamic entry length followed immediately by a heated section in which all pressure drop and heat transfer measurements were conducted. The total length for the test section was 8.5 meter, of which 3.8 m was used as a hydrodynamic entry length. Pressure drop measurements were taken across a length of 4.7 m, which was uniformly heated by electrical wire wrapped around the duct.

Thermocouple stations were set along the test section to measure wall temperature. A thermocouple was used to measure the upstream bulk temperature immediately ahead of the hydrodynamic entry section. After passing through the test section, the working fluid flowed into a mixing chamber forcing the fluids to mix uniformly before the downstream bulk temperature was taken. The working fluids were then introduced to two heat exchangers

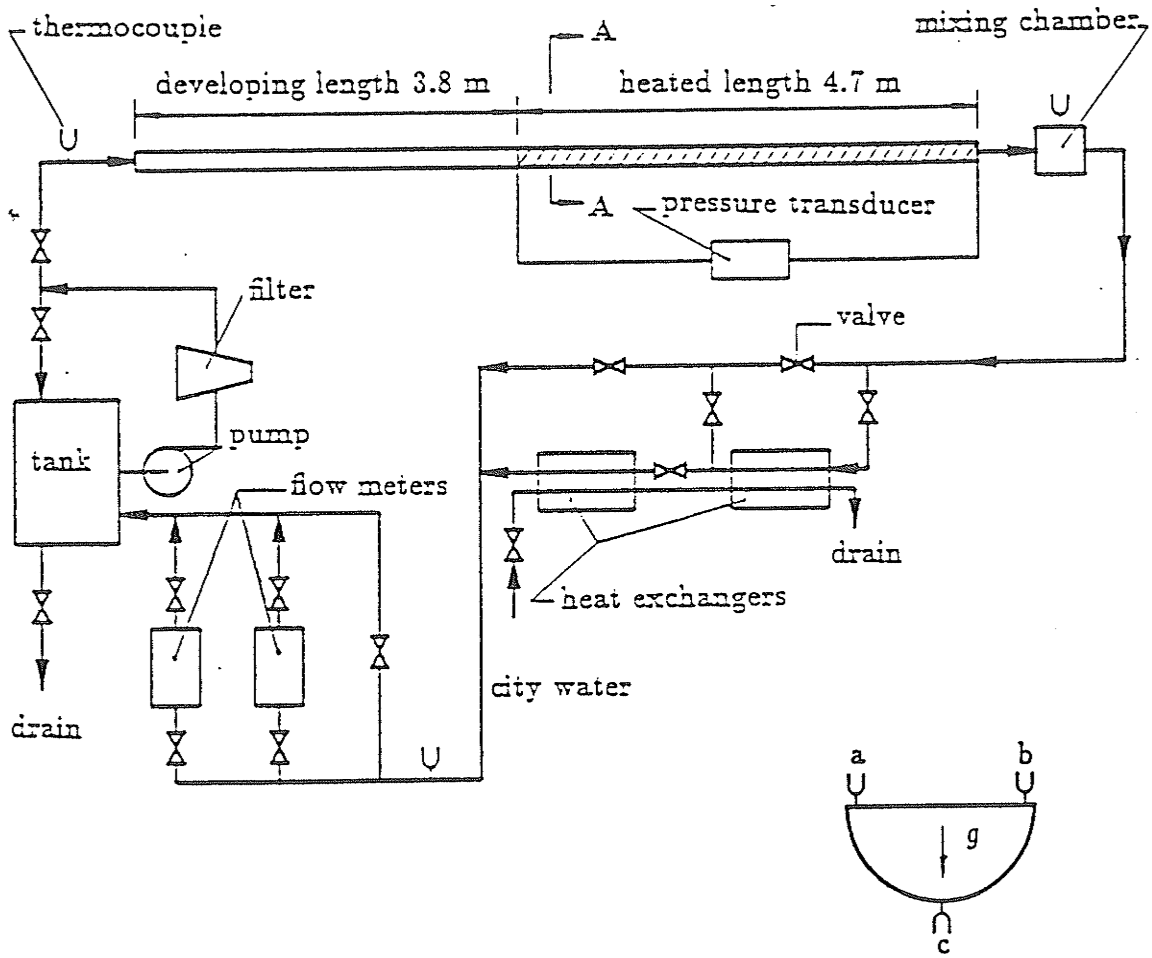


Figure 3.4: Experimental Set Up

and cooled to the initial temperature.

After the fluid was cooled it passed through a flowmeter measurement station where a combination of 3 variable area rotameters of different ranges made by Fisher and Porter are used. The flowmeters are connected in parallel so that one or two, or three could be operated depending on the flow magnitude. The smallest flowmeter had a maximum capacity of 18 cm^3/s, and the largest one had a maximum capacity of 70 cm^3/s. The flowmeters were calibrated beforehand. If not needed, the flowmeters could be by-passed. After flow measurement, the working fluid then flowed back to the accumulating tank.

3.3 Detailed description of experimental facility

3.3.1 Heated section

Fig.3.4 and Table 1 show the dimensions of the test section. Two pressure taps were installed before and after the heated section, respectively. Lead lines from each pressure station were connected to a pressure transducer with adjustable range of 0 - 50.8 mm of water up to 0 - 152.4 mm of water. The transducer was manufactured by Rosemount Inc., model no.1151DP, and excited by a D.C power supply with a 0 - 100 mA and 0 -120 V ranges. The transducer output in mA was measured by a digital multimeter. An analog computer, Macsym 2, was employed to receive the transducer outputs and to average the pressure readings.

For the 4.7 m long test section, the wall temperatures were measured at 19 axial stations (see the experimental results in Appendix for exact locations). At each station, there are three[two at the top flat surface and one the bottom,see Fig.3.4 for exact locations], 24 gage, copper-constantan thermocouples attached to the wall. In addition to that, eight thermocouples were mounted on the duct wall just before and after the heated section for estimating heat conduction losses along the duct ends. All the recorded data are shown in the Appendix.

The axial locations of the measuring station were designed in such a way that more thermocouples were assigned in the entry region of the heated section , and as the distance from the beginning of heating increased, thermocouples were allotted more sparsely. Along the last one - third of the heated section, more stations of thermocouples were set up for the purpose of watching buoyancy effects on the streamwise main flow. For each thermocouple location, a small copper tube or well of 2.5 mm diameter was soldered onto the duct wall for the installation of a thermocouple.

For the construction of the heated section, before a thin dielectric tape was wrapped around the duct, a thin layer of insulating varnish (dielectric strength of 2000 volts per one-thousandth inch) had been sprayed on the outside of the wall. Then two parallel lines of electric resistance wires, which had a total resistance of 6.61 ohms, were wound tightly around the duct. Uniformity had been tested and indicated that this wrapping resulted in a maximum nonuniformity error of 6% relative to its mean value. For the final touch, the duct was coated with cement of high thermal conductivity at high temperature to fix the position of wiring and distribute input heat uniformly. This layer of cement was then covered by a 25 mm layer of fiberglass insulation to largely eliminate external heat losses from the test section.

A 2000 V.A. isolation transformer and a power variac were used to control the power supply to heating. This impact power was measured by a digital watt-meter. The input voltage and current were displayed in a voltmeter and an ammeter, the accurate readings was obtained by a digital multimeter as well.

All thermocouple outputs were measured by a digital potentiometer in °F. The input voltage and current were displayed in a voltmeter and an ammeter, the accurate readings was obtained by a digital multimeter as well. A thermo-electric heat flux transducer (Heatprobe, model HA-100, range of 0.3-300 W/m^2) was used at the different locations for estimating the heat conduction losses through the insulation.

A specially designed bed was used for supporting the test section and the horizontality of the duct was checked. The duct was carefully connected to the test loop and calibrated thermocouples were installed into the wells prepared before and attached to the wall. Each well was then filled with a high thermally conductive paste (Omegathrem 201, k=125 w/mK) and sealed with solid epoxy to keep the paste always in good contact with the duct wall.

3.3.2 Mixing chamber

The purpose of the mixing chamber was to mix the working fluid properly at the exit of the heated section. The chamber had a diameter of 60 mm, and a length of 200mm. A thermocouple filled with high thermally conductive paste (k=125 W/mK) was used to measure the downstream bulk temperature using 24 gage copper-constant constant thermocouple. Two grids were fixed at both ends of the chamber with several inclined holes to create a vortex in the chamber. This vortex mixes the fluid thoroughly so that a uniform temperature is reached around the thermocouple well.

Since the vorticity generated within the mixing chamber depends upon the flow velocity of the fluid, at very low flowrates (low Re) the mixing chamber had to take longer period of time to have the whole system stablized for each run.

3.3.3 Heat exchangers

Two 1.5m long, counter-current, double-pipe heat exchangers were used to cool the test fluid back to the initial temperature. The inner tube had an inside diameter of 12.7 mm and an outer diameter of 15.9 mm. The outer tube had 19.0-mm inside diameter, and 22.2-mm outside diameter. The test fluid was flowing in the annulus and the cooling fluid was flowing in the inner tube. The heat exchangers were connected in series by a set of valves. By changing the opening of the valves, the flow could be directed to only one or both exchangers depending on the required heat duty. These heat exchanger were essential for the establishment of steady-state condition.

3.4 Experimental procedure

3.4.1 Calibration

To detect any errors in the wall thermocouple readings due to the method of attaching the thermocouples to the wall, as well as the changes of running condition for new working fluids, all the thermocouples were recalibrated again. All these thermocouples have been calibrated after being attached to the wall for the previous experiments. The following procedures were followed for calibration:

a) The flowmeters and heat exchangers were isolated from the system by adjusting their bypass lines.

b) The bypass line of the test fluid circulating pump was shut down completely, thus forcing the maximum flowrate to be circulated in the system.

c) No heat was added in the test section. Thus, it was possible to assume that the upstream and downstream bulk temperatures as well as all wall temperatures were equal since the heat losses from the test section were minimized by the insulation.

d) The water in the accumulating tank was controlled at the temperature of 70°F by circulating the city water coolant through the heat exchanger.

e) Operation was continued until steady state was reached, which was indicated by the consistency of all thermocouple readings.

f) The upstream and downstream bulk temperatures along with all wall thermocouple readings were recorded.

Steps d,e,and f were repeated for the temperature range 40-80$°C$ expected to be covered during testing.

All the readings at each wall thermocouple and the corresponding bulk temperature were used to generate a calibration formula which was used to correct the readings of that particular thermocouple during the heat transfer tests in the program of data reduction.

All other measuring devices such as the flowmeters, and the pressure transducer were calibrated as well. The pressure transducer was calibrated at room temperature using a water - column manometer, a multimeter, and an analog computer.

3.4.2 Heat transfer tests

A similar procedure was followed for each mixture of different Prandtl number. Two flowrates were selected within the laminar flow range for each mixture. The Reynold numbers of the two flowrates were about 150 and 250, respectively. At each flowrate, several test runs were conducted corresponding to different input power to the heated section, creating a Rayleigh number ranging from 3.5×10^6 to 4.3×10^7.

For each run, corresponding to a certain flowrate and a certain power input, at least a period of time of 5 hours was needed to have a thermal equilibrium established, for which steady state conditions were indicated by the constancy of all thermocouples, flowmeters and pressure - transducer readings. Then, the following data were recorded:

1) Upstream and downstream temperature.

2) All wall thermocouples readings.

3) Electrical input power in watts.

4) Pressure - transducer readings.

5) Flowmeter readings of the fluids.

Meanwhile, heat conduction losses through the insulation were measured by attaching the thermal electric heat flux transducer on the insulation at a number of axial locations.

Steps for determining the reference pressure were:

a) Shut-off power to the pump.

b) Terminate input power to the heated section.

c) Record the pressure transducer readings for over 10 minutes.

d) Determine the reference pressure at which the pressure transducer would have given zero output if it had been calibrated under the condition.

3.5 Data Reduction

3.5.1 Data selection

The recorded data were fed to a digital computer to be reduced. A FORTRAN computer program was prepared for this purpose; the program is listed in the Appendix. The program accommodated the tables of thermophysical properties of mixtures of fluids with different Prandtl numbers for interpolating any property values at any required temperature. A procedure of taking account of heat conduction dissipation along the longitudinal duct at the beginning and the end of heating was followed in the program. This procedure was necessary to correct the upstream and downstream bulk temperatures. Once these were established, the bulk temperature variations along the duct were assumed to vary linearly with distance between the two values of inlet and outlet temperature.

The rate of heat gained by the test fluid Q_f was calculated and then compared with the electric power input Q_e. Only those data with an overall energy balance error within ± 9% were accepted.

3.5.2 Parameter Definition

For the computation of flow and heat transfer characteristics, it is necessary to defined key parameters appearing in the calculation. In this research they are:

1) Reynold number:

$$Re = \frac{D_h \cdot \dot{m}}{\mu \cdot A_{fl}} \tag{3.1}$$

2) Fanning friction factor:

$$f = \frac{\Delta P \cdot D_h \cdot \rho \cdot A_{fl}^2}{2L \cdot \dot{m}^2} \tag{3.2}$$

3) Grashof number:

$$Gr = \frac{\beta \cdot g \cdot \rho^2 \cdot D_h^4 \cdot Q_f}{\mu^2 \cdot k \cdot A_{iw}} \tag{3.3}$$

4) Rayleigh number:

$$Ra = Gr \cdot Pr \tag{3.4}$$

5) Local Nusselt number:

$$Nu_{x,j} = \frac{h_{x,j} \cdot D_h}{k} = \frac{Q_f \cdot D_h}{A_{iw} \cdot k \cdot (t_{x,j} - t_{x,m})} \tag{3.5}$$

where j refers to one of the three thermocouples of each cross - section at distance x.

Also local and peripherally averaged Nusselt numbers :

$$\overline{Nu_{x,t}} = \frac{Q_f \cdot D_h}{A_{i,w} \cdot k \cdot (\overline{t_{x,j}} - t_{x,m})} \tag{3.6}$$

by averaging the peripheral wall temperature $t_{x,j}$, and alternatively:

$$\overline{Nu_{x,h}} = \frac{Q_f \cdot D_h}{A_{i,w} \cdot k \cdot \overline{(t_{x,j} - t_{x,m})}} \tag{3.7}$$

by averaging the peripheral heat transfer coefficients $h_{x,j}$.

Experimental uncertainties in the experimental were considered. Reynold numbers and Rayleigh number are estimated to be correct within ±4% and ±15%, and friction factor and Nusselt number are estimated to be within ±8% and ±17%, respectively. A maximum difference of ±3% between the fluid heat flux and the input flux on the outer surface of the duct is estimated as well [20].

3.5.3 Brief outline of computer program

A computer program for experimental data reduction was written and the followings are the highlights of the program:

1) All wall thermocouples were corrected according to the formula develop for each one by the calibration process.

2) The rate of heat gained by the fluid was calculated as :

$$Q_f = \dot{m} \cdot C_p(T_{out} - T_{in}) \tag{3.8}$$

3) The percentage deviation between the electrical power supplied and the rate of heat gained by the fluid was calculated as

$$E = \{(Q_e - Q_f)/Q_e\} \times 100 \tag{3.9}$$

As already noted, runs with more than 9% heat balance error were rejected. As a matter of fact, most of the runs had values of error within 6% .

4) Knowing the wall cross-sectional area and the wall thermal conductivity, the rate of heat conducted axially at both ends of the test section was calculated.

5) The inlet bulk temperature at the beginning of the heated of the heated section was evaluated by adding the amount of increase in the bulk temperature due to the axial heat conduction to the upstream bulk temperature.

6) The outlet temperature was evaluated as in the above step, except that the bulk temperature difference due to the axial heat conduction in the wall was subtracted from the downstream bulk temperature.

7) After the inlet and outlet bulk temperatures were evaluated, a straight line was fitted between them, and the local bulk temperature was evaluated at each measurement station of wall temperature.

8) At each station the difference between the average wall temperature and the bulk temperature was evaluated and used

to calculate the local Nusselt number.

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

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

11) The average, diabatic friction factor was calculated based on the pressure drop through the heated section for each run.

Chapter 4

Results and Discussion

The experimental results are discussed in this chapter. All the data are from the 12 runs for Pr=100 and 12 runs for Pr=20. Discussions are made on the results of pressure drop with heating, local and fully-developed Nusselt number and the axial and circumferential variations of wall temperature. Comparison with predictions and other information are presented whenever possible. Experimental runs were completed for Re ranging from 150 to 250, and Ra ranging from 3.5×10^6 to 4.3×10^7, where all the corresponding fluid properties were evaluated at the average of the upstream bulk temperature and downstream bulk temperature. More details on the ranges of the parameters of the running conditions are listed in the following table.

Table 1: **Detailed Running Conditions**

Mass flowrate $\dot{m}$ (g/s)	47.2 - 88.1
Heat input Q_e (KW)	0.12 - 1.12
Heat intensity Q_f/A_{iw} (KW/mm^2)	0.2 - 1.86
Reynold number Re	150 - 250
Grashof number Gr	3.5×10^4 - 4.3×10^5
Rayleigh number Ra	3.5×10^6 - 4.3×10^7
Prandtl number Pr	20 and 100

As mentioned previously, viscosity of aqueous solutions of ethylene glycol are extremely dependent on temperature variation. The temperature rise of the working fluid when it passed through the heating section had to be controlled in order to maintain the Prandtl number at the required average value. For each combination of Reynold and Rayleigh numbers, the inlet bulk temperatures were controlled not to exceed 26°C while the downstream bulk temperatures (outlet temperature) were controlled not to exceed 50°C.

It has been shown that critical Reynold number for semicircular duct is about 2100. Due to the facility limitation, the maximum Reynold number achieved was as high as 250 in all current experiments. This value is well below the critical value of

2100 and thus all the runnings were within the laminar region.

4.1 Temperature Variation

Discussions on both axial and peripheral wall temperature distribution are made separatively in the following sections. Axial temperature distribution can show the onset of significant free convection effect for the range of heating rate for Pr=100 and Pr=20 for this particular geometry. Peripheral temperature distribution will demonstrate the significance of free convection effects on the different locations at certain sections for Pr=100 and 20.

4.1.1 Axial wall temperature distributions

Two sets of readings of axial wall temperature distribution are shown in Figs.4.1 to 4.4 regarding the two different Prandtl numbers. Fig.4.1 and Fig.4.2 are the wall temperatures of Pr=100, and Fig.4.3 and Fig.4.4 are the wall temperatures for Pr=20. For each Prandtl number, two levels of Reynolds number had been run for each heating condition. Altogether, there are 12 tests for Pr=100 and 12 tests for Pr=20 in the experiments; the detailed data of those tests are shown in the Appendix. Temperature readings at the semicircular bottom for each axial location are displayed for the current duct orientation. Some features observed are:

1. It is seen from each figure that free convection effect starts building up gradually as soon as the heating started, but this effect remains insignificant in the early part of the thermal entry length

which vary depending on Pr. The indicator showing the end of the thermal entry length is immediately following the small dip in temperature rise in each figure. This is due to the fact that free convection effect takes some certain length to develop before it can manifest itself. The thermal entry length was found to be about 130 cm from the onset of heating for Pr=100. Similar trends are observed for Pr=20, where the thermal entry length was about 75 cm from the onset of heating.

2. For both Pr=100 and Pr=20, experimental data shown that Reynolds number is not an very influential fact affecting the axial temperature distributions. Although only two basic Reynold numbers of 150 and 250 were tested, the experimental results coincide with the results from Lei's experiments, where a weak Reynold number influence for this particular geometry was recorded as well.

3. The significance of free convection effects are seen after the thermal entry region, which is indicated by seeing that temperature difference between wall and bulk have been depressed by the induced free convection for both cases of Pr=100 and 20.

4.1.2 Peripheral Distribution of Wall Temperature

Peripheral variations of wall temperature among the three locations of thermocouples are shown in Figs.4.5 to 4.10. Temperatures t_a and t_b are the two wall temperatures at the flat surface and values of t_c are the temperatures at the bottom of the semicircular part. Some features from the observation of these figures

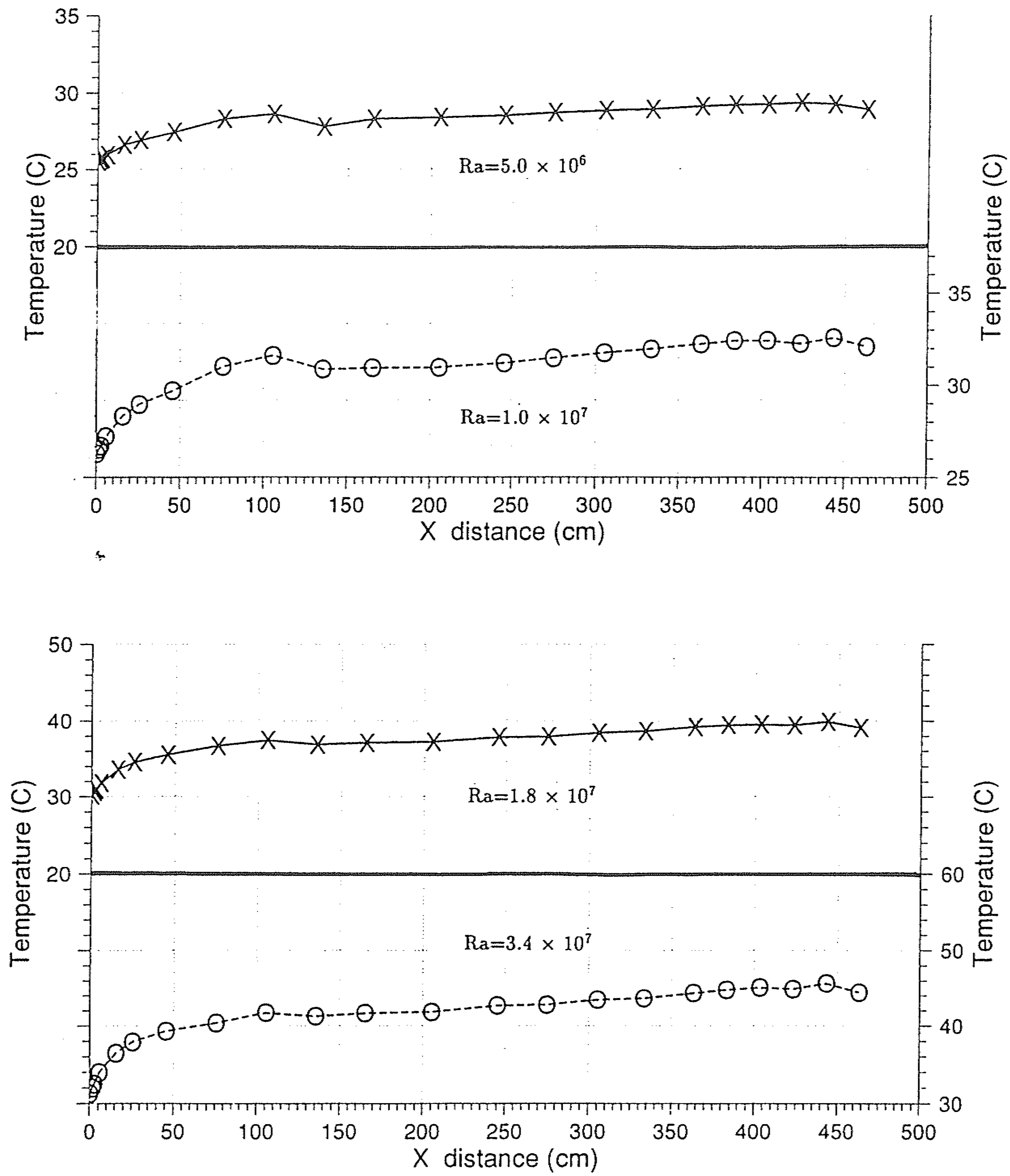
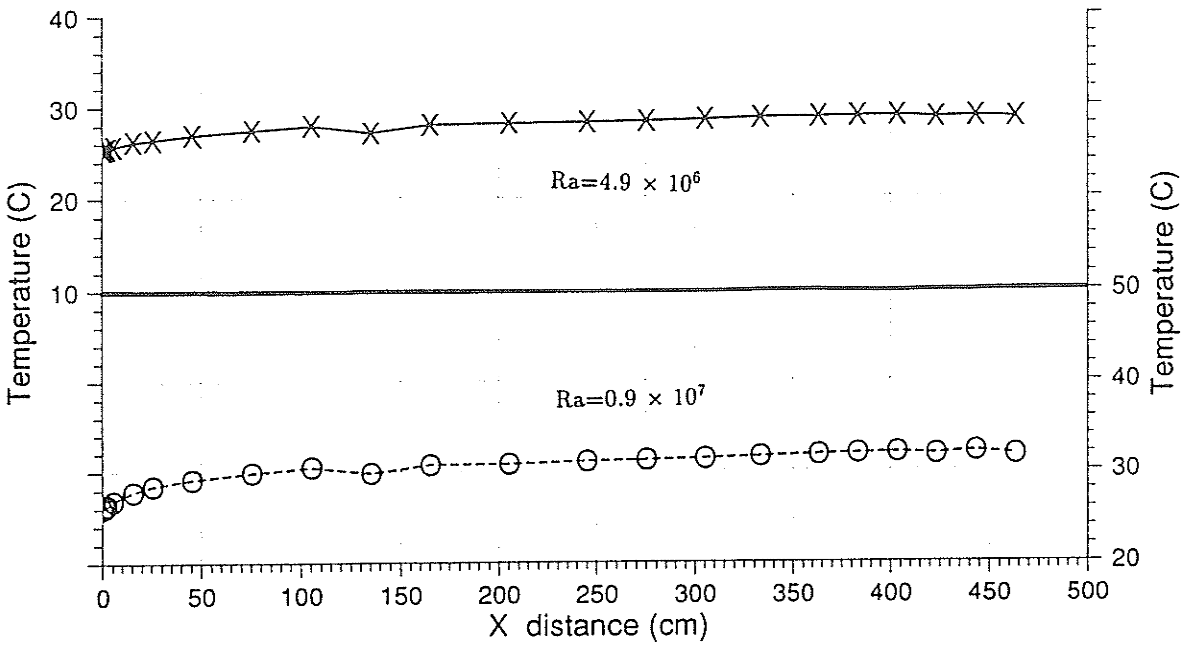


Figure 4.1: Axial wall temperature variation for Pr=100 and Re=150



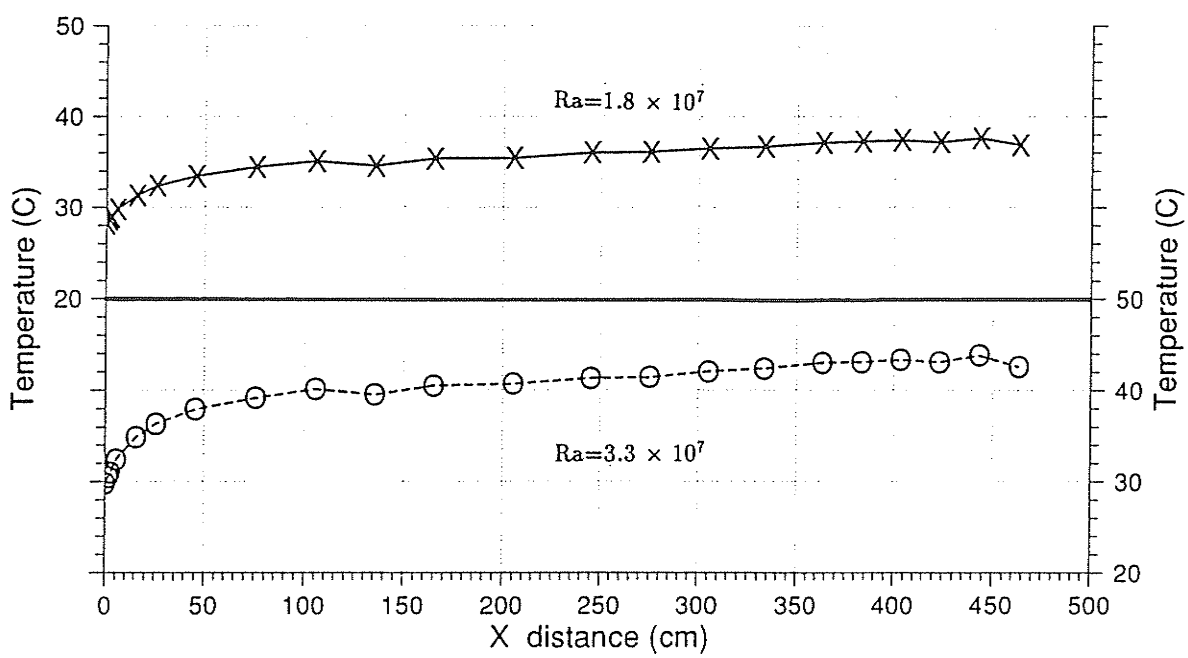


Figure 4.2: Axial wall temperature variation for Pr=100 and Re=250

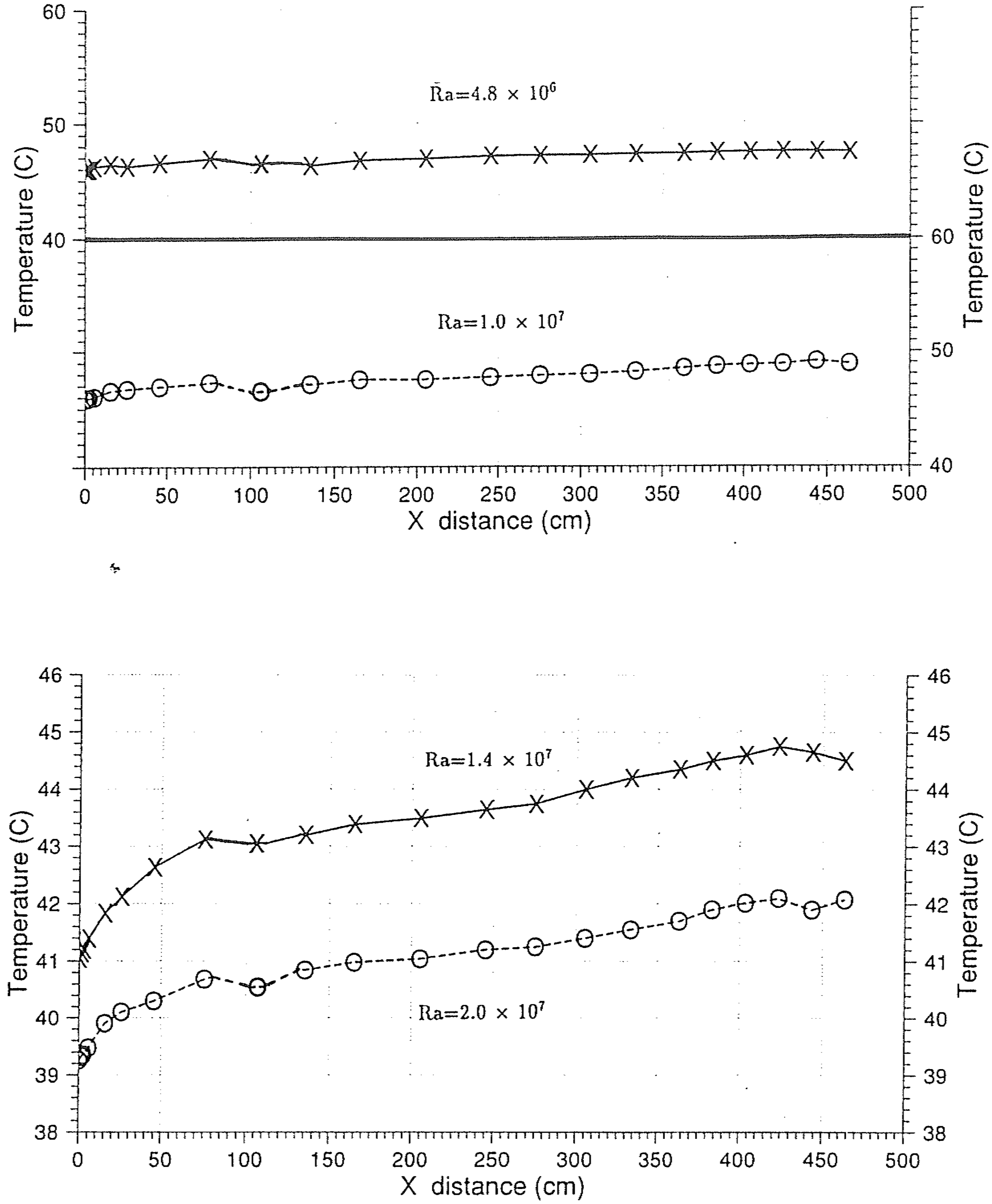
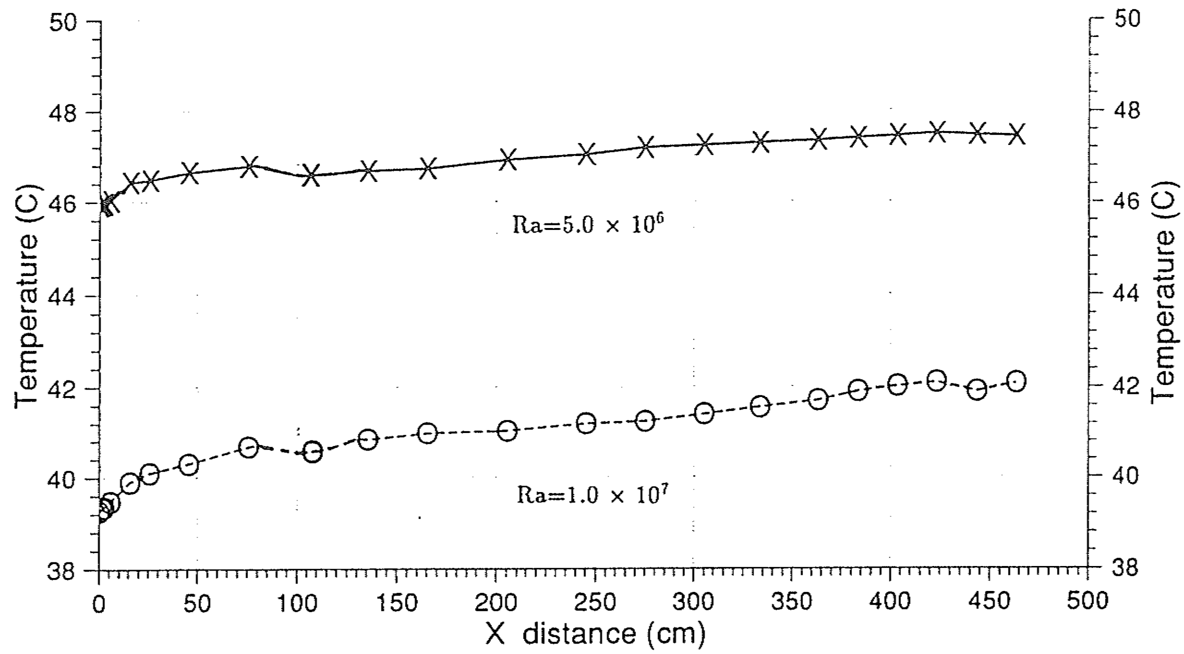


Figure 4.3: Axial wall temperature variation for Pr=20 and Re=150



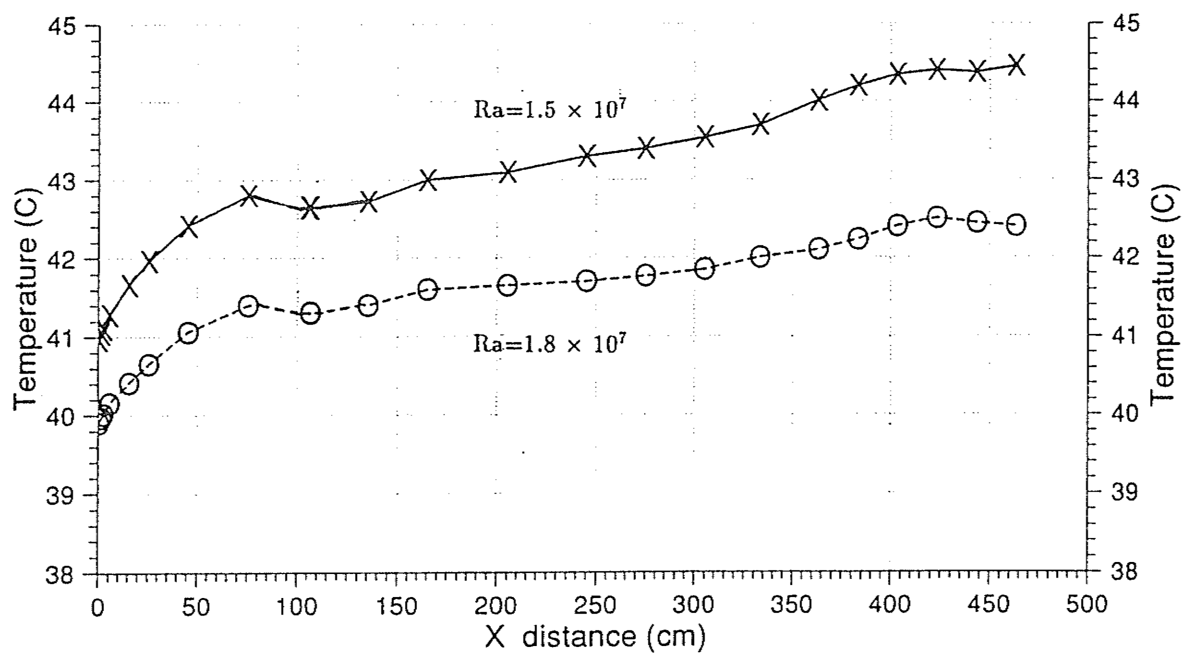


Figure 4.4: Axial wall temperature variation for Pr=20 and Re=250

are:

1. For both Pr=100 and 20, values of t_a and t_b are closely equal to each other under all different running and heating conditions. In relation to secondary flow, this indicates a symmetric two dimensional flow about the vertical center plane of the duct. Furthermore, it indicates that this pattern of flow is independent of the Prandtl number of the working fluid inside the semicircular duct.

2. For both Pr=100 and 20, temperature readings of t_c at the bottom of duct are considerably lower than those of t_a and t_b except for the region near the entrance. As mentioned previously, free convection effects are not significant in the early stage of entry region, and therefore the temperature difference between the top and bottom which is induced by the buoyant movement of fluids is negligible.

3. For the run of Pr=100, and average difference between t_a (or t_b) and t_c is about 0.3°C for the lowest heating rate of $Gr=4.1\times10^4$, and this difference is about 2.0°C for the highest heating rate of $Gr=3.4\times10^5$. This indicates that higher heating will comparatively intensify the free convection effects and cause wider temperature difference between the top and the bottom. The similar pattern is also observed from the results of Pr=20, where temperature difference between t_a(or t_b) and t_c is about 0.1°C for the lowest heating rate and about 1.5°C for the highest heating rate. As a result, it is reasonable to conclude that

more significant free convection effects exist for the fluid of higher Prandtl number than that of lower Prandtl number when the same heating condition are applied to them.

4. The onset of secondary flow caused by free convection is indicated by the first discernible reduction of t_c relative to t_a (or t_b). It is found that locations of the onset of secondary flow are affected by both Grashof number and Prandtl number. But Reynold number effects are not remarkable in the current running condition, which is expected for the narrow range of Reynold number. It is found that the onset of secondary flow is at about x=90 for Pr=100, and at x=60 for Pr=20, therefore it is concluded that lower Prandtl number brought the onset of secondary flow earlier than that of higher Prandtl number. As for the Grashof number effects, there are slight indications that higher Grashof number slightly moved the onset of secondary flow earlier, which would be due to the reason that higher heating rate induces more significant free convection effects.

4.2 Diabatic Friction Factor

This section contains the results of friction factor for Pr=100, Pr=20 and Pr=5. The influences of heating and running condition on friction factor, in terms of Ra and Re numbers, will be presented and discussed, and Prandtl effects on friction factor will be examined as well.

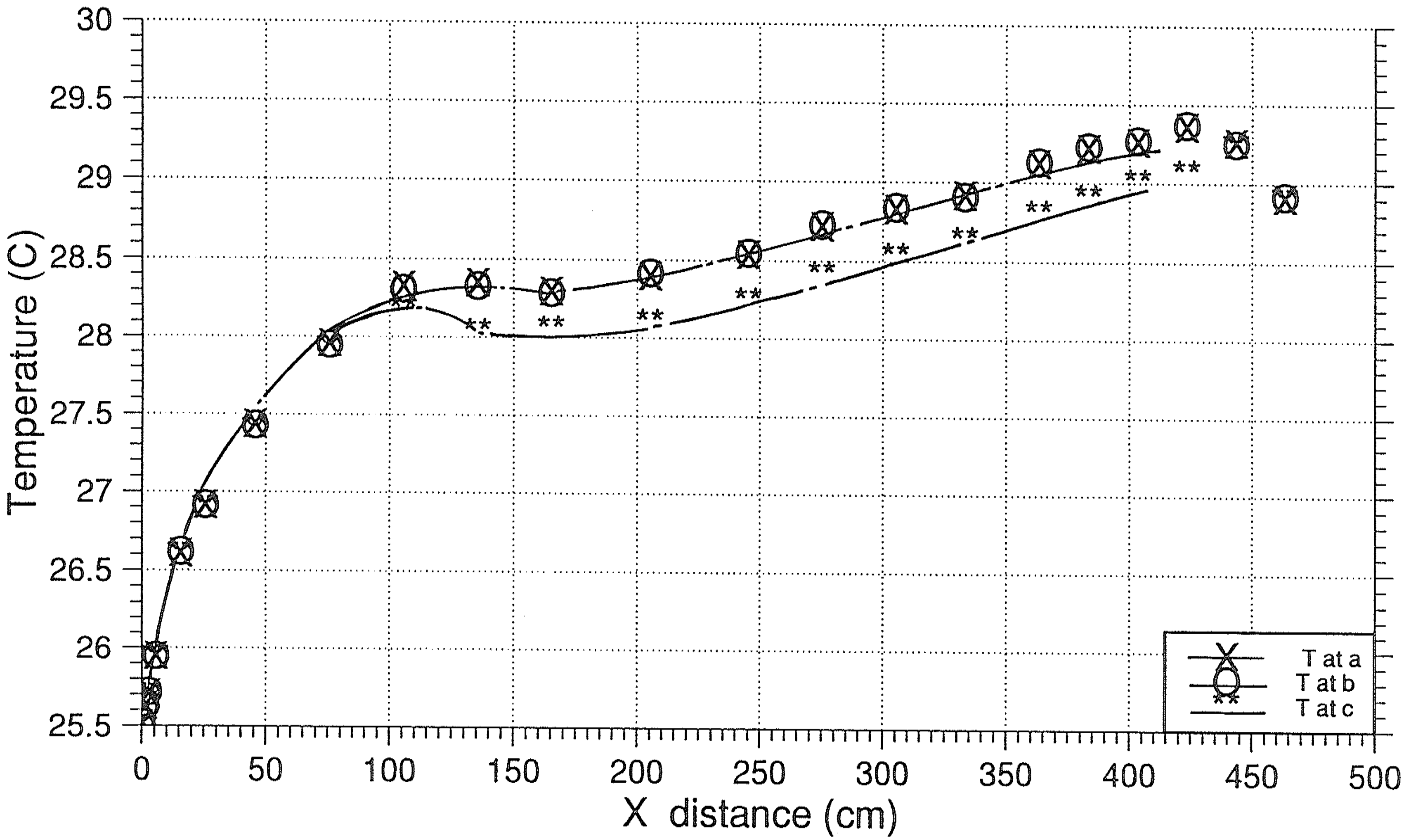


Figure 4.5: **Peripheral wall temperature variation for Pr=100, Re=150 and Gr=3.5×10^4**

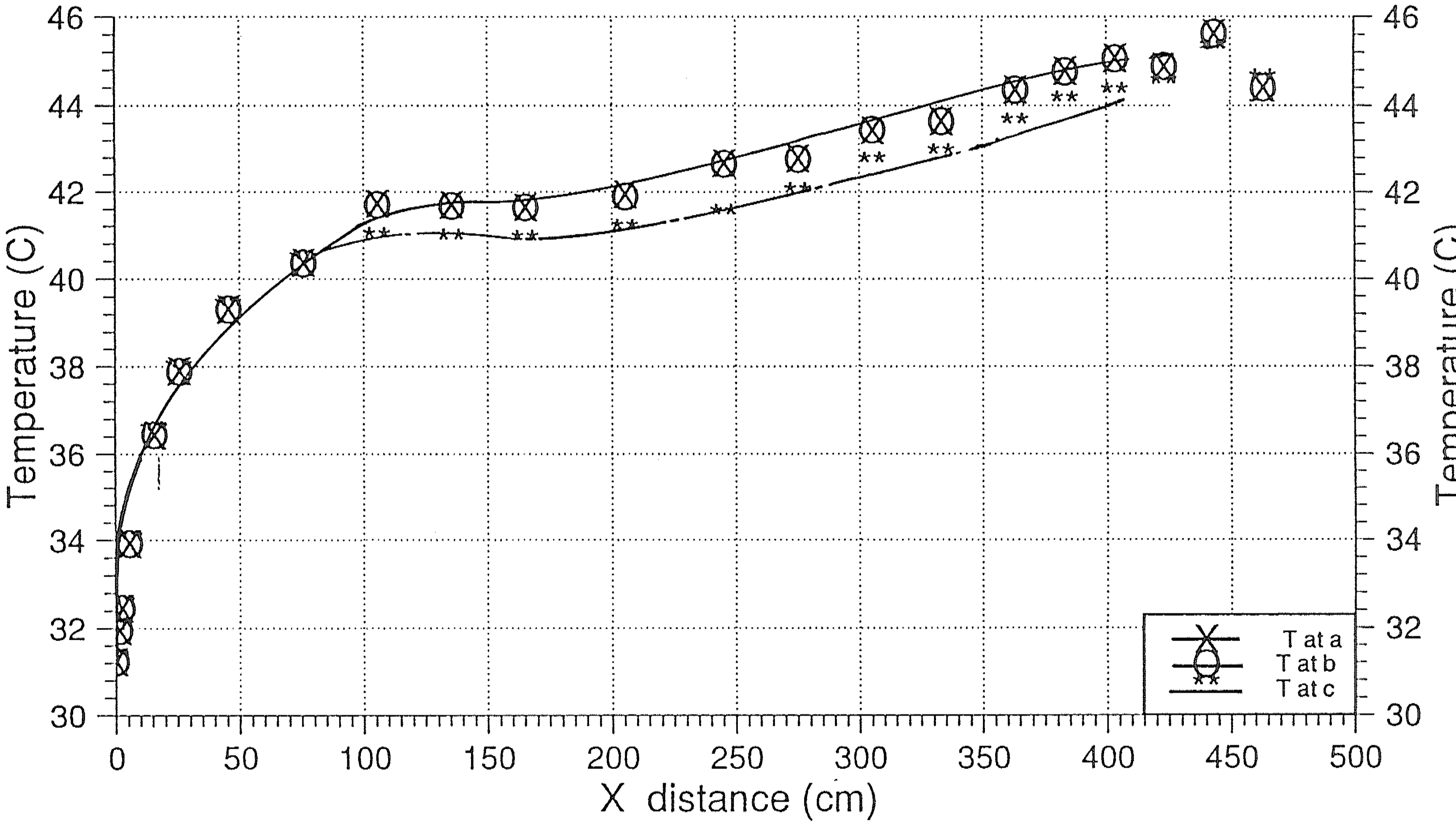


Figure 4.6: **Peripheral wall temperature variation for Pr=100, Re=150 and Gr=4.3×10^5**

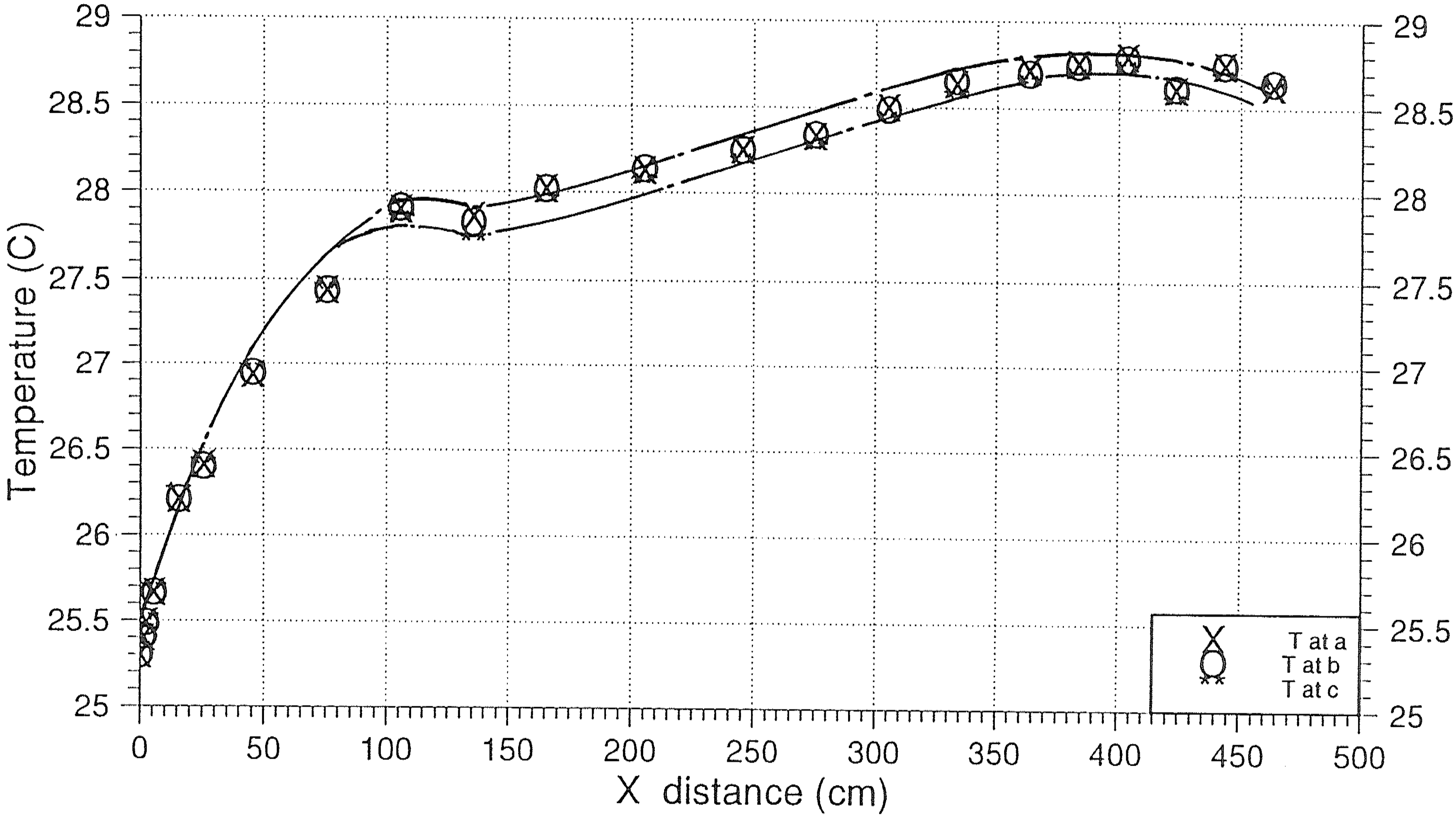


Figure 4.7: **Peripheral wall temperature variation for Pr=100, Re=250 and Gr=3.5$\times 10^4$**

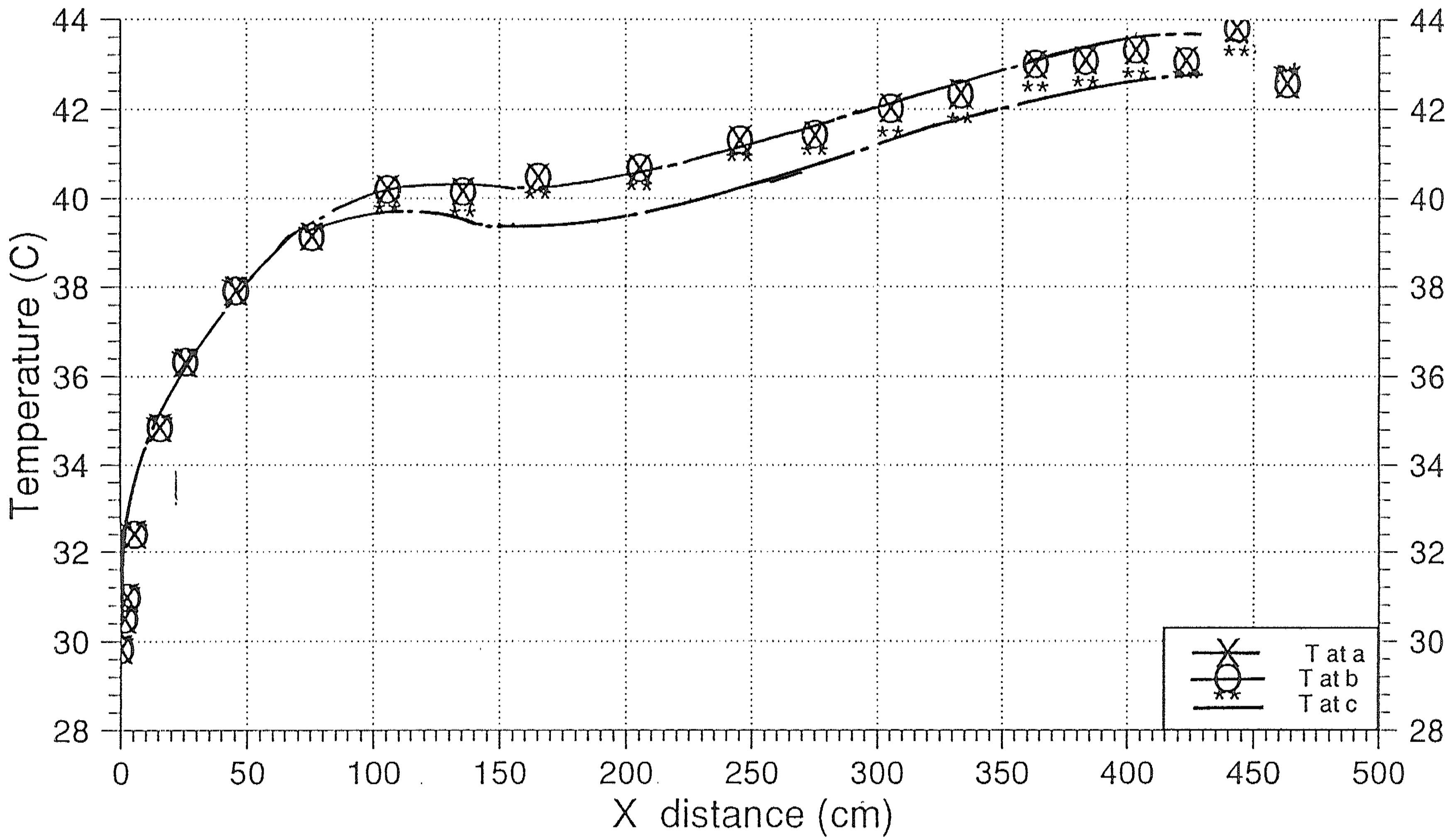


Figure 4.8: **Peripheral wall temperature variation for Pr=100, Re=250 and Gr=4.3×10^5**

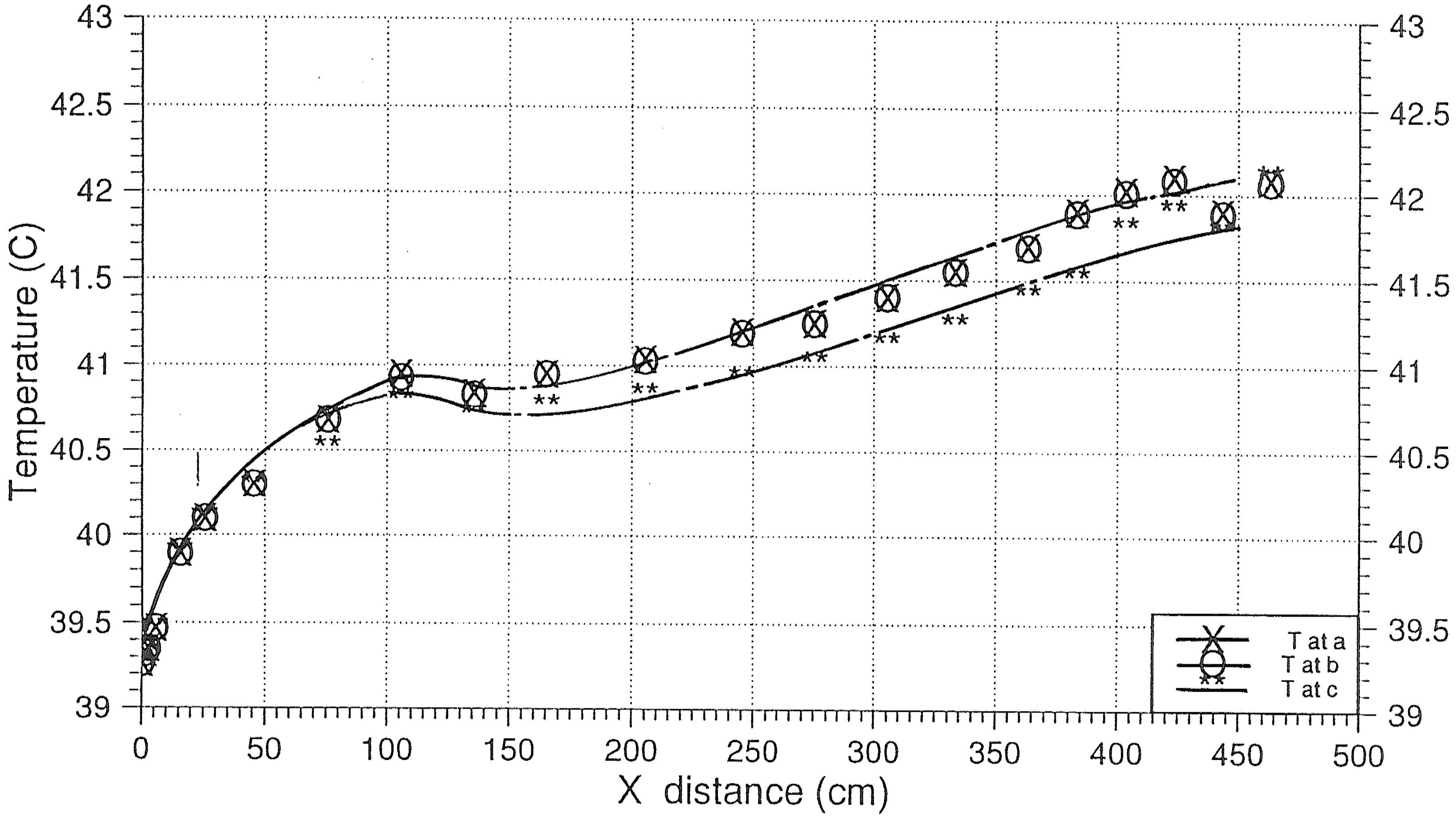


Figure 4.9: **Peripheral wall temperature variation for Pr=20, Re=150 and Gr=3.5×10^4**

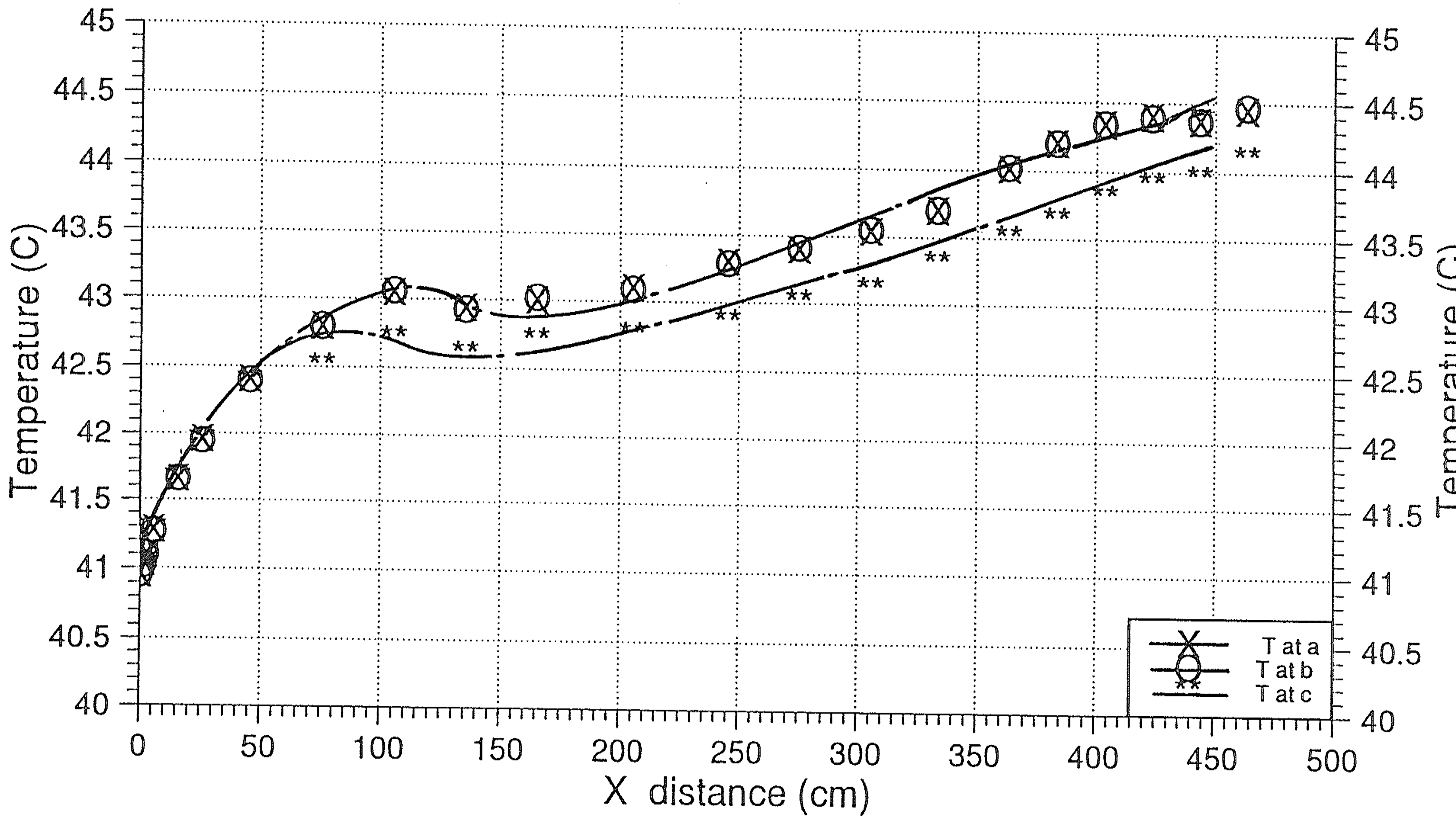


Figure 4.10: **Peripheral wall temperature variation for Pr=20, Re=250 and Gr=4.3×10^5**

4.2.1 Calculation of friction factor

The relationship between values of friction factor and Re number had been studied by Lei and Trupp [18]. It was showed that, when the fully developed condition was reached, friction factor values monotonically dropped with increasing Re in the laminar region. It was also predicted that $(fRe)_{fd,0}$ is 15.7668, $(fRe)_{fd,0}$ is the product of friction factor f and Reynold number without heating.

The friction factor and Reynolds number were calculated based on the hydraulic diameter as follows:

$$Re = \frac{D_h \cdot \dot{m}}{\mu \cdot A_{fl}} \tag{4.1}$$

$$f = \frac{D_h(-\Delta P/\Delta X)}{2\rho \cdot \overline{W}^2} \tag{4.2}$$

The diabatic friction factors are subjected to hydraulically fully-developed condition at the onset of heating. The ratio $(fRe)_{f,d}/(fRe)_{fd,0}$ will be used, where $(fRe)_{f,d}$ is the product of friction factor and Reynold number under the heating condition. This ratio indicates the significance of free convection effect.

4.2.2 Reynold Number Effects

The diabatic friction factors in each experimental run were averaged over the heated section. The effects of variable property were not considered specifically during the reduction of experimental data for the current study. All the properties were evaluated at each average bulk temperature. Table 2 and Table 3 are some sample results of the product fRe for Pr=100 and Pr=20. It is shown that fRe values do not vary significantly with Re for each Prandtl number when different heating conditions were imposed. The difference shown are all within the error band and they do not form a consistant pattern.

Table 2: fRe at Re=150 and 250 for Pr=100

Gr	fRe for Re≈150	fRe for Re≈250	Δ%
5.0×10^4	$16.00_{(Re=150.1)}$	$15.98_{(Re=230.5)}$	nil decr.
1.0×10^5	$16.03_{(Re=150.0)}$	$15.92_{(Re=229.9)}$	nil decr.
3.3×10^5	$16.28_{(Re=168.0)}$	$16.23_{(Re=249.9)}$	nil decr.

Table 3: fRe at Re=150 and 250 for Pr=20

Gr	fRe for Re≈150	fRe for Re≈250	Δ%
4.8×10^4	$16.32_{(Re=142.0)}$	$16.52_{(Re=230.0)}$	1% incr.
1.0×10^5	$16.61_{(Re=147.0)}$	$16.28_{(Re=225.5)}$	2% decr.
3.3×10^5	$15.51_{(Re=139.3)}$	$16.38_{(Re=254.4)}$	5% incr.

4.2.3 Grashof Number Effects

As shown in Fig.4.11, as Grashof number varied from 3.5×10^4 to 4.3×10^5 for each Prandtl number, the ratio of $(fRe)_{f,d}/(fRe)_{fd,0}$ increased very gradually. The same trend had been detected in the earlier study [20]. It is seen that the increases for each Prandtl number are very modest, 0.7% increase for Pr=100, 0.8% increase for Pr=20 and 1.9% increase for Pr=5. This change can be explained that as buoyancy effects become relatively stronger when heating rate increases, more severe distortion of the axial velocity profile is believed to occur thus causing the increase of friction factor under the higher heating rate.

4.2.4 Prandtl Number Effects

Prandtl number effects are also demonstrated in Fig.4.11. For the same heating rate, it is shown that a fluid with higher Prandtl number has a lower level of fRe ratio. The average decrease of fRe for Pr=100 is about 2% comparing to fRe values for Pr=20; and 3% for Pr=20 comparing to these for Pr=5. This could be contributed to the fact that higher Prandtl number fluid will have less severe distortions of axial velocity profile than that of lower Prandtl number fluid due to the difference of viscosity when the same heating rates are imposed. It is believed that increase of f values is the result of distortions of the axial velocity profile caused by the buoyancy-induced secondary flow.

4.3 Heat Transfer Rate

The significance of Reynold, Grashof and Prandtl effects are demonstrated in the following discussion by introducing the dimensionless parameter Nusselt number for both local and fully developed conditions. To show the free convection effects induced by external heating on heat transfer rate along the duct, local Nusselt numbers at different locations are displayed. The Prandtl number impact on heat transfer rate is mainly demonstrated through the

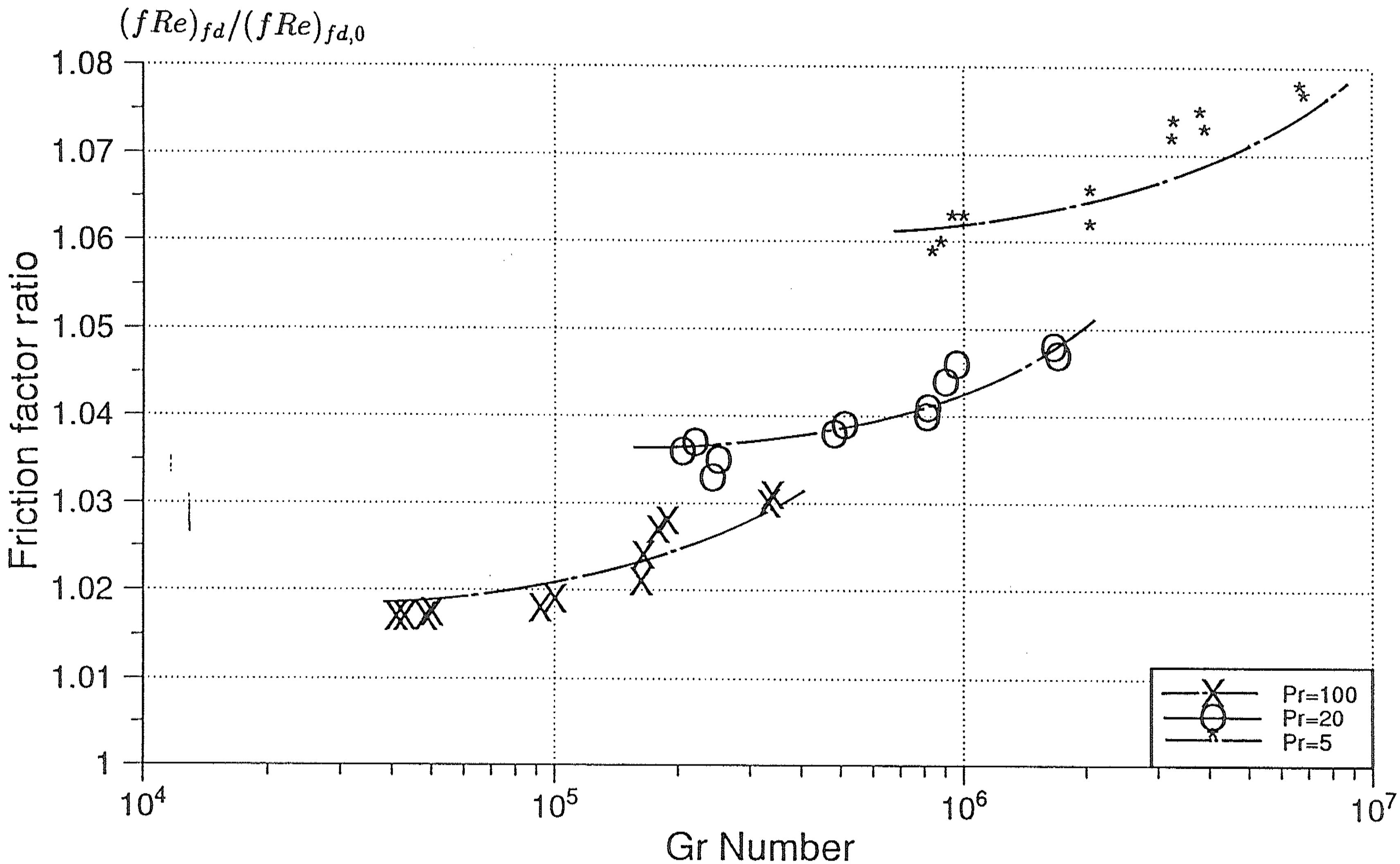


Figure 4.11: Gr vs f ratio for Pr=100, 20 and 5

average Nusselt numbers for the fully developed section for the three working fluids.

4.3.1 Local Heat Transfer Rate

Fig.4.12 shows the distributions of local cross-section average Nusselt numbers at various axial locations for different Prandtl numbers each at two mass flow rates and at about the same Grashof number.

Reynold Number Effects: The effects of Reynold number on $Nu_{x,th}$ appeared to be insignificant at current heating conditions for all Prandtl numbers. The change of Reynold number from about 150 to 250 does not substantially influence the values of $Nu_{x,th}$ with the exception of the area before x=20 and in the fully developed part especially for Pr=100 (with a 3-5% change at the ends), which could be due to the effect of fluid property variations. It is believed that Reynold number effect on local Nusselt number is very limited. Other experimental results and numerical predication have demonstrated similar trends [20]. It also has been pointed out that essential independence of Reynold number in combined convection flow is only true for low and medium heating rates. The insensitivity of $Nu_{x,th}$ values to the change of Reynold number in those data is believed to be the results of both low heating rate and small difference in Reynold number in the current experiments. Previous results by Lei suggested that the influence of Reynold number was limited under low and medium heating rates up to about 3.0×10^8. Only the advance of onset of secondary flow could be detected in those cases.

Grashof Number Effects: Fig.4.13 demonstrates the influence of Grashof number on local Nusselt number for the working fluid of Pr=100. Three different Gr numbers at approximately the same Re number are arranged in the figure. It is noticed that heat transfer rate has been enhanced noticably by increasing Gr number. Other similar trends have been found for Pr=20 and Pr=5 as well. The physical significance behind this enhancement is believed to be the presence of free convection currents which become more vigorous with increasing Gr, to form a dynamic mechanism for the fluids to exchange thermal energy. Meanwhile, the onset of the secondary flow have been advanced by increasing Gr number for each Prandtl number, and this also can be explained as increasing Gr number can relatively enhance free convection effects. As well, it can be noticed in the figure that the frequency and magnitude of oscillations in $Nu_{x,th}$ decrease as Gr number is reduced, which is the weakening of secondary flow.

Prandtl Number Effects: The influence of Prandtl number were investigated by running the fluids of different viscosity. Data for Prandtl numbers of 100 and 20 were examined along with those of Pr=5, under similar heating and running conditions. Fig.4.12 is used again to display Prandtl effect on local heat transfer rates in terms of $Nu_{x,th}$. It is apparent that heat transfer rate can be enhanced significantly along the heating section by us-

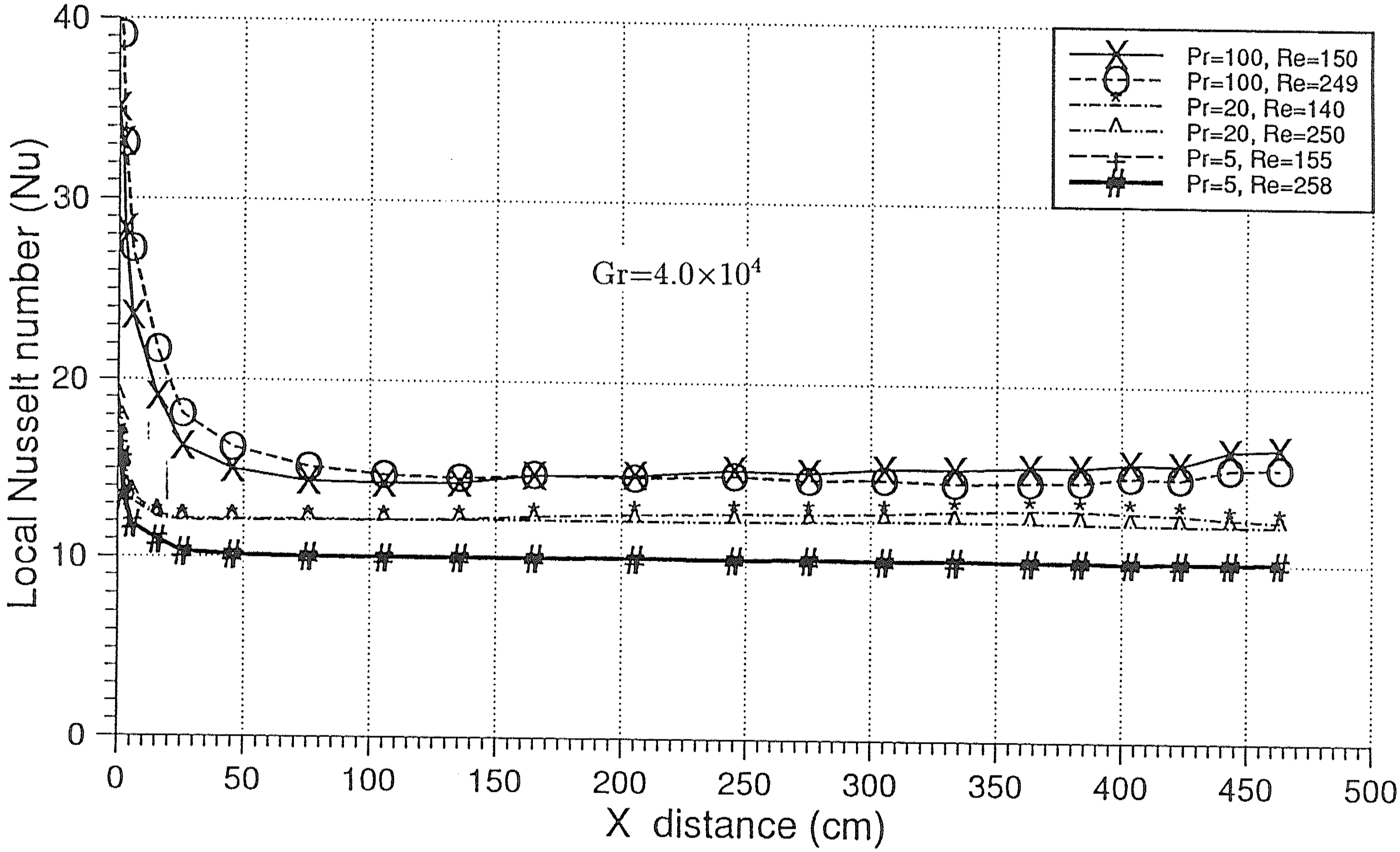


Figure 4.12: **Local Nusselt number vs. X distance for Pr=100, 20 and 5**

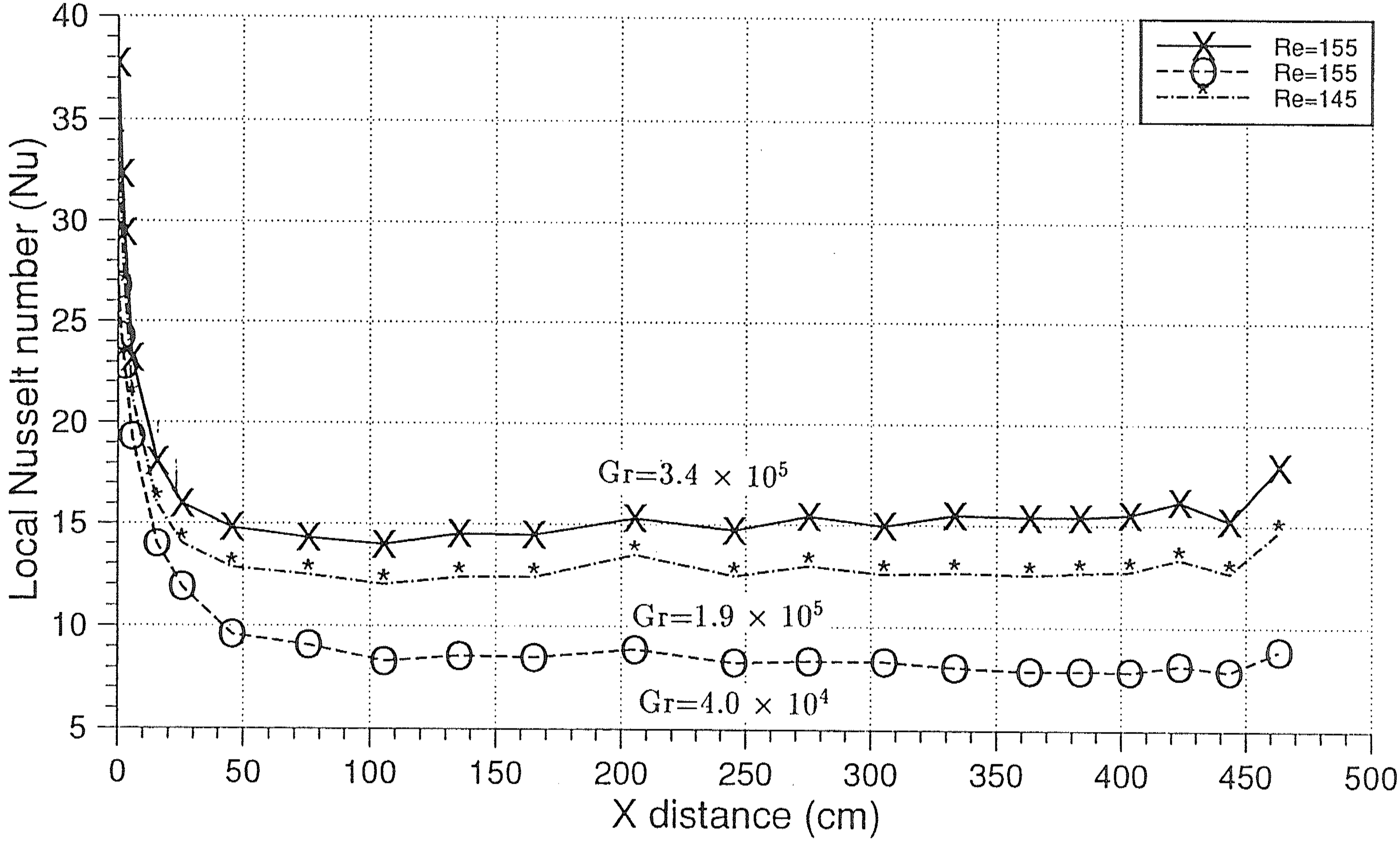


Figure 4.13: **Gr effects on $Nu_{x,th}$ for Pr=100**

ing fluids of higher Prandtl number. For example, at Re=250 and Gr=6.0×10^4, an average of about 15% increase of heat transfer rate occurs for Pr=100 compared to Pr=20 nearing fully developed conditions. Other similar increases of 30% is shown as well between Pr=20 and Pr=5. Thus, it appears that Prandtl number has a significant impact on local heat transfer rate, and furthermore higher Prandtl number can enhance local heat transfer rate.

4.3.2 Average Nusselt Number

As one of the key parameters in the practical design of heat transfer equipment, the fully developed Nusselt numbers were found to be well established in most tests after the seventh or eighth wall-temperature measuring station. Due to the consideration of reducing the influences of some buoyancy-induced fluctuation and property variations in the flow direction, values for the fully developed Nusselt number $Nu_{f,d}$ were determined by computing the length-mean average Nu_x after the twelfth station.

Reynold Number Effects: Table 4 was constructed to allow detection of the Re effect on fully developed Nusselt number for the fluid of Pr=100. The two Reynold numbers are still about 150 and 250 as before. Although running conditions are rather limited, there is no discernible trend of Reynold number effect. Hence it is believed that Re has little or no influence on heat transfer enhancement $\overline{Nu_{f,d}}$. This observation agrees with the previous study [20], which found that $\overline{Nu_{f,d}}$ was almost independent of Re for low heating rate (Gr number less than 1.0×10^7).

Table 4: $\overline{Nu_{f,d}}$ for Pr=100 at Re=150 and 250

Gr	Re=150	Re=250	Δ%
5.0×10^4	8.6	8.5	1.2% decr.
4.2×10^4	8.0	8.1	1.2% incr.
3.3×10^5	15.5	15.0	3.2% decr.

Grashof Number Effects: The influence of heating rate in terms of Gr number is found to be very influential on fully developed Nusselt number. Fig.4.14 demonstrates these effects. The normalized ratio of $(Nu_{fd,th})/(Nu_{fd,H1})_0$ is used to indicate the significance of heating rate effect on enhancement of $(Nu_{fd,th})$, where $(Nu_{fd,H1})_0$ is forced convection Nusselt number for H_1 condition and the value is 4.0880 as predicted [20]. It is seen that heat transfer rate can be enhanced by increasing heating rate, and more significant increases are observed at higher heating rates for each Prandtl number. The results for Pr=20 and Pr=5 show similar significant increase by significant as well. Therefore, it is concluded that increasing heating rate enhances heat transfer rate for all Prandtl numbers.

Prandtl Number Effects: Fig.4.14 also serves to show the significance of Prandtl number effect on fully developed Nusselt number. Apparently, the working fluid with a higher Prandtl number has higher level of fully developed Nusselt number when the same Grashof numbers are imposed. Fully developed Nusselt number for Pr =100 are at a higher level than those of Pr=20 for the same Gr number, and Nusselt numbers for Pr=5 remain

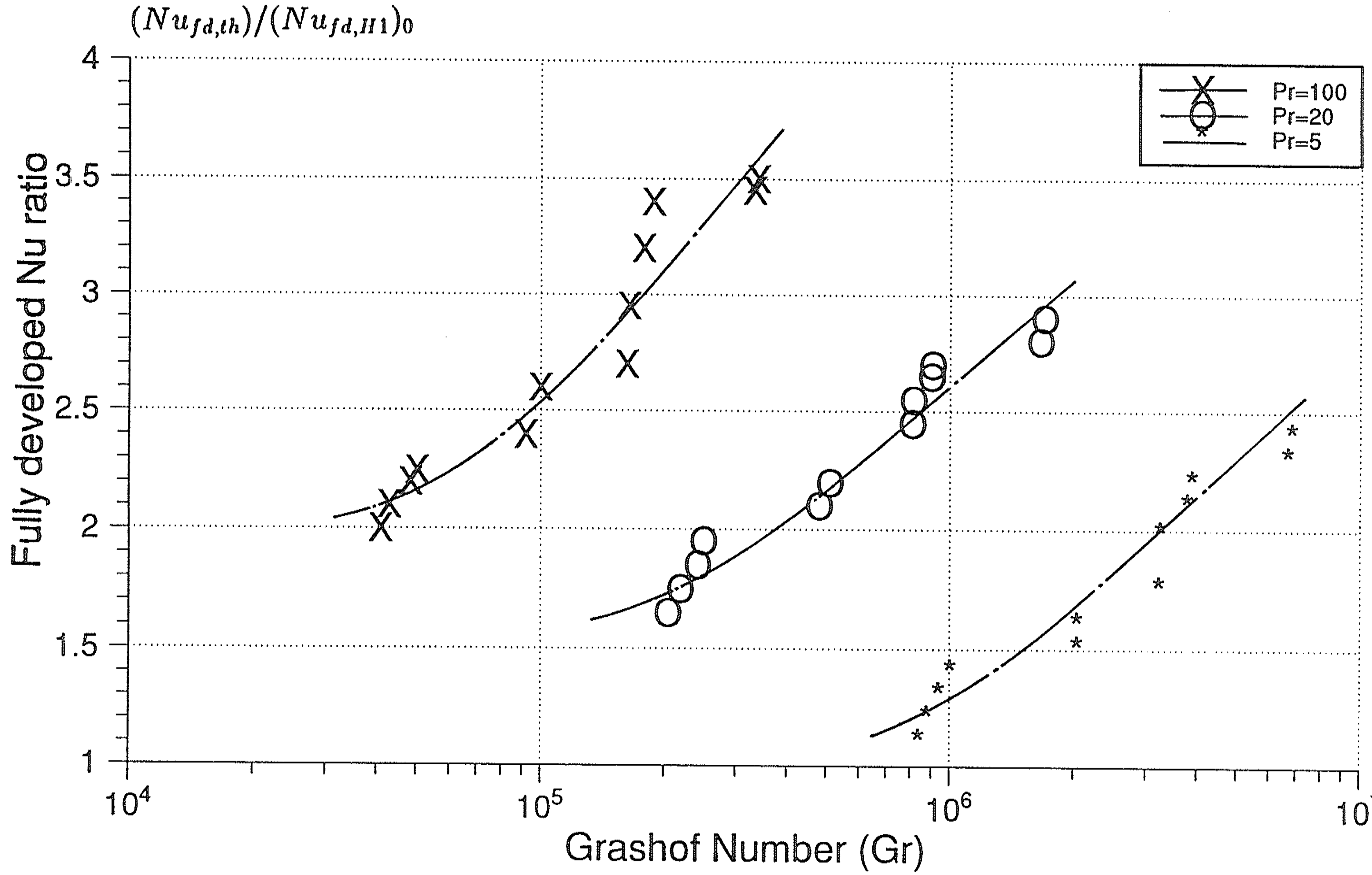


Figure 4.14: Gr effects on $\overline{Nu_{f,d}}$ for Pr=100,20 and5

the lowest. Approximately 15% increase in the Nu ratio is found between Pr=100 and Pr=20 at Gr=4.0×10^4; while a 30% increase is also found between Pr=20 and Pr=5 at Gr=1.2×10^5. It is seen that Prandtl number plays an active role in the enhancement of heat transfer rate, and a fluid with higher Prandtl number has a higher level of fully developed Nusselt number. Fig.4.15 shows the same Nusselt number ratio plotted against Ra number, and it is seen that residual Pr number effects remain. Theoretically speaking, Pr number effects would be removed from this figure. It is suspected that this discrepancy may be largely due to property variations of the fluid.

In order to provide a empirical correlation for the fully developed Nusselt number ratio in terms of Grashof number and Prandtl number, but it is found that one correlation for all three Prandtl numbers is hardly satisfactory. Therefore, three correlations for three Prandtl numbers are used here in terms of Ra^n. The experimental data were used to obtain the following equations:

For Pr=100: $(Nu_{fd,th})/(Nu_{fd,H1})_0= 0.043651\times Ra^{0.25348}$, ($\sigma$=4.0%, and σ_{max}=9.0%)

For Pr=20: $(Nu_{fd,th})/(Nu_{fd,H1})_0= 0.042216\times Ra^{0.24515}$, ($\sigma$=3.0%, and σ_{max}=6.5%)

For Pr=5: $(Nu_{fd,th})/(Nu_{fd,H1})_0= 0.009089\times Ra^{0.32296}$, ($\sigma$=5.0%, and σ_{max}=9.0%)

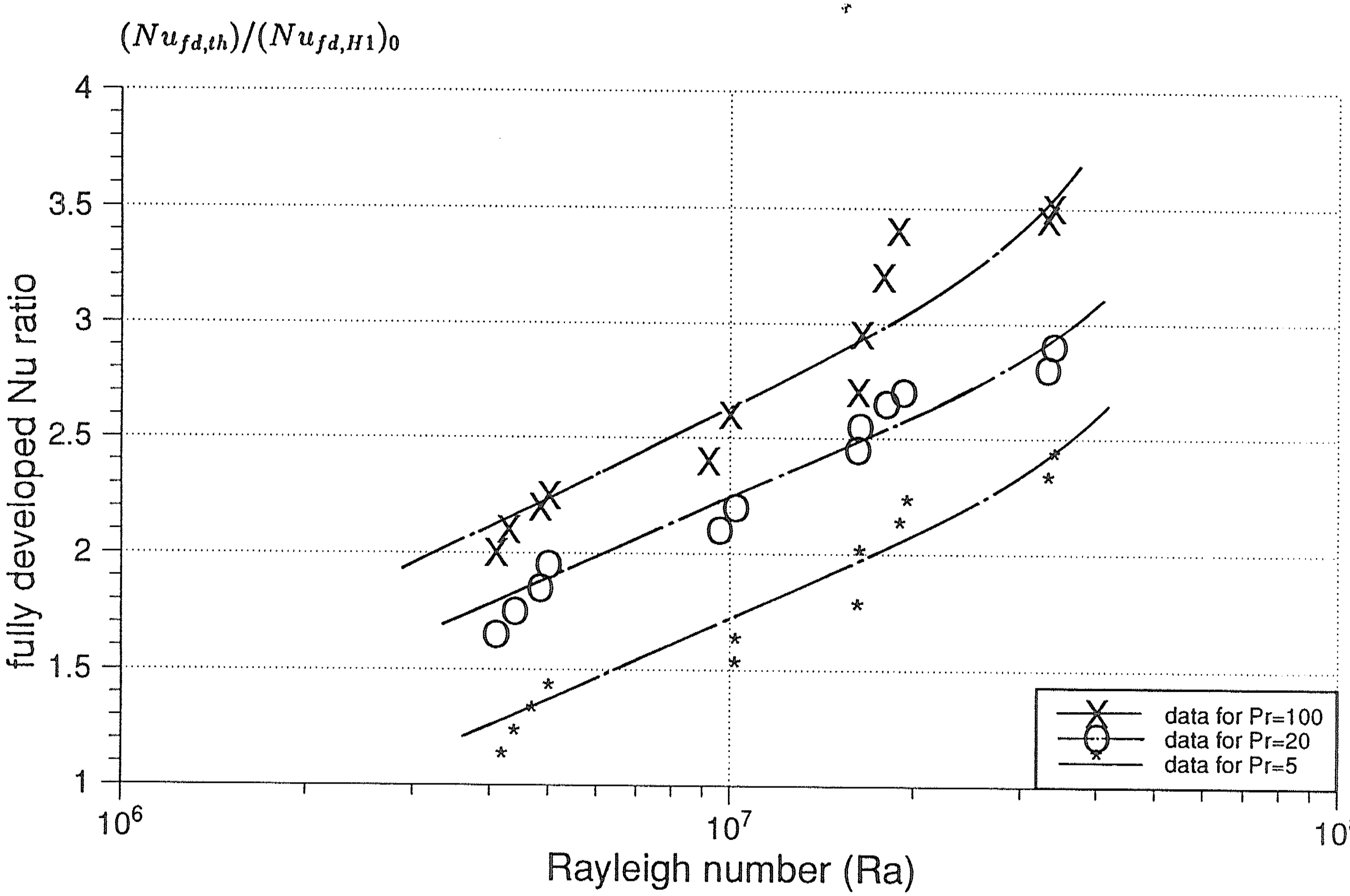


Figure 4.15: **Residual Ra effects on $\overline{Nu_{f,d}}$**

Chapter 5

Conclusions

Experimental study has been conducted to investigate Prandtl number effects on combined free and forced convection flow in a horizontal semicircular duct. Prandtl number was found to have significant effects on friction factor and heat transfer rate. Higher Prandtl number was seen to enhance the heat transfer rate and decrease the friction factor compared to fluids of lower Prandtl number. Both axial and peripheral wall temperature distributions were affected by the Prandtl number as well. An empirical correlation for fully developed Nusselt number was obtained from the experimental data, and fairly reasonable agreement has been found between the correlation and experimental data.

It is concluded that Prandtl number played a very active role in the experimental results and this should provided some useful information for the relevant engineering consideration and design.

For the future study of combined free and forced convection flow in a semicircular duct, it is suggested that a further study is needed regarding property variation, and the knowledge of its effects on wall temperature distribution, friction factors and heat transfer rate will be important to further understand the problem.

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Appendix A: Experimental Results

No. 1

INPUT ELECTRIC POWER = 186.8 W | HEAT RATE GAINED BY WATER = 183.4 W | HEAT BALANCE ERROR = 1.80%
MASS FLOW RATE = 57.4340 G/S | PRESSURE DROP = 11.098 MM H2O | FRICTION FACTOR = 0.106666 | FREM = 16.0103

REM = 150.1 | GRM+ = 0.50346E 05 | UPSTREAM BULK TEMPERATURE = 24.42 DEG C | DOWNSTREAM BULK TEMPERATURE = 25.67 DEG C
PRM = 99.57 | RAM+ = 0.50129E 07 | INLET BULK TEMPERATURE = 24.42 DEG C | OUTLET BULK TEMPERATURE = 25.66 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.51	25.52	25.49	25.50	24.42	147.1	****	0.490E 07	0.00000	27.71	27.33	28.26	27.88	27.89	27.89
1	1.5	25.63	25.65	25.62	25.63	24.42	147.1	****	0.490E 07	0.00003	25.07	24.64	25.30	25.07	25.08	25.07
2	2.5	25.71	25.73	25.71	25.71	24.43	147.1	****	0.490E 07	0.00006	23.53	23.07	23.59	23.44	23.45	23.44
3	5.5	25.95	25.99	25.97	25.97	24.43	147.2	****	0.490E 07	0.00012	19.87	19.38	19.62	19.62	19.62	19.62
4	15.5	26.61	26.56	26.59	26.59	24.46	147.3	****	0.491E 07	0.00034	14.05	14.36	14.19	14.20	14.20	14.20
5	25.5	26.92	27.01	26.92	26.94	24.49	147.4	****	0.491E 07	0.00056	12.43	11.96	12.43	12.31	12.31	12.31
6	45.5	27.44	27.40	27.41	27.41	24.54	147.7	****	0.492E 07	0.00100	10.40	10.57	10.53	10.51	10.51	10.51
7	75.5	27.95	27.74	27.76	27.80	24.62	148.1	****	0.493E 07	0.00166	9.06	9.69	9.63	9.50	9.50	9.50
8	105.5	28.14	28.03	28.08	28.08	24.70	148.4	****	0.495E 07	0.00232	8.79	9.07	8.94	8.93	8.93	8.93
9	135.5	28.34	28.28	27.85	28.08	24.78	148.8	****	0.496E 07	0.00298	8.48	8.62	9.83	9.15	9.19	9.17
10	165.2	28.30	28.26	28.17	28.22	24.86	149.2	****	0.498E 07	0.00364	8.77	8.88	9.13	8.97	8.98	8.97
11	205.2	28.33	28.30	28.08	28.20	24.96	149.7	99.8	0.500E 07	0.00452	8.97	9.05	9.70	9.34	9.36	9.35
12	245.2	28.54	28.66	28.37	28.48	25.07	150.2	99.5	0.502E 07	0.00540	8.72	8.42	9.16	8.85	8.86	8.86
13	275.2	28.72	28.61	28.41	28.54	25.15	150.6	99.2	0.503E 07	0.00606	8.46	8.73	9.27	8.92	8.93	8.93
14	305.2	28.83	28.77	28.59	28.70	25.23	151.0	99.0	0.505E 07	0.00671	8.39	8.54	8.99	8.72	8.72	8.72
15	333.3	28.92	28.94	28.74	28.83	25.30	151.4	98.8	0.506E 07	0.00733	8.35	8.32	8.81	8.57	8.57	8.57
16	363.3	29.12	29.12	28.75	28.94	25.38	151.8	98.6	0.508E 07	0.00799	8.09	8.09	8.98	8.51	8.54	8.52
17	383.3	29.22	29.17	28.81	29.00	25.44	152.1	98.4	0.509E 07	0.00843	8.00	8.11	8.96	8.48	8.51	8.50
18	403.3	29.26	29.12	28.90	29.04	25.49	152.3	98.2	0.510E 07	0.00887	8.03	8.33	8.87	8.51	8.52	8.52
19	423.3	29.06	29.04	28.70	28.88	25.54	152.6	98.1	0.511E 07	0.00930	8.59	8.65	9.57	9.07	9.10	9.09
20	443.3	29.26	29.31	28.84	29.06	25.60	152.9	97.9	0.512E 07	0.00974	8.26	8.14	9.33	8.73	8.77	8.75
21	463.3	28.91	28.97	28.50	28.72	25.65	153.1	97.8	0.513E 07	0.01018	9.28	9.11	10.63	9.86	9.91	9.89
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	29.14	29.12	28.79	28.96	25.46	152.2	98.3	0.509E 07	0.00861	8.22	8.27	9.09	8.65	8.67	8.66

------------------ NO.2 --

INPUT ELECTRIC POWER = 190.1 W
HEAT RATE GAINED BY WATER = 178.4 W
HEAT BALANCE ERROR = 6.16%
MASS FLOW RATE = 88.7122 G/S
PRESSURE DROP = 17.217 MM H2O
FRICTION FACTOR = 0.069367
FREM = 15.9857

REM = 230.5
GRM+ = 0.48361E 05
UPSTREAM BULK TEMPERATURE = 24.46 DEG C
DOWNSTREAM BULK TEMPERATURE = 25.25 DEG C
PRM = 100.12
RAM+ = 0.48417E 07
INLET BULK TEMPERATURE = 24.46 DEG C
OUTLET BULK TEMPERATURE = 25.25 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.30	25.31	25.24	25.27	24.46	227.6	****	0.477E 07	0.00000	35.33	34.69	37.87	36.38	36.44	36.41
1	1.5	25.40	25.42	25.36	25.38	24.47	227.6	****	0.477E 07	0.00002	31.62	30.91	32.89	32.05	32.08	32.07
2	2.5	25.46	25.49	25.44	25.46	24.47	227.6	****	0.477E 07	0.00004	29.49	28.74	30.16	29.62	29.64	29.63
3	5.5	25.67	25.71	25.69	25.69	24.47	227.6	****	0.477E 07	0.00008	24.53	23.76	24.14	24.14	24.14	24.14
4	15.5	26.21	26.17	26.14	26.16	24.49	227.8	****	0.478E 07	0.00022	17.06	17.51	17.84	17.56	17.56	17.56
5	25.5	26.41	26.50	26.47	26.46	24.51	227.9	****	0.478E 07	0.00036	15.44	14.73	14.99	15.03	15.04	15.03
6	45.5	26.94	26.95	26.84	26.89	24.54	228.1	****	0.479E 07	0.00065	12.25	12.21	12.75	12.49	12.49	12.49
7	75.5	27.44	27.29	27.31	27.34	24.59	228.5	****	0.479E 07	0.00108	10.29	10.89	10.82	10.70	10.70	10.70
8	105.5	27.74	27.69	27.68	27.70	24.64	228.9	****	0.480E 07	0.00151	9.47	9.62	9.67	9.61	9.61	9.61
9	135.5	27.95	28.00	27.68	27.83	24.69	229.2	****	0.481E 07	0.00193	9.02	8.88	9.82	9.36	9.38	9.37
10	165.2	28.02	27.92	27.83	27.90	24.74	229.6	****	0.482E 07	0.00236	8.95	9.23	9.52	9.30	9.31	9.30
11	205.2	27.99	28.02	27.80	27.90	24.81	230.1	****	0.483E 07	0.00293	9.22	9.14	9.82	9.49	9.50	9.50
12	245.2	28.25	28.33	28.03	28.16	24.87	230.6	****	0.484E 07	0.00350	8.70	8.52	9.32	8.95	8.96	8.96
13	275.2	28.33	28.28	28.13	28.21	24.92	231.0	99.9	0.485E 07	0.00392	8.63	8.77	9.18	8.93	8.94	8.94
14	305.2	28.60	28.49	28.25	28.37	24.97	231.3	99.8	0.486E 07	0.00435	8.34	8.36	8.96	8.65	8.66	8.65
15	333.3	28.64	28.54	28.39	28.49	25.02	231.7	99.6	0.487E 07	0.00475	8.12	8.35	8.72	8.47	8.47	8.47
16	363.3	28.72	28.67	28.41	28.55	25.07	232.1	99.5	0.488E 07	0.00518	8.05	8.18	8.79	8.44	8.45	8.45
17	383.3	28.76	28.72	28.48	28.61	25.11	232.3	99.4	0.489E 07	0.00546	8.04	8.14	8.72	8.39	8.41	8.40
18	403.3	28.80	28.78	28.50	28.65	25.14	232.6	99.3	0.489E 07	0.00575	8.02	8.06	8.74	8.38	8.39	8.38
19	423.3	28.61	28.59	28.31	28.46	25.17	232.8	99.2	0.490E 07	0.00603	8.54	8.60	9.37	8.95	8.97	8.96
20	443.3	28.75	28.92	28.44	28.64	25.21	233.1	99.1	0.491E 07	0.00631	8.30	7.92	9.09	8.57	8.60	8.58
21	463.3	28.63	28.57	28.03	28.32	25.24	233.3	99.0	0.491E 07	0.00660	8.67	8.83	10.52	9.56	9.64	9.60
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	28.72	28.70	28.42	28.57	25.12	232.4	99.3	0.489E 07	0.00558	8.18	8.21	8.90	8.53	8.55	8.54

------------------------- No.3 -----------------------------

INPUT ELECTRIC POWER = 369.1 W   HEAT RATE GAINED BY WATER = 358.6 W   HEAT BALANCE ERROR = 2.86%
MASS FLOW RATE = 56.2586 G/S   PRESSURE DROP = 10.677 MM H2O   FRICTION FACTOR = 0.106909   FREM = 16.0324

REM = 150.0   GRM+ = 0.10252E 06   UPSTREAM BULK TEMPERATURE = 24.40 DEG C   DOWNSTREAM BULK TEMPERATURE = 26.89 DEG C
PRM = 97.79   RAM+ = 0.10025E 08   INLET BULK TEMPERATURE = 24.40 DEG C   OUTLET BULK TEMPERATURE = 26.88 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	26.27	26.29	26.18	26.23	24.40	144.0	****	0.957E 07	0.00000	31.60	31.36	33.17	32.30	32.32	32.31
1	1.5	26.52	26.54	26.46	26.49	24.41	144.1	****	0.957E 07	0.00003	28.01	27.75	28.84	28.35	28.36	28.36
2	2.5	26.69	26.71	26.65	26.67	24.42	144.1	****	0.957E 07	0.00006	25.98	25.71	26.46	26.15	26.15	26.15
3	5.5	27.20	27.23	27.22	27.22	24.43	144.2	****	0.958E 07	0.00012	21.34	21.07	21.20	21.20	21.20	21.20
4	15.5	28.31	28.20	28.23	28.24	24.48	144.4	****	0.960E 07	0.00035	15.42	15.90	15.76	15.71	15.71	15.71
5	25.5	28.94	28.99	28.72	28.84	24.54	144.7	****	0.962E 07	0.00057	13.40	13.25	14.12	13.71	13.72	13.72
6	45.5	29.69	29.65	29.39	29.53	24.64	145.1	****	0.965E 07	0.00102	11.69	11.79	12.44	12.08	12.09	12.09
7	75.5	30.30	30.20	29.90	30.09	24.80	145.9	****	0.971E 07	0.00170	10.59	10.93	11.59	11.16	11.18	11.17
8	105.5	30.67	30.61	30.31	30.47	24.96	146.6	99.8	0.977E 07	0.00237	10.36	10.47	11.04	10.72	10.73	10.72
9	135.5	30.89	30.83	30.16	30.51	25.12	147.4	99.3	0.983E 07	0.00304	10.24	10.35	11.73	10.96	11.01	10.99
10	165.2	30.94	30.85	30.50	30.70	25.28	148.2	98.9	0.989E 07	0.00371	10.44	10.61	11.32	10.91	10.92	10.92
11	205.2	30.93	30.95	30.44	30.69	25.49	149.2	98.2	0.997E 07	0.00460	10.87	10.83	11.94	11.37	11.40	11.38
12	245.2	31.43	31.46	30.94	31.19	25.70	150.2	97.6	0.100E 08	0.00550	10.32	10.27	11.28	10.77	10.79	10.78
13	275.2	31.48	31.42	31.26	31.35	25.86	151.0	97.2	0.101E 08	0.00617	10.53	10.63	10.96	10.77	10.77	10.77
14	305.2	31.75	31.74	31.20	31.47	26.02	151.9	96.7	0.102E 08	0.00684	10.31	10.33	11.42	10.85	10.87	10.86
15	333.3	31.96	31.98	31.35	31.66	26.17	152.6	96.2	0.102E 08	0.00746	10.22	10.18	11.41	10.77	10.80	10.79
16	363.3	32.24	32.24	31.57	31.90	26.33	153.4	95.8	0.103E 08	0.00813	10.02	10.01	11.29	10.62	10.65	10.64
17	383.3	32.40	32.26	31.56	31.94	26.43	154.0	95.5	0.103E 08	0.00858	9.92	10.15	11.54	10.74	10.79	10.76
18	403.3	32.42	32.32	31.68	32.03	26.54	154.5	95.2	0.104E 08	0.00902	10.07	10.24	11.51	10.79	10.83	10.81
19	423.3	32.27	32.29	31.56	31.92	26.64	155.1	94.8	0.104E 08	0.00947	10.52	10.49	12.05	11.23	11.28	11.25
20	443.3	32.59	32.82	31.95	32.33	26.75	155.7	94.5	0.105E 08	0.00991	10.15	9.75	11.38	10.61	10.66	10.64
21	463.3	32.11	32.17	31.27	31.70	26.86	156.2	94.2	0.105E 08	0.01035	11.27	11.14	13.42	12.21	12.31	12.26
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	32.31	32.32	31.61	31.96	26.48	154.2	95.3	0.104E 08	0.00876	10.15	10.14	11.53	10.79	10.84	10.81

------------------ No.4 ------------------------------

INPUT ELECTRIC POWER = 372.8 W HEAT RATE GAINED BY WATER = 333.5 W HEAT BALANCE ERROR = 10.55%
MASS FLOW RATE = 87.5233 G/S PRESSURE DROP = 16.734 MM H2O FRICTION FACTOR = 0.069251 FREM = 15.9216

REM = 229.9 GRM+ = 0.92510E 05 UPSTREAM BULK TEMPERATURE = 24.45 DEG C DOWNSTREAM BULK TEMPERATURE = 25.94 DEG C
PRM = 99.10 RAM+ = 0.91681E 07 INLET BULK TEMPERATURE = 24.46 DEG C OUTLET BULK TEMPERATURE = 25.94 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.95	25.98	25.94	25.95	24.46	224.5	****	0.892E 07	0.00000	36.88	35.99	37.13	36.77	36.78	36.78
1	1.5	26.17	26.23	26.18	26.19	24.46	224.5	****	0.892E 07	0.00002	32.07	31.13	31.97	31.78	31.79	31.78
2	2.5	26.33	26.39	26.35	26.35	24.46	224.5	****	0.892E 07	0.00004	29.42	28.47	29.18	29.06	29.06	29.06
3	5.5	26.80	26.90	26.85	26.85	24.47	224.6	****	0.892E 07	0.00008	23.58	22.67	23.12	23.12	23.12	23.12
4	15.5	27.80	27.75	27.78	27.78	24.51	224.8	****	0.893E 07	0.00022	16.66	16.94	16.78	16.79	16.79	16.79
5	25.5	28.44	28.48	28.32	28.39	24.54	225.0	****	0.894E 07	0.00037	14.08	13.91	14.50	14.24	14.25	14.25
6	45.5	29.13	29.14	28.94	29.04	24.60	225.5	****	0.897E 07	0.00066	12.12	12.09	12.66	12.38	12.38	12.38
7	75.5	29.87	29.70	29.56	29.67	24.70	226.2	****	0.900E 07	0.00109	10.61	10.98	11.29	11.04	11.04	11.04
8	105.5	30.27	30.21	30.08	30.16	24.79	226.9	****	0.903E 07	0.00152	10.02	10.13	10.38	10.23	10.23	10.23
9	135.5	30.55	30.55	29.99	30.27	24.89	227.6	****	0.906E 07	0.00196	9.70	9.71	10.76	10.21	10.23	10.22
10	165.2	30.72	30.68	30.33	30.51	24.98	228.3	99.8	0.909E 07	0.00239	9.58	9.64	10.28	9.93	9.94	9.94
11	205.2	30.81	30.72	30.27	30.52	25.11	229.2	99.4	0.914E 07	0.00296	9.63	9.79	10.64	10.15	10.17	10.16
12	245.2	31.09	31.12	30.66	30.88	25.23	230.2	99.0	0.918E 07	0.00354	9.38	9.34	10.13	9.73	9.75	9.74
13	275.2	31.20	31.08	30.63	30.89	25.33	230.9	98.7	0.921E 07	0.00397	9.37	9.55	10.37	9.89	9.91	9.90
14	305.2	31.36	31.35	30.86	31.11	25.42	231.6	98.4	0.925E 07	0.00440	9.26	9.27	10.12	9.67	9.69	9.68
15	333.3	31.56	31.53	31.01	31.28	25.51	232.3	98.2	0.928E 07	0.00481	9.09	9.14	10.00	9.53	9.55	9.54
16	363.3	31.78	31.84	31.17	31.49	25.61	233.0	97.9	0.931E 07	0.00524	8.91	8.82	9.88	9.35	9.37	9.36
17	383.3	31.89	31.75	31.17	31.49	25.67	233.5	97.7	0.933E 07	0.00553	8.85	9.04	10.00	9.44	9.47	9.46
18	403.3	31.97	31.87	31.28	31.60	25.73	234.0	97.5	0.936E 07	0.00581	8.82	8.96	9.91	9.37	9.40	9.39
19	423.3	31.77	31.78	31.22	31.50	25.80	234.5	97.3	0.938E 07	0.00610	9.22	9.19	10.14	9.65	9.67	9.66
20	443.3	32.08	32.32	31.44	31.82	25.86	235.0	97.1	0.940E 07	0.00639	8.85	8.52	9.86	9.23	9.27	9.25
21	463.3	31.72	31.71	30.86	31.29	25.92	235.5	97.0	0.943E 07	0.00667	9.49	9.50	11.14	10.25	10.32	10.29
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	31.84	31.85	31.22	31.53	25.70	233.7	97.6	0.934E 07	0.00565	8.95	8.95	9.97	9.43	9.46	9.44

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INPUT ELECTRIC POWER = 1063.1 W HEAT RATE GAINED BY WATER = 1010.9 W HEAT BALANCE ERROR = 4.90%
MASS FLOW RATE = 53.7132 G/S PRESSURE DROP = 8.858 MM H2O FRICTION FACTOR = 0.096947 FREM = 16.2894

REM = 168.0 GRM+ = 0.40094E 06 UPSTREAM BULK TEMPERATURE = 26.69 DEG C DOWNSTREAM BULK TEMPERATURE = 33.97 DEG C
PRM = 84.64 RAM+ = 0.33937E 08 INLET BULK TEMPERATURE = 26.71 DEG C OUTLET BULK TEMPERATURE = 33.96 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	31.23	31.29	31.01	31.13	26.71	148.4	94.6	0.295E 08	0.00000	36.89	36.45	38.85	37.73	37.76	37.74
1	1.5	31.95	32.03	31.80	31.90	26.73	148.5	94.6	0.295E 08	0.00004	31.98	31.52	32.93	32.33	32.34	32.33
2	2.5	32.45	32.54	32.35	32.42	26.75	148.6	94.5	0.295E 08	0.00006	29.30	28.83	29.79	29.42	29.43	29.43
3	5.5	33.93	34.07	34.00	34.00	26.79	148.9	94.4	0.296E 08	0.00013	23.40	22.96	23.18	23.18	23.18	23.18
4	15.5	36.43	36.21	36.04	36.18	26.95	149.6	94.0	0.297E 08	0.00036	17.61	18.04	18.37	18.09	18.10	18.09
5	25.5	37.90	38.00	37.16	37.56	27.10	150.4	93.5	0.299E 08	0.00060	15.47	15.32	16.60	15.98	16.00	15.99
6	45.5	39.31	39.07	38.21	38.70	27.41	151.9	92.7	0.303E 08	0.00106	14.04	14.33	15.47	14.80	14.83	14.81
7	75.5	40.37	40.02	38.96	39.58	27.88	154.3	91.4	0.308E 08	0.00176	13.38	13.76	15.08	14.28	14.32	14.30
8	105.5	40.95	40.74	39.81	40.33	28.34	156.7	90.1	0.313E 08	0.00246	13.26	13.49	14.58	13.95	13.98	13.97
9	135.5	41.35	41.13	39.50	40.37	28.80	159.2	88.9	0.319E 08	0.00315	13.34	13.58	15.65	14.47	14.55	14.51
10	165.2	41.65	41.36	40.21	40.86	29.26	161.7	87.6	0.325E 08	0.00384	13.52	13.84	15.29	14.44	14.49	14.46
11	205.2	41.81	41.63	39.99	40.86	29.88	165.3	85.9	0.333E 08	0.00475	14.05	14.26	16.57	15.27	15.36	15.31
12	245.2	42.67	42.52	41.24	41.92	30.50	169.0	84.2	0.342E 08	0.00567	13.78	13.94	15.62	14.69	14.74	14.71
13	275.2	42.77	42.49	41.10	41.87	30.97	172.0	82.9	0.348E 08	0.00635	14.21	14.55	16.55	15.39	15.47	15.43
14	305.2	43.43	43.35	41.95	42.67	31.43	175.0	81.6	0.355E 08	0.00703	13.99	14.08	15.95	14.93	14.99	14.96
15	333.3	43.64	43.76	41.77	42.73	31.86	177.9	80.4	0.362E 08	0.00766	14.26	14.11	16.95	15.45	15.57	15.51
16	363.3	44.35	44.42	42.20	43.29	32.33	180.6	79.3	0.368E 08	0.00834	13.97	13.89	17.01	15.32	15.47	15.40
17	383.3	44.78	44.48	42.55	43.59	32.64	182.4	78.6	0.372E 08	0.00880	13.83	14.19	16.95	15.34	15.48	15.41
18	403.3	45.07	44.72	42.75	43.82	32.95	184.2	77.8	0.376E 08	0.00925	13.86	14.28	17.14	15.45	15.60	15.53
19	423.3	44.88	44.50	42.69	43.69	33.26	186.1	77.1	0.380E 08	0.00971	14.47	14.95	17.81	16.11	16.26	16.19
20	443.3	45.62	45.91	43.56	44.66	33.57	188.1	76.3	0.384E 08	0.01016	13.95	13.62	16.82	15.15	15.30	15.23
21	463.3	44.41	44.64	42.12	43.33	33.88	190.0	75.6	0.389E 08	0.01061	15.96	15.62	20.39	17.79	18.09	17.94
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	44.72	44.63	42.59	43.63	32.77	183.2	78.3	0.374E 08	0.00899	14.06	14.17	17.12	15.47	15.62	15.54

-------------------- No.6 ------------------------------------

INPUT ELECTRIC POWER = 1115.8 W　　HEAT RATE GAINED BY WATER = 1077.7 W　　HEAT BALANCE ERROR = 3.42%
MASS FLOW RATE = 86.0483 G/S　　PRESSURE DROP = 15.212 MM H2O　　FRICTION FACTOR = 0.064979　　FREM = 16.2375

REM = 249.9　　GRM+ = 0.36731E 06　　UPSTREAM BULK TEMPERATURE = 25.78 DEG C　　DOWNSTREAM BULK TEMPERATURE = 30.64 DEG C
PRM = 90.49　　RAM+ = 0.33238E 08　　INLET BULK TEMPERATURE = 25.79 DEG C　　OUTLET BULK TEMPERATURE = 30.63 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE B	AVERAGE T+B
0	0.0	29.82	29.87	29.65	29.75	25.79	230.5	97.4	0.303E 08	0.00000	44.09	43.49	45.96	44.85	44.88	44.86
1	1.5	30.50	30.58	30.40	30.47	25.80	230.6	97.3	0.303E 08	0.00002	37.79	37.17	38.62	38.04	38.05	38.05
2	2.5	30.98	31.07	30.92	30.97	25.81	230.7	97.3	0.303E 08	0.00004	34.40	33.79	34.79	34.44	34.44	34.44
3	5.5	32.40	32.54	32.47	32.47	25.84	230.9	97.2	0.304E 08	0.00008	27.10	26.53	26.82	26.82	26.82	26.82
4	15.5	34.84	34.63	34.51	34.62	25.95	231.7	96.9	0.305E 08	0.00023	19.98	20.48	20.76	20.49	20.50	20.49
5	25.5	36.32	36.47	35.76	36.08	26.05	232.5	96.6	0.306E 08	0.00037	17.31	17.06	18.32	17.73	17.75	17.74
6	45.5	37.91	37.72	36.86	37.33	26.26	234.1	96.0	0.309E 08	0.00067	15.26	15.52	16.78	16.05	16.09	16.07
7	75.5	39.13	38.84	37.89	38.44	26.57	236.6	95.1	0.312E 08	0.00110	14.16	14.49	15.71	14.99	15.02	15.00
8	105.5	39.83	39.56	38.72	39.21	26.88	239.1	94.2	0.316E 08	0.00154	13.74	14.03	15.03	14.43	14.46	14.45
9	135.5	40.16	40.00	38.43	39.25	27.19	241.6	93.3	0.320E 08	0.00198	13.72	13.90	15.84	14.76	14.82	14.79
10	165.2	40.47	40.18	39.25	39.79	27.49	244.0	92.5	0.323E 08	0.00241	13.72	14.04	15.16	14.49	14.52	14.51
11	205.2	40.68	40.40	38.98	39.76	27.91	247.4	91.3	0.329E 08	0.00299	13.95	14.27	16.09	15.04	15.10	15.07
12	245.2	41.31	41.18	40.09	40.67	28.32	250.8	90.2	0.334E 08	0.00357	13.73	13.86	15.15	14.44	14.47	14.45
13	275.2	41.42	41.20	39.85	40.58	28.63	253.5	89.3	0.338E 08	0.00400	13.94	14.19	15.90	14.93	14.98	14.96
14	305.2	42.03	41.95	40.59	41.29	28.94	256.2	88.5	0.342E 08	0.00443	13.64	13.72	15.31	14.45	14.49	14.47
15	333.3	42.34	42.41	40.57	41.48	29.23	258.8	87.7	0.346E 08	0.00483	13.61	13.54	15.74	14.58	14.66	14.62
16	363.3	42.99	43.00	40.91	41.95	29.54	261.6	86.8	0.350E 08	0.00526	13.27	13.26	15.71	14.39	14.49	14.44
17	383.3	43.08	42.73	40.92	41.91	29.75	263.6	86.3	0.353E 08	0.00555	13.40	13.76	15.98	14.68	14.78	14.73
18	403.3	43.32	42.92	41.10	42.11	29.96	265.5	85.7	0.356E 08	0.00583	13.37	13.78	16.02	14.69	14.80	14.74
19	423.3	43.07	42.59	40.90	41.87	30.16	267.5	85.1	0.359E 08	0.00612	13.84	14.37	16.64	15.26	15.37	15.32
20	443.3	43.82	43.98	41.63	42.77	30.37	269.5	84.5	0.362E 08	0.00640	13.29	13.13	15.87	14.42	14.54	14.48
21	463.3	42.56	42.76	40.33	41.50	30.58	271.6	84.0	0.365E 08	0.00668	14.92	14.68	18.32	16.37	16.56	16.46
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	43.10	42.94	41.01	42.02	29.84	264.4	86.0	0.355E 08	0.00566	13.46	13.64	15.99	14.67	14.77	14.72

--------------------- No.7 ---------------------------------

INPUT ELECTRIC POWER = 611.1 W HEAT RATE GAINED BY WATER = 574.7 W HEAT BALANCE ERROR = 5.96%
MASS FLOW RATE = 47.4160 G/S PRESSURE DROP = 7.909 MM H2O FRICTION FACTOR = 0.111139 FREM = 16.1026

REM = 144.9 GRM+ = 0.21730E 06 UPSTREAM BULK TEMPERATURE = 27.33 DEG C DOWNSTREAM BULK TEMPERATURE = 32.03 DEG C
PRM = 86.44 RAM+ = 0.18703E 08 INLET BULK TEMPERATURE = 27.34 DEG C OUTLET BULK TEMPERATURE = 32.02 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	30.18	30.26	30.07	30.14	27.34	133.8	92.9	0.172E 08	0.00000	33.44	32.55	34.86	33.90	33.93	33.91
1	1.5	30.61	30.72	30.55	30.61	27.36	133.9	92.8	0.172E 08	0.00004	29.22	28.27	29.76	29.24	29.25	29.25
2	2.5	30.90	31.03	30.88	30.92	27.37	133.9	92.8	0.172E 08	0.00007	26.88	25.92	27.03	26.71	26.72	26.71
3	5.5	31.78	31.98	31.88	31.88	27.40	134.0	92.7	0.172E 08	0.00015	21.68	20.74	21.20	21.20	21.20	21.20
4	15.5	33.59	33.50	33.32	33.43	27.50	134.5	92.4	0.173E 08	0.00041	15.58	15.83	16.11	16.00	16.01	16.00
5	25.5	34.58	34.60	34.18	34.38	27.60	134.9	92.2	0.173E 08	0.00067	13.61	13.56	14.43	14.00	14.01	14.00
6	45.5	35.65	35.46	34.93	35.22	27.80	135.8	91.6	0.174E 08	0.00120	12.26	12.40	13.31	12.80	12.82	12.81
7	75.6	36.31	35.53	35.53	35.72	28.10	137.2	90.8	0.176E 08	0.00199	11.58	12.78	12.79	12.46	12.48	12.47
8	105.5	36.62	36.48	36.09	36.32	28.40	138.6	90.0	0.179E 08	0.00278	11.55	11.75	12.36	12.00	12.01	12.00
9	135.5	36.94	36.94	35.84	36.39	28.69	140.0	89.2	0.181E 08	0.00357	11.54	11.54	13.31	12.36	12.42	12.39
10	165.2	37.11	36.98	36.35	36.70	28.99	141.4	88.3	0.183E 08	0.00435	11.72	11.91	12.93	12.35	12.38	12.36
11	205.2	37.24	37.13	35.72	36.45	29.39	143.4	87.2	0.186E 08	0.00540	12.12	12.29	15.03	13.47	13.62	13.55
12	245.2	37.85	37.83	37.06	37.45	29.79	145.4	86.1	0.189E 08	0.00644	11.82	11.85	13.09	12.43	12.46	12.45
13	275.2	37.94	37.83	37.00	37.44	30.09	147.0	85.3	0.191E 08	0.00722	12.13	12.31	13.78	12.95	13.00	12.98
14	305.2	38.43	38.42	37.54	37.98	30.39	148.6	84.5	0.193E 08	0.00800	11.84	11.87	13.33	12.55	12.59	12.57
15	333.3	38.64	38.80	37.73	38.22	30.67	150.1	83.7	0.196E 08	0.00872	11.96	11.72	13.50	12.62	12.67	12.64
16	363.3	39.20	39.21	37.98	38.59	30.97	151.8	82.9	0.198E 08	0.00950	11.58	11.57	13.60	12.51	12.59	12.55
17	383.3	39.44	39.18	38.12	38.72	31.17	152.9	82.4	0.200E 08	0.01001	11.53	11.90	13.72	12.63	12.71	12.67
18	403.3	39.54	39.33	38.32	38.88	31.37	154.1	81.8	0.202E 08	0.01052	11.68	11.98	13.71	12.70	12.77	12.74
19	423.3	39.42	39.23	38.16	38.74	31.57	155.3	81.3	0.203E 08	0.01104	12.15	12.45	14.47	13.30	13.39	13.34
20	443.3	39.87	40.08	38.69	39.33	31.77	156.5	80.7	0.205E 08	0.01155	11.78	11.49	13.79	12.62	12.71	12.66
21	463.3	39.08	39.27	37.74	38.45	31.97	157.5	80.2	0.207E 08	0.01206	13.42	13.07	16.54	14.71	14.90	14.80
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	39.35	39.31	38.17	38.75	31.25	153.5	82.1	0.201E 08	0.01022	11.78	11.85	13.80	12.73	12.81	12.77

--------------------------- No.8 ------------------------------------

INPUT ELECTRIC POWER = 666.5 W
MASS FLOW RATE = 78.7169 G/S

HEAT RATE GAINED BY WATER = 604.5 W
PRESSURE DROP = 14.305 MM H2O

HEAT BALANCE ERROR = 9.30%
FRICTION FACTOR = 0.073090
FREM = 16.0510

REM = 219.6
PRM = 93.83

GRM+ = 0.18983E 06
RAM+ = 0.17812E 08

UPSTREAM BULK TEMPERATURE = 25.50 DEG C
INLET BULK TEMPERATURE = 25.51 DEG C

DOWNSTREAM BULK TEMPERATURE = 28.49 DEG C
OUTLET BULK TEMPERATURE = 28.49 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE B	AVERAGE T+B
0	0.0	28.16	28.17	28.04	28.10	25.51	208.9	98.2	0.168E 08	0.00000	37.58	37.40	39.35	38.40	38.42	38.41
1	1.5	28.58	28.60	28.50	28.54	25.51	208.9	98.2	0.168E 08	0.00002	32.52	32.33	33.43	32.92	32.93	32.92
2	2.5	28.87	28.89	28.81	28.85	25.52	209.0	98.2	0.168E 08	0.00004	29.76	29.57	30.29	29.97	29.98	29.97
3	5.5	29.74	29.77	29.76	29.76	25.54	209.1	98.1	0.168E 08	0.00009	23.71	23.54	23.62	23.62	23.62	23.62
4	15.5	31.32	31.24	31.17	31.23	25.60	209.6	97.9	0.169E 08	0.00025	17.43	17.68	17.90	17.73	17.73	17.73
5	25.5	32.38	32.45	31.98	32.20	25.67	210.0	97.7	0.169E 08	0.00041	14.85	14.69	15.78	15.26	15.28	15.27
6	45.5	33.46	33.37	32.90	33.16	25.79	210.9	97.3	0.170E 08	0.00073	13.00	13.15	14.04	13.54	13.56	13.55
7	75.6	34.45	34.19	33.73	34.02	25.99	212.2	96.8	0.171E 08	0.00121	11.79	12.16	12.88	12.41	12.43	12.42
8	105.5	34.88	34.75	34.43	34.62	26.18	213.6	96.2	0.173E 08	0.00169	11.46	11.64	12.09	11.81	11.82	11.81
9	135.6	35.19	35.13	34.10	34.63	26.37	215.0	95.7	0.174E 08	0.00217	11.31	11.39	12.91	12.08	12.13	12.10
10	165.2	35.37	35.23	34.64	34.97	26.56	216.4	95.1	0.175E 08	0.00264	11.32	11.50	12.34	11.86	11.88	11.87
11	205.2	35.44	35.39	34.54	34.98	26.81	218.3	94.3	0.177E 08	0.00328	11.57	11.64	12.91	12.22	12.26	12.24
12	245.2	36.03	36.04	35.35	35.69	27.06	220.1	93.6	0.179E 08	0.00391	11.14	11.13	12.06	11.58	11.60	11.59
13	275.2	36.09	35.92	35.18	35.59	27.25	221.5	93.1	0.180E 08	0.00439	11.31	11.53	12.60	11.98	12.01	12.00
14	305.2	36.47	36.45	35.61	36.04	27.45	222.9	92.6	0.181E 08	0.00487	11.07	11.09	12.23	11.63	11.66	11.64
15	333.3	36.67	36.77	35.79	36.26	27.62	224.2	92.1	0.182E 08	0.00531	11.04	10.92	12.23	11.57	11.61	11.59
16	363.3	37.10	37.17	35.96	36.55	27.82	225.6	91.6	0.184E 08	0.00578	10.76	10.69	12.28	11.45	11.50	11.47
17	383.3	37.23	37.05	35.88	36.51	27.94	226.6	91.2	0.185E 08	0.00610	10.77	10.98	12.60	11.67	11.74	11.70
18	403.3	37.39	37.09	36.05	36.65	28.07	227.5	90.9	0.185E 08	0.00642	10.73	11.09	12.52	11.66	11.71	11.69
19	423.3	37.17	36.94	35.87	36.46	28.20	228.5	90.5	0.186E 08	0.00673	11.15	11.44	13.04	12.10	12.17	12.13
20	443.3	37.61	37.81	36.37	37.04	28.32	229.5	90.2	0.187E 08	0.00705	10.77	10.54	12.43	11.48	11.54	11.51
21	463.3	36.83	36.98	35.54	36.22	28.45	230.5	89.8	0.188E 08	0.00736	11.94	11.73	14.11	12.87	12.97	12.92
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	37.19	37.14	35.99	36.58	28.00	227.0	91.1	0.185E 08	0.00623	10.87	10.94	12.52	11.65	11.71	11.68

No.9

INPUT ELECTRIC POWER = 150.3 W   HEAT RATE GAINED BY WATER = 144.1 W   HEAT BALANCE ERROR = 4.14%
MASS FLOW RATE = 57.6790 G/S   PRESSURE DROP = 10.806 MM H2O   FRICTION FACTOR = 0.102911   FREM = 15.9705

REM = 155.2   GRM+ = 0.42000E 05   UPSTREAM BULK TEMPERATURE = 25.44 DEG C   DOWNSTREAM BULK TEMPERATURE = 26.41 DEG C
PRM = 96.97   RAM+ = 0.40727E 07   INLET BULK TEMPERATURE = 25.44 DEG C   OUTLET BULK TEMPERATURE = 26.41 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	26.34	26.33	26.31	26.32	25.44	152.7	98.4	0.400E 07	0.00000	26.25	26.47	27.16	26.75	26.76	26.75
1	1.5	26.43	26.42	26.41	26.42	25.44	152.7	98.4	0.400E 07	0.00003	23.89	24.15	24.50	24.26	24.26	24.26
2	2.5	26.50	26.49	26.48	26.48	25.44	152.7	98.4	0.400E 07	0.00005	22.50	22.78	22.96	22.80	22.80	22.80
3	5.5	26.69	26.67	26.68	26.68	25.45	152.8	98.4	0.400E 07	0.00012	19.15	19.45	19.30	19.30	19.30	19.30
4	15.5	27.23	27.13	27.15	27.17	25.47	152.9	98.3	0.400E 07	0.00034	13.46	14.33	14.10	13.99	14.00	13.99
5	25.5	27.54	27.58	27.42	27.49	25.49	153.0	98.2	0.401E 07	0.00056	11.61	11.38	12.29	11.88	11.89	11.88
6	45.5	27.89	28.52	27.80	28.01	25.53	153.2	98.1	0.401E 07	0.00100	10.06	7.94	10.45	9.60	9.72	9.66
7	75.5	28.29	28.13	28.21	28.21	25.59	153.5	97.9	0.402E 07	0.00165	8.81	9.37	9.09	9.09	9.09	9.09
8	105.5	28.53	28.48	28.54	28.52	25.66	153.8	97.8	0.403E 07	0.00231	8.27	8.42	8.25	8.30	8.30	8.30
9	135.5	28.68	28.68	28.30	28.49	25.72	154.1	97.6	0.404E 07	0.00296	8.02	8.03	9.20	8.57	8.61	8.59
10	165.2	28.70	28.60	28.51	28.58	25.78	154.4	97.4	0.405E 07	0.00361	8.15	8.43	8.71	8.49	8.50	8.50
11	205.2	28.61	28.70	28.42	28.54	25.86	154.9	97.1	0.406E 07	0.00449	8.64	8.39	9.30	8.89	8.91	8.90
12	245.2	28.88	29.00	28.71	28.83	25.95	155.3	96.9	0.408E 07	0.00536	8.11	7.79	8.59	8.26	8.27	8.26
13	275.2	28.95	28.95	28.75	28.85	26.01	155.6	96.7	0.409E 07	0.00601	8.08	8.08	8.66	8.36	8.37	8.37
14	305.2	29.06	29.00	28.82	28.92	26.07	156.0	96.5	0.410E 07	0.00667	7.95	8.13	8.65	8.33	8.34	8.34
15	333.3	29.15	29.22	28.96	29.07	26.13	156.3	96.4	0.411E 07	0.00728	7.87	7.69	8.39	8.07	8.08	8.08
16	363.3	29.35	29.29	29.09	29.20	26.19	156.6	96.2	0.412E 07	0.00794	7.53	7.67	8.20	7.89	7.90	7.90
17	383.3	29.44	29.33	29.09	29.24	26.23	156.8	96.1	0.412E 07	0.00837	7.40	7.67	8.31	7.90	7.92	7.91
18	403.3	29.43	29.40	29.18	29.30	26.27	157.0	95.9	0.413E 07	0.00881	7.55	7.60	8.17	7.86	7.87	7.87
19	423.3	29.35	29.37	29.09	29.23	26.31	157.3	95.8	0.414E 07	0.00924	7.85	7.77	8.56	8.17	8.18	8.18
20	443.3	29.48	29.65	29.18	29.37	26.36	157.5	95.7	0.414E 07	0.00968	7.61	7.22	8.43	7.89	7.92	7.90
21	463.3	29.30	29.31	28.84	29.07	26.40	157.7	95.6	0.415E 07	0.01011	8.19	8.16	9.73	8.88	8.95	8.92
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	29.37	29.38	29.10	29.24	26.25	156.9	96.0	0.412E 07	0.00855	7.64	7.60	8.34	7.96	7.98	7.97

---------------------- No. 10 ----------------------------------

INPUT ELECTRIC POWER = 151.0 W   HEAT RATE GAINED BY WATER = 139.8 W   HEAT BALANCE ERROR = 7.44%
MASS FLOW RATE = 88.9505 G/S   PRESSURE DROP = 17.104 MM H2O   FRICTION FACTOR = 0.068529   FREM = 16.0108

REM = 233.6   GRM+ = 0.38775E 05   UPSTREAM BULK TEMPERATURE = 24.89 DEG C   DOWNSTREAM BULK TEMPERATURE = 25.50 DEG C
PRM = 99.11   RAM+ = 0.38430E 07   INLET BULK TEMPERATURE = 24.89 DEG C   OUTLET BULK TEMPERATURE = 25.50 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.79	25.78	25.73	25.76	24.89	231.3	****	0.380E 07	0.00000	25.56	25.76	27.56	26.57	26.61	26.59
1	1.5	25.86	25.85	25.81	25.84	24.89	231.3	****	0.380E 07	0.00002	23.68	23.93	24.98	24.38	24.39	24.38
2	2.5	25.91	25.90	25.87	25.89	24.89	231.3	****	0.380E 07	0.00004	22.54	22.81	23.46	23.06	23.07	23.06
3	5.5	26.07	26.05	26.06	26.06	24.90	231.4	****	0.380E 07	0.00008	19.69	20.00	19.85	19.85	19.85	19.85
4	15.5	26.55	26.51	26.53	26.53	24.91	231.5	****	0.380E 07	0.00022	14.03	14.43	14.20	14.21	14.21	14.21
5	25.5	26.75	26.78	26.69	26.73	24.92	231.6	99.9	0.380E 07	0.00036	12.63	12.37	13.03	12.76	12.76	12.76
6	45.5	27.05	27.06	27.01	27.03	24.95	231.8	99.8	0.381E 07	0.00065	10.97	10.92	11.16	11.05	11.05	11.05
7	75.5	27.50	27.34	27.36	27.39	24.99	232.1	99.7	0.381E 07	0.00107	9.17	9.78	9.70	9.58	9.59	9.59
8	105.5	27.69	27.64	27.68	27.67	25.03	232.4	99.6	0.382E 07	0.00150	8.67	8.82	8.69	8.72	8.72	8.72
9	135.5	27.89	27.89	27.51	27.70	25.07	232.7	99.5	0.382E 07	0.00193	8.16	8.17	9.41	8.74	8.79	8.77
10	165.2	27.86	27.81	27.71	27.77	25.11	232.9	99.4	0.383E 07	0.00235	8.38	8.51	8.84	8.64	8.64	8.64
11	205.2	27.88	27.91	27.63	27.76	25.16	233.3	99.2	0.384E 07	0.00292	8.46	8.38	9.32	8.85	8.87	8.86
12	245.2	28.19	28.27	28.03	28.13	25.21	233.7	99.1	0.385E 07	0.00348	7.72	7.53	8.18	7.89	7.90	7.90
13	275.2	28.22	28.16	28.13	28.16	25.25	234.0	99.0	0.385E 07	0.00391	7.76	7.91	8.01	7.92	7.92	7.92
14	305.2	28.33	28.27	28.14	28.22	25.29	234.3	98.8	0.386E 07	0.00433	7.58	7.74	8.08	7.86	7.87	7.87
15	333.3	28.42	28.43	28.28	28.35	25.33	234.6	98.7	0.386E 07	0.00473	7.45	7.42	7.80	7.61	7.62	7.62
16	363.3	28.61	28.55	28.30	28.44	25.36	234.9	98.6	0.387E 07	0.00516	7.10	7.23	7.85	7.49	7.50	7.50
17	383.3	28.65	28.60	28.31	28.47	25.39	235.1	98.5	0.387E 07	0.00544	7.07	7.18	7.90	7.49	7.51	7.50
18	403.3	28.58	28.56	28.45	28.51	25.42	235.3	98.5	0.388E 07	0.00573	7.29	7.33	7.61	7.46	7.46	7.46
19	423.3	28.50	28.53	28.31	28.41	25.44	235.5	98.4	0.388E 07	0.00601	7.53	7.46	8.04	7.76	7.77	7.76
20	443.3	28.69	28.86	28.39	28.58	25.47	235.7	98.3	0.388E 07	0.00629	7.15	6.80	7.90	7.41	7.44	7.42
21	463.3	28.52	28.51	28.21	28.36	25.50	235.9	98.2	0.389E 07	0.00658	7.63	7.64	8.50	8.04	8.07	8.06
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	28.57	28.59	28.34	28.46	25.40	235.2	98.5	0.387E 07	0.00556	7.27	7.24	7.85	7.54	7.55	7.54

---------------------- No.11 ----------------------

INPUT ELECTRIC POWER = 545.6 W HEAT RATE GAINED BY WATER = 516.9 W HEAT BALANCE ERROR = 5.26%
MASS FLOW RATE = 55.0871 G/S PRESSURE DROP = 9.431 MM H2O FRICTION FACTOR = 0.098242 FREM = 16.0924

REM = 163.8 GRM+ = 0.18488E 06 UPSTREAM BULK TEMPERATURE = 27.08 DEG C DOWNSTREAM BULK TEMPERATURE = 30.72 DEG C
PRM = 88.58 RAM+ = 0.16377E 08 INLET BULK TEMPERATURE = 27.09 DEG C OUTLET BULK TEMPERATURE = 30.72 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	29.25	29.26	29.13	29.20	27.09	154.2	93.6	0.153E 08	0.00000	39.52	39.30	41.77	40.55	40.59	40.57
1	1.5	29.59	29.61	29.51	29.56	27.10	154.2	93.5	0.153E 08	0.00003	34.28	34.04	35.44	34.79	34.80	34.79
2	2.5	29.83	29.85	29.77	29.80	27.11	154.2	93.5	0.153E 08	0.00006	31.41	31.17	32.08	31.68	31.69	31.68
3	5.5	30.53	30.57	30.55	30.55	27.13	154.4	93.5	0.153E 08	0.00013	25.10	24.87	24.99	24.99	24.99	24.99
4	15.5	31.89	31.75	31.79	31.81	27.21	154.8	93.2	0.154E 08	0.00035	18.25	18.81	18.63	18.58	18.58	18.58
5	25.5	32.77	32.79	32.49	32.64	27.29	155.1	93.0	0.154E 08	0.00058	15.57	15.52	16.42	15.97	15.98	15.97
6	45.5	33.69	33.66	33.35	33.51	27.44	155.9	92.6	0.155E 08	0.00104	13.68	13.75	14.46	14.08	14.09	14.08
7	75.5	34.61	34.36	34.06	34.27	27.67	157.1	92.0	0.156E 08	0.00172	12.31	12.79	13.37	12.95	12.96	12.95
8	105.5	34.99	34.92	34.66	34.81	27.91	158.4	91.3	0.158E 08	0.00240	12.06	12.19	12.66	12.38	12.39	12.39
9	135.5	35.36	35.24	34.38	34.84	28.14	159.6	90.7	0.159E 08	0.00308	11.85	12.03	13.70	12.76	12.82	12.79
10	165.2	35.48	35.40	34.93	35.18	28.37	160.8	90.1	0.160E 08	0.00375	12.02	12.16	13.04	12.54	12.56	12.55
11	205.2	35.66	35.50	34.77	35.17	28.68	162.5	89.2	0.162E 08	0.00466	12.25	12.53	14.05	13.17	13.22	13.19
12	245.2	35.97	35.93	35.40	35.68	28.99	164.3	88.4	0.164E 08	0.00556	12.25	12.33	13.34	12.79	12.81	12.80
13	275.2	36.03	35.86	35.30	35.62	29.22	165.6	87.7	0.166E 08	0.00623	12.57	12.89	14.09	13.37	13.41	13.39
14	305.2	36.30	36.23	35.73	36.00	29.45	167.0	87.1	0.167E 08	0.00691	12.50	12.63	13.64	13.08	13.10	13.09
15	333.3	36.50	36.55	35.85	36.19	29.67	168.2	86.5	0.169E 08	0.00754	12.53	12.45	13.85	13.14	13.17	13.15
16	363.3	36.88	36.88	35.96	36.42	29.90	169.6	85.8	0.170E 08	0.00821	12.28	12.27	14.15	13.14	13.21	13.18
17	383.3	37.06	36.88	35.93	36.45	30.06	170.6	85.4	0.172E 08	0.00865	12.24	12.56	14.57	13.40	13.49	13.44
18	403.3	37.11	36.98	36.11	36.58	30.21	171.5	85.0	0.173E 08	0.00910	12.42	12.67	14.53	13.46	13.54	13.50
19	423.3	36.94	36.77	35.87	36.36	30.36	172.5	84.6	0.174E 08	0.00955	13.03	13.38	15.58	14.30	14.39	14.34
20	443.3	37.33	37.53	36.37	36.90	30.52	173.5	84.1	0.175E 08	0.00999	12.59	12.23	14.66	13.44	13.54	13.49
21	463.3	36.61	36.81	35.54	36.12	30.67	174.5	83.7	0.176E 08	0.01044	14.46	13.98	17.62	15.73	15.92	15.83
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	36.97	36.93	36.01	36.48	30.12	171.0	85.2	0.172E 08	0.00884	12.52	12.59	14.56	13.48	13.56	13.52

------------------- No.12 -------------------------

INPUT ELECTRIC POWER = 558.6 W
MASS FLOW RATE = 86.3410 G/S

HEAT RATE GAINED BY WATER = 529.8 W
PRESSURE DROP = 15.212 MM H2O

HEAT BALANCE ERROR = 5.17%
FRICTION FACTOR = 0.064551
FREM = 16.0657

REM = 248.9
PRM = 91.10

GRM+ = 0.17785E 06
RAM+ = 0.16202E 08

UPSTREAM BULK TEMPERATURE = 26.80 DEG C
INLET BULK TEMPERATURE = 26.80 DEG C

DOWNSTREAM BULK TEMPERATURE = 29.18 DEG C
OUTLET BULK TEMPERATURE = 29.18 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE H	AVERAGE T+H
0	0.0	29.41	29.40	29.31	29.36	26.80	239.3	94.4	0.155E 08	0.00000	33.56	33.69	34.80	34.20	34.21	34.21
1	1.5	29.77	29.75	29.70	29.73	26.81	239.4	94.4	0.155E 08	0.00002	29.56	29.71	30.30	29.96	29.96	29.96
2	2.5	30.02	30.00	29.96	29.98	26.81	239.4	94.3	0.155E 08	0.00004	27.32	27.47	27.81	27.60	27.60	27.60
3	5.5	30.76	30.73	30.75	30.75	26.83	239.6	94.3	0.155E 08	0.00008	22.25	22.40	22.32	22.32	22.32	22.32
4	15.5	32.06	31.98	31.91	31.96	26.88	240.0	94.2	0.155E 08	0.00023	16.89	17.17	17.40	17.21	17.22	17.21
5	25.5	32.89	33.02	32.60	32.78	26.93	240.4	94.0	0.156E 08	0.00037	14.69	14.37	15.43	14.96	14.98	14.97
6	45.5	33.86	33.82	33.46	33.65	27.03	241.2	93.7	0.156E 08	0.00066	12.82	12.88	13.61	13.22	13.23	13.22
7	75,5	34.73	34.52	34.23	34.43	27.18	242.3	93.3	0.157E 08	0.00110	11.60	11.92	12.42	12.08	12.09	12.09
8	105.5	35.22	35.14	34.83	35.01	27.34	243.6	92.9	0.158E 08	0.00153	11.10	11.22	11.68	11.41	11.42	11.42
9	135.5	35.52	35.47	34.66	35.08	27.49	244.8	92.5	0.159E 08	0.00197	10.89	10.97	12.21	11.53	11.57	11.55
10	165.2	35.65	35.57	35.15	35.38	27.64	246.0	92.1	0.160E 08	0.00240	10.93	11.04	11.65	11.31	11.32	11.31
11	205.2	35.78	35.73	35.05	35.40	27.84	247.7	91.5	0.161E 08	0.00298	11.04	11.11	12.15	11.59	11.61	11.60
12	245.2	36.20	36.21	35.63	35.92	28.04	249.3	90.9	0.162E 08	0.00356	10.74	10.73	11.55	11.13	11.14	11.13
13	275.2	36.25	36.14	35.52	35.86	28.20	250.6	90.5	0.163E 08	0.00399	10.87	11.03	11.96	11.43	11.46	11.44
14	305.2	36.58	36.45	35.90	36.21	28.35	251.9	90.1	0.164E 08	0.00442	10.65	10.81	11.61	11.15	11.17	11.16
15	333.3	36.73	36.83	36.08	36.43	28.49	253.1	89.7	0.165E 08	0.00483	10.64	10.51	11.55	11.04	11.06	11.05
16	363.3	37.10	37.11	36.12	36.62	28.64	254.4	89.3	0.166E 08	0.00526	10.36	10.35	11.72	11.00	11.04	11.02
17	383.3	37.28	37.05	36.16	36.66	28.74	255.3	89.0	0.167E 08	0.00555	10.27	10.56	11.83	11.07	11.12	11.10
18	403.3	37.33	37.09	36.28	36.75	28.84	256.2	88.7	0.167E 08	0.00583	10.33	10.64	11.80	11.10	11.14	11.12
19	423.3	37.05	36.94	36.09	36.54	28.95	257.1	88.5	0.168E 08	0.00612	10.82	10.98	12.28	11.55	11.59	11.57
20	443.3	37.49	37.70	36.54	37.07	29.05	258.0	88.2	0.169E 08	0.00641	10.38	10.14	11.71	10.94	10.99	10.96
21	463.3	36.94	37.04	35.77	36.38	29.15	258.9	87.9	0.169E 08	0.00670	11.26	11.12	13.25	12.13	12.22	12.17
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	37.17	37.12	36.21	36.68	28.79	255.7	88.9	0.167E 08	0.00567	10.47	10.53	11.81	11.12	11.16	11.14

---------------- #01 -----------------------

INPUT ELECTRIC POWER = 53.7 W HEAT RATE GAINED BY WATER = 52.2 W HEAT BALANCE ERROR = 2.78%
MASS FLOW RATE = 11.6414 G/S PRESSURE DROP = 0.462 MM H2O FRICTION FACTOR = 0.114900 FREM = 16.3180

REM = 142.0 GRM+ = 0.23469E 06 UPSTREAM BULK TEMPERATURE = 53.22 DEG C DOWNSTREAM BULK TEMPERATURE = 54.68 DEG C
PRM = 20.52 RAM+ = 0.48166E 07 INLET BULK TEMPERATURE = 53.22 DEG C OUTLET BULK TEMPERATURE = 54.68 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	54.32	54.31	54.29	54.30	53.23	139.6	20.8	0.468E 07	0.00001	6.99	7.01	7.13	7.07	7.07	7.07
1	1.5	54.34	54.33	54.32	54.33	53.23	139.7	20.8	0.468E 07	0.00017	6.87	6.91	6.98	6.94	6.94	6.94
2	2.5	54.35	54.35	54.34	54.35	53.23	139.7	20.8	0.468E 07	0.00028	6.79	6.83	6.88	6.85	6.85	6.85
3	5.5	54.40	54.39	54.40	54.40	53.24	139.7	20.8	0.468E 07	0.00062	6.57	6.63	6.60	6.60	6.60	6.60
4	15.5	54.71	54.48	54.54	54.57	53.27	139.8	20.8	0.469E 07	0.00175	5.29	6.34	6.01	5.89	5.91	5.90
5	25.5	54.46	54.66	54.39	54.48	53.30	139.9	20.8	0.469E 07	0.00288	6.59	5.61	7.02	6.51	6.56	6.53
6	45.5	54.56	54.63	54.62	54.61	53.37	140.1	20.8	0.470E 07	0.00514	6.38	6.02	6.07	6.13	6.14	6.14
7	75.5	54.94	54.66	54.79	54.79	53.46	140.4	20.7	0.472E 07	0.00853	5.16	6.33	5.74	5.71	5.74	5.73
8	105.5	54.90	54.74	55.49	55.15	53.55	140.7	20.7	0.474E 07	0.01192	5.67	6.43	3.94	4.76	5.00	4.88
9	135.5	55.26	55.33	54.92	55.11	53.64	141.0	20.7	0.476E 07	0.01530	4.72	4.52	5.99	5.22	5.31	5.26
10	165.2	55.00	54.97	55.32	55.15	53.74	141.3	20.6	0.477E 07	0.01865	6.05	6.18	4.81	5.38	5.46	5.42
11	205.2	55.29	55.19	55.00	55.12	53.86	141.7	20.6	0.480E 07	0.02316	5.35	5.74	6.72	6.07	6.13	6.10
12	245.2	55.62	55.21	55.59	55.50	53.98	142.1	20.5	0.482E 07	0.02767	4.67	6.20	4.76	5.03	5.10	5.06
13	275.2	55.36	55.36	55.67	55.51	54.08	142.4	20.5	0.484E 07	0.03105	5.96	5.96	4.80	5.32	5.38	5.35
14	305.2	55.44	55.24	55.48	55.41	54.17	142.8	20.4	0.486E 07	0.03443	6.00	7.12	5.82	6.15	6.19	6.17
15	333.3	55.54	55.49	55.83	55.67	54.26	143.0	20.4	0.488E 07	0.03759	5.94	6.20	4.87	5.40	5.47	5.43
16	363.3	55.90	55.76	55.48	55.66	54.35	143.4	20.3	0.490E 07	0.04097	4.92	5.43	6.74	5.85	5.96	5.90
17	383.3	56.09	55.73	55.46	55.68	54.41	143.6	20.3	0.491E 07	0.04322	4.55	5.77	7.36	6.02	6.26	6.14
18	403.3	55.92	55.66	56.03	55.91	54.47	143.8	20.3	0.492E 07	0.04547	5.29	6.44	4.89	5.31	5.38	5.34
19	423.3	55.79	55.76	55.56	55.67	54.54	144.0	20.3	0.493E 07	0.04771	6.08	6.24	7.43	6.74	6.80	6.77
20	443.3	56.00	56.28	56.01	56.08	54.60	144.2	20.2	0.495E 07	0.04996	5.43	4.55	5.39	5.16	5.19	5.17
21	463.3	56.04	56.54	56.73	56.51	54.66	144.4	20.2	0.496E 07	0.05221	5.53	4.05	3.68	4.12	4.24	4.18
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	55.87	55.78	55.73	55.78	54.44	143.7	20.3	0.491E 07	0.04415	5.37	5.77	6.11	5.75	5.84	5.79

****************** #2 *********************

INPUT ELECTRIC POWER = 75.5 W HEAT RATE GAINED BY WATER = 75.1 W HEAT BALANCE ERROR = 0.59%
MASS FLOW RATE = 24.6827 G/S PRESSURE DROP = 1.425 MM H2O FRICTION FACTOR = 0.071835 FREM = 16.5188

REM = 230.0 GRM+ = 0.19883E 06 UPSTREAM BULK TEMPERATURE = 44.44 DEG C DOWNSTREAM BULK TEMPERATURE = 45.44 DEG C
PRM = 26.17 RAM+ = 0.52039E 07 INLET BULK TEMPERATURE = 44.45 DEG C OUTLET BULK TEMPERATURE = 45.44 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	45.92	45.92	45.95	45.94	44.45	226.3	26.6	0.515E 07	0.00000	7.35	7.34	7.22	7.28	7.28	7.28
1	1.5	45.95	45.95	45.97	45.96	44.45	226.3	26.6	0.515E 07	0.00008	7.22	7.21	7.12	7.17	7.17	7.17
2	2.5	45.97	45.97	45.99	45.98	44.45	226.3	26.6	0.515E 07	0.00014	7.14	7.12	7.06	7.09	7.09	7.09
3	5.5	46.03	46.04	46.03	46.03	44.46	226.3	26.6	0.515E 07	0.00030	6.89	6.87	6.88	6.88	6.88	6.88
4	15.5	46.43	46.19	46.22	46.26	44.48	226.5	26.5	0.515E 07	0.00085	5.57	6.35	6.22	6.07	6.09	6.08
5	25.5	46.24	46.28	46.17	46.21	44.50	226.6	26.5	0.515E 07	0.00140	6.25	6.11	6.49	6.33	6.33	6.33
6	45.5	46.52	46.46	46.36	46.42	44.54	227.0	26.5	0.516E 07	0.00249	5.50	5.67	5.96	5.77	5.77	5.77
7	75.5	46.70	46.42	46.62	46.59	44.61	227.4	26.4	0.517E 07	0.00413	5.19	5.99	5.39	5.47	5.49	5.48
8	105.5	46.63	46.56	47.08	46.84	44.67	227.9	26.4	0.517E 07	0.00577	5.53	5.73	4.51	5.01	5.07	5.04
9	135.5	46.95	46.90	46.65	46.78	44.73	228.4	26.3	0.518E 07	0.00741	4.90	5.01	5.68	5.29	5.32	5.30
10	165.2	46.75	46.76	46.91	46.84	44.80	228.8	26.3	0.519E 07	0.00903	5.55	5.53	5.13	5.32	5.33	5.33
11	205.2	46.94	46.81	46.68	46.78	44.88	229.5	26.2	0.520E 07	0.01122	5.27	5.64	6.04	5.73	5.75	5.74
12	245.2	47.16	46.83	47.01	47.00	44.97	230.1	26.2	0.521E 07	0.01340	4.96	5.83	5.31	5.34	5.36	5.35
13	275.2	46.93	46.76	47.02	46.93	45.03	230.6	26.1	0.521E 07	0.01504	5.72	6.28	5.47	5.72	5.73	5.72
14	305.2	46.91	46.89	46.82	46.86	45.10	231.1	26.1	0.522E 07	0.01667	5.99	6.07	6.30	6.16	6.16	6.16
15	333.3	47.06	46.98	47.00	47.01	45.16	231.6	26.0	0.523E 07	0.01820	5.70	5.96	5.87	5.85	5.85	5.85
16	363.3	47.30	47.14	46.87	47.05	45.22	232.0	26.0	0.524E 07	0.01984	5.23	5.65	6.57	5.95	6.01	5.98
17	383.3	47.45	47.18	46.92	47.12	45.26	232.4	25.9	0.524E 07	0.02093	4.96	5.67	6.53	5.85	5.92	5.88
18	403.3	47.27	47.07	46.95	47.06	45.30	232.7	25.9	0.525E 07	0.02202	5.52	6.14	6.60	6.18	6.21	6.19
19	423.3	47.13	47.13	47.00	47.06	45.35	233.0	25.9	0.525E 07	0.02311	6.11	6.09	6.57	6.33	6.33	6.33
20	443.3	47.20	47.38	47.01	47.15	45.39	233.4	25.8	0.526E 07	0.02419	6.00	5.45	6.70	6.17	6.21	6.19
21	463.3	47.22	47.45	46.92	47.13	45.43	233.7	25.8	0.526E 07	0.02528	6.08	5.39	7.32	6.42	6.53	6.47
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	47.24	47.15	46.96	47.08	45.28	232.5	25.9	0.524E 07	0.02138	5.58	5.83	6.47	6.05	6.09	6.07

******************** 3 **********************

INPUT ELECTRIC POWER = 144.6 W   HEAT RATE GAINED BY WATER = 141.9 W   HEAT BALANCE ERROR = 1.90%
MASS FLOW RATE = 15.5568 G/S   PRESSURE DROP = 0.886 MM H2O   FRICTION FACTOR = 0.112311   FREM = 16.6098

REM = 147.9   GRM+ = 0.38787E 06   UPSTREAM BULK TEMPERATURE = 44.06 DEG C   DOWNSTREAM BULK TEMPERATURE = 47.06 DEG C
PRM = 25.70   RAM+ = 0.99681E 07   INLET BULK TEMPERATURE = 44.06 DEG C   OUTLET BULK TEMPERATURE = 47.05 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	45.82	45.78	45.82	45.81	44.06	140.8	26.9	0.964E 07	0.00000	11.64	11.93	11.61	11.70	11.70	11.70
1	1.5	45.88	45.82	45.86	45.86	44.07	140.9	26.9	0.965E 07	0.00013	11.34	11.73	11.41	11.47	11.47	11.47
2	2.5	45.92	45.84	45.89	45.89	44.08	140.9	26.8	0.965E 07	0.00022	11.14	11.59	11.27	11.31	11.32	11.32
3	5.5	46.03	45.92	45.98	45.98	44.09	141.0	26.8	0.965E 07	0.00048	10.58	11.20	10.88	10.88	10.88	10.88
4	15.5	46.54	46.36	46.39	46.42	44.16	141.3	26.8	0.966E 07	0.00135	8.61	9.32	9.17	9.06	9.07	9.06
5	25.5	46.69	46.79	46.45	46.59	44.22	141.6	26.7	0.968E 07	0.00222	8.31	7.99	9.19	8.64	8.67	8.65
6	45.5	46.91	46.91	46.87	46.89	44.35	142.2	26.6	0.970E 07	0.00395	8.01	8.01	8.13	8.07	8.07	8.07
7	75.5	47.26	46.92	47.18	47.14	44.54	143.0	26.5	0.974E 07	0.00656	7.54	8.61	7.76	7.90	7.92	7.91
8	105.5	47.19	47.12	47.65	47.40	44.73	143.9	26.3	0.979E 07	0.00915	8.33	8.58	7.03	7.68	7.74	7.71
9	135.5	47.51	47.58	47.26	47.41	44.92	144.8	26.2	0.983E 07	0.01175	7.92	7.72	8.76	8.26	8.29	8.28
10	165.2	47.32	47.27	47.54	47.42	45.11	145.7	26.0	0.987E 07	0.01432	9.32	9.53	8.46	8.91	8.94	8.93
11	205.2	47.50	47.48	47.30	47.40	45.37	147.0	25.8	0.993E 07	0.01777	9.61	9.70	10.64	10.12	10.15	10.14
12	245.2	47.72	47.56	47.53	47.58	45.62	148.2	25.6	0.998E 07	0.02122	9.77	10.63	10.80	10.48	10.50	10.49
13	275.2	47.72	47.66	47.93	47.81	45.82	149.2	25.5	0.100E 08	0.02380	10.80	11.13	9.72	10.31	10.34	10.33
14	305.2	47.92	47.78	47.84	47.85	46.01	150.2	25.3	0.101E 08	0.02638	10.74	11.56	11.21	11.17	11.18	11.18
15	333.3	48.19	48.22	48.37	48.29	46.19	151.1	25.2	0.101E 08	0.02879	10.28	10.12	9.41	9.79	9.80	9.80
16	363.3	48.60	48.50	48.28	48.41	46.38	152.1	25.1	0.102E 08	0.03136	9.26	9.68	10.81	10.09	10.14	10.11
17	383.3	48.87	48.53	48.33	48.51	46.50	152.7	25.0	0.102E 08	0.03307	8.68	10.16	11.28	10.23	10.35	10.29
18	403.3	48.80	48.65	48.94	48.83	46.63	153.4	24.9	0.102E 08	0.03478	9.49	10.22	8.92	9.36	9.38	9.37
19	423.3	48.87	48.76	48.62	48.72	46.76	154.1	24.8	0.103E 08	0.03649	9.75	10.31	11.04	10.50	10.53	10.52
20	443.3	49.12	49.31	49.11	49.16	46.89	154.8	24.7	0.103E 08	0.03820	9.22	8.50	9.27	9.05	9.06	9.06
21	463.3	49.13	49.45	49.69	49.49	47.02	155.3	24.6	0.103E 08	0.03991	9.73	8.45	7.69	8.31	8.39	8.35
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	48.74	48.66	48.61	48.65	46.56	153.0	24.9	0.102E 08	0.03378	9.45	9.83	10.12	9.84	9.88	9.86

********************** # 4 ****************************

INPUT ELECTRIC POWER = 154.4 W   HEAT RATE GAINED BY WATER = 151.8 W   HEAT BALANCE ERROR = 1.70%
MASS FLOW RATE = 26.5828 G/S   PRESSURE DROP = 1.658 MM H2O   FRICTION FACTOR = 0.072187   FREM = 16.2768

REM = 225.5   GRM+ = 0.34685E 06   UPSTREAM BULK TEMPERATURE = 41.00 DEG C   DOWNSTREAM BULK TEMPERATURE = 42.89 DEG C
PRM = 28.50   RAM+ = 0.98862E 07   INLET BULK TEMPERATURE = 41.00 DEG C   OUTLET BULK TEMPERATURE = 42.89 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE H	AVERAGE T+H
0	0.0	42.74	42.74	42.72	42.73	41.00	218.7	29.3	0.954E 07	0.00000	12.57	12.55	12.68	12.62	12.62	12.62
1	1.5	42.77	42.78	42.76	42.77	41.01	218.7	29.3	0.954E 07	0.00008	12.30	12.34	12.44	12.40	12.40	12.40
2	2.5	42.79	42.80	42.79	42.79	41.01	218.8	29.3	0.954E 07	0.00013	12.24	12.20	12.28	12.25	12.25	12.25
3	5.5	42.86	42.87	42.87	42.87	41.02	218.9	29.3	0.955E 07	0.00028	11.86	11.79	11.82	11.82	11.82	11.82
4	15.5	43.08	42.86	42.94	42.95	41.06	219.1	29.2	0.956E 07	0.00080	10.85	12.16	11.62	11.54	11.56	11.55
5	25.5	43.31	43.50	43.13	43.27	41.10	219.4	29.2	0.958E 07	0.00131	9.91	9.11	10.77	10.09	10.14	10.11
6	45.5	43.65	43.64	43.48	43.56	41.18	220.0	29.1	0.961E 07	0.00233	8.87	8.90	9.53	9.19	9.20	9.20
7	75.5	43.87	43.56	43.75	43.73	41.31	220.9	29.0	0.965E 07	0.00387	8.50	9.70	8.93	9.00	9.02	9.01
8	105.6	43.82	43.82	44.21	44.02	41.43	221.7	28.9	0.970E 07	0.00541	9.12	9.12	7.83	8.42	8.47	8.45
9	135.5	44.12	44.07	43.83	43.96	41.55	222.6	28.8	0.975E 07	0.00694	8.48	8.65	9.55	9.03	9.06	9.05
10	165.2	43.95	44.06	44.13	44.07	41.67	223.5	28.7	0.979E 07	0.00846	9.56	9.12	8.86	9.09	9.10	9.09
11	205.2	44.18	44.11	43.93	44.03	41.83	224.7	28.6	0.986E 07	0.01051	9.29	9.57	10.40	9.89	9.92	9.91
12	245.2	44.55	44.43	43.98	44.23	41.99	225.8	28.5	0.989E 07	0.01255	8.54	8.96	10.96	9.73	9.86	9.79
13	275.2	44.35	44.35	44.29	44.32	42.11	226.6	28.4	0.992E 07	0.01408	9.77	9.77	10.03	9.90	9.90	9.90
14	305.2	44.38	44.25	44.16	44.24	42.23	227.4	28.3	0.994E 07	0.01561	10.14	10.81	11.32	10.88	10.90	10.89
15	333.3	44.48	44.50	44.44	44.47	42.34	228.2	28.2	0.996E 07	0.01704	10.23	10.15	10.40	10.29	10.30	10.30
16	363.3	44.75	44.59	44.28	44.48	42.46	229.0	28.1	0.999E 07	0.01857	9.57	10.27	12.00	10.86	10.96	10.91
17	383.3	44.90	44.64	44.40	44.59	42.54	229.6	28.0	0.100E 08	0.01959	9.29	10.40	11.76	10.70	10.81	10.75
18	403.3	44.85	44.66	44.85	44.80	42.62	230.1	28.0	0.100E 08	0.02061	9.84	10.73	9.82	10.04	10.05	10.04
19	423.3	44.82	44.72	44.54	44.65	42.70	230.7	27.9	0.100E 08	0.02162	10.34	10.83	11.92	11.21	11.25	11.23
20	443.3	45.06	45.12	44.92	45.00	42.78	231.3	27.9	0.101E 08	0.02264	9.63	9.30	10.25	9.86	9.88	9.87
21	463.3	45.20	45.39	45.53	45.41	42.86	231.8	27.8	0.101E 08	0.02366	9.37	8.67	8.20	8.59	8.61	8.60
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	44.81	44.71	44.57	44.66	42.58	229.8	28.0	0.100E 08	0.02001	9.82	10.29	11.03	10.49	10.54	10.52

*************** 5 *********************

INPUT ELECTRIC POWER = 221.0 W
MASS FLOW RATE = 18.6933 G/S

HEAT RATE GAINED BY WATER = 211.6 W
PRESSURE DROP = 1.261 MM H2O

HEAT BALANCE ERROR = 4.23%
FRICTION FACTOR = 0.111375 FREM = 15.5128

REM = 139.3 GRM+ = 0.36744E 06
PRM = 32.02 RAM+ = 0.11766E 08

UPSTREAM BULK TEMPERATURE = 35.89 DEG C
INLET BULK TEMPERATURE = 35.89 DEG C

DOWNSTREAM BULK TEMPERATURE = 39.67 DEG C
OUTLET BULK TEMPERATURE = 39.66 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE H	AVERAGE T+H
0	0.0	39.26	39.22	39.25	39.24	35.89	131.0	33.6	0.109E 08	0.00000	8.98	9.08	9.00	9.02	9.02	9.02
1	1.5	39.32	39.26	39.30	39.29	35.90	131.9	33.6	0.109E 08	0.00011	8.86	9.00	8.91	8.92	8.92	8.92
2	2.5	39.35	39.29	39.33	39.32	35.91	131.9	33.6	0.109E 08	0.00019	8.78	8.95	8.85	8.86	8.86	8.86
3	5.5	39.47	39.37	39.42	39.42	35.94	132.0	33.6	0.109E 08	0.00041	8.55	8.79	8.67	8.67	8.67	8.67
4	15.5	39.90	39.93	40.00	39.96	36.02	132.3	33.5	0.109E 08	0.00115	7.79	7.73	7.59	7.68	7.68	7.68
5	25.5	40.10	40.10	40.15	40.12	36.10	132.6	33.5	0.110E 08	0.00189	7.56	7.55	7.47	7.51	7.51	7.51
6	45.5	40.55	40.42	40.31	40.40	36.26	133.2	33.3	0.111E 08	0.00337	7.04	7.26	7.46	7.30	7.31	7.31
7	75.5	40.77	40.58	40.65	40.66	36.50	134.2	33.1	0.112E 08	0.00559	7.08	7.41	7.28	7.26	7.26	7.26
8	105.5	40.90	40.85	40.72	40.80	36.74	135.2	32.9	0.113E 08	0.00780	7.28	7.36	7.59	7.45	7.45	7.45
9	135.5	40.84	41.13	40.79	40.89	36.98	136.1	32.7	0.114E 08	0.01002	7.84	7.30	7.93	7.74	7.75	7.75
10	165.2	40.98	40.91	40.78	40.86	37.22	137.1	32.5	0.115E 08	0.01220	8.05	8.19	8.50	8.31	8.31	8.31
11	205.2	40.91	41.13	41.00	41.01	37.54	138.3	32.2	0.117E 08	0.01514	8.99	8.44	8.74	8.72	8.73	8.73
12	245.2	41.37	41.52	41.29	41.37	37.86	139.6	31.9	0.118E 08	0.01808	8.64	8.20	8.83	8.64	8.64	8.64
13	275.2	41.25	41.54	41.44	41.42	38.10	140.6	31.7	0.119E 08	0.02028	9.61	8.82	9.08	9.14	9.15	9.14
14	305.2	41.86	41.89	41.73	41.80	38.34	141.6	31.5	0.120E 08	0.02247	8.62	8.53	8.96	8.76	8.77	8.77
15	333.3	42.01	42.07	41.94	41.99	38.57	142.6	31.3	0.121E 08	0.02453	8.82	8.65	8.99	8.86	8.86	8.86
16	363.3	42.31	42.27	42.03	42.16	38.81	143.6	31.1	0.122E 08	0.02672	8.66	8.77	9.41	9.05	9.06	9.05
17	383.3	42.62	42.39	42.10	42.31	38.97	144.3	31.0	0.123E 08	0.02817	8.30	8.86	9.68	9.09	9.13	9.11
18	403.3	42.59	42.47	42.64	42.58	39.13	145.0	30.9	0.124E 08	0.02963	8.78	9.07	8.65	8.79	8.79	8.79
19	423.3	42.68	42.65	42.41	42.54	39.29	145.7	30.7	0.124E 08	0.03108	8.95	9.03	9.72	9.34	9.36	9.35
20	443.3	42.91	43.00	42.82	42.91	39.45	146.5	30.6	0.125E 08	0.03253	8.77	8.37	9.00	8.78	8.79	8.78
21	463.3	43.12	43.33	43.45	43.34	39.61	147.2	30.5	0.126E 08	0.03398	8.65	8.17	7.91	8.15	8.16	8.15
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	42.52	42.49	42.32	42.41	39.04	144.6	31.0	0.123E 08	0.02878	8.71	8.79	9.24	8.99	9.00	8.99

****************** 6 ********************

INPUT ELECTRIC POWER = 193.0 W   HEAT RATE GAINED BY WATER = 189.3 W   HEAT BALANCE ERROR = 1.88%
MASS FLOW RATE = 33.4180 G/S   PRESSURE DROP = 2.332 MM H2O   FRICTION FACTOR = 0.064409   FREM = 16.3846

REM = 254.4   GRM+ = 0.34414E 06   UPSTREAM BULK TEMPERATURE = 37.56 DEG C   DOWNSTREAM BULK TEMPERATURE = 39.44 DEG C
PRM = 21.99   RAM+ = 0.16213E 08   INLET BULK TEMPERATURE = 37.56 DEG C   OUTLET BULK TEMPERATURE = 39.44 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE H	AVERAGE T+H
0	0.0	39.90	39.88	39.87	39.88	37.56	247.4	22.5	0.154E 08	0.00000	11.56	11.65	11.73	11.67	11.67	11.67
1	1.5	39.97	39.94	39.94	39.95	37.56	247.5	22.5	0.154E 08	0.00009	11.27	11.38	11.41	11.37	11.37	11.37
2	2.5	40.01	39.98	39.99	39.99	37.57	247.5	22.5	0.154E 08	0.00015	11.08	11.21	11.21	11.18	11.18	11.18
3	5.5	40.15	40.11	40.13	40.13	37.58	247.6	22.5	0.154E 08	0.00032	10.54	10.72	10.63	10.63	10.63	10.63
4	15.5	40.41	40.55	40.56	40.52	37.62	247.9	22.5	0.154E 08	0.00091	9.73	9.26	9.20	9.34	9.35	9.34
5	25.5	40.66	40.61	40.48	40.56	37.66	248.2	22.5	0.154E 08	0.00150	9.03	9.19	9.60	9.35	9.35	9.35
6	45.5	41.06	40.99	40.87	40.95	37.74	248.8	22.4	0.155E 08	0.00268	8.17	8.35	8.65	8.45	8.45	8.45
7	75.5	41.33	41.14	41.16	41.20	37.86	249.6	22.4	0.155E 08	0.00445	7.81	8.26	8.22	8.12	8.13	8.12
8	105.5	41.40	41.36	41.35	41.37	37.98	250.5	22.3	0.156E 08	0.00621	7.92	8.03	8.04	8.01	8.01	8.01
9	135.5	41.41	41.58	41.24	41.37	38.10	251.4	22.2	0.157E 08	0.00798	8.21	7.79	8.63	8.30	8.31	8.31
10	165.2	41.54	41.36	41.57	41.51	38.22	252.3	22.1	0.157E 08	0.00972	8.17	8.63	8.09	8.24	8.24	8.24
11	205.2	41.30	41.52	41.40	41.40	38.30	253.5	22.1	0.158E 08	0.01207	9.29	8.64	8.99	8.97	8.98	8.97
12	245.2	41.65	41.74	41.58	41.64	38.54	254.7	22.0	0.159E 08	0.01442	8.73	8.48	8.93	8.76	8.77	8.77
13	275.2	41.54	41.76	41.73	41.69	38.66	255.6	21.9	0.160E 08	0.01618	9.44	8.76	8.86	8.97	8.98	8.97
14	305.2	41.91	42.01	41.84	41.90	38.78	256.6	21.8	0.161E 08	0.01794	8.67	8.42	8.88	8.71	8.71	8.71
15	333.3	42.18	42.24	42.05	42.13	38.89	257.4	21.8	0.161E 08	0.01958	8.27	8.11	8.60	8.39	8.39	8.39
16	363.3	42.20	42.15	42.15	42.16	39.02	258.4	21.7	0.162E 08	0.02134	8.53	8.65	8.67	8.63	8.63	8.63
17	383.3	42.62	42.34	42.16	42.32	39.10	259.0	21.6	0.162E 08	0.02250	7.70	8.38	8.86	8.42	8.45	8.44
18	403.3	42.42	42.25	42.24	42.29	39.18	259.6	21.6	0.163E 08	0.02367	8.38	8.83	8.86	8.73	8.73	8.73
19	423.3	42.46	42.48	42.30	42.38	39.26	260.3	21.5	0.163E 08	0.02484	8.49	8.42	8.92	8.68	8.69	8.68
20	443.3	42.86	43.08	42.82	42.89	39.34	260.9	21.5	0.164E 08	0.02601	7.72	7.26	7.79	7.63	7.64	7.64
21	463.3	43.01	43.16	43.28	43.18	39.42	261.6	21.4	0.164E 08	0.02717	7.56	7.26	7.03	7.22	7.22	7.22
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	42.45	42.42	42.29	42.36	39.13	259.3	21.6	0.163E 08	0.02299	8.18	8.28	8.62	8.41	8.42	8.42

********************* 7 **********************

INPUT ELECTRIC POWER = 160.3 W   HEAT RATE GAINED BY WATER = 159.7 W   HEAT BALANCE ERROR = 0.31%
MASS FLOW RATE = 18.6863 G/S   PRESSURE DROP = 1.141 MM H2O   FRICTION FACTOR = 0.100600   FREM = 15.6190

REM = 155.3   GRM+ = 0.34985E 06   UPSTREAM BULK TEMPERATURE = 39.89 DEG C   DOWNSTREAM BULK TEMPERATURE = 42.72 DEG C
PRM = 29.04   RAM+ = 0.10158E 08   INLET BULK TEMPERATURE = 39.89 DEG C   OUTLET BULK TEMPERATURE = 42.72 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	B	T+B
0	0.0	41.04	41.11	41.09	41.08	39.89	148.4	30.2	0.961E 07	0.00000	20.07	18.88	19.25	19.35	19.36	19.36
1	1.5	41.13	41.23	41.19	41.19	39.90	148.5	30.2	0.961E 07	0.00011	18.66	17.24	17.79	17.86	17.87	17.86
2	2.5	41.20	41.32	41.26	41.26	39.91	148.5	30.2	0.962E 07	0.00018	17.80	16.27	16.91	16.95	16.97	16.96
3	5.5	41.39	41.58	41.48	41.48	39.93	148.6	30.2	0.962E 07	0.00040	15.63	13.91	14.72	14.72	14.75	14.73
4	15.5	41.83	41.96	41.92	41.91	39.99	148.9	30.1	0.965E 07	0.00114	12.47	11.64	11.85	11.95	11.95	11.95
5	25.5	42.12	42.20	42.12	42.14	40.05	149.1	30.1	0.967E 07	0.00187	11.04	10.67	11.08	10.97	10.97	10.97
6	45.5	42.63	42.56	42.29	42.44	40.17	149.7	30.0	0.971E 07	0.00333	9.30	9.57	10.82	10.08	10.13	10.10
7	75.5	42.86	42.66	42.74	42.75	40.35	150.6	29.8	0.978E 07	0.00553	9.15	9.94	9.61	9.57	9.58	9.57
8	105.5	43.09	43.04	43.01	43.04	40.53	151.4	29.7	0.985E 07	0.00772	8.96	9.16	9.24	9.15	9.15	9.15
9	135.5	43.10	43.39	42.93	43.09	40.71	152.3	29.5	0.992E 07	0.00991	9.60	8.56	10.33	9.65	9.71	9.68
10	165.2	43.39	43.22	42.99	43.15	40.89	153.2	29.4	0.999E 07	0.01207	9.18	9.86	10.91	10.16	10.21	10.19
11	205.2	43.33	43.49	43.36	43.39	41.13	154.4	29.2	0.101E 08	0.01490	10.43	9.73	10.28	10.17	10.18	10.18
12	245.2	43.86	43.87	43.75	43.81	41.37	155.6	29.0	0.102E 08	0.01789	9.22	9.21	9.65	9.43	9.43	9.43
13	275.2	43.84	43.56	43.94	43.82	41.55	156.5	28.8	0.103E 08	0.02006	10.05	11.45	9.60	10.12	10.18	10.15
14	305.2	44.44	44.47	44.27	44.37	41.73	157.4	28.7	0.103E 08	0.02224	8.49	8.38	9.05	8.73	8.74	8.74
15	333.3	44.70	44.67	44.50	44.59	41.90	158.3	28.5	0.104E 08	0.02427	8.21	8.32	8.85	8.55	8.56	8.55
16	363.3	44.92	44.87	44.68	44.79	42.08	159.2	28.4	0.104E 08	0.02644	8.11	8.24	8.86	8.50	8.52	8.51
17	383.3	45.41	45.04	44.85	45.04	42.20	159.7	28.3	0.105E 08	0.02789	7.18	8.11	8.69	8.12	8.17	8.14
18	403.3	45.24	-11.55	45.02	30.93	42.32	160.3	28.2	0.105E 08	0.02934	7.89	-0.43	8.53	-2.02	6.13	2.05
19	423.3	45.33	45.34	45.15	45.24	42.44	160.9	28.1	0.105E 08	0.03078	7.99	7.95	8.49	8.22	8.23	8.22
20	443.3	45.23	45.46	45.26	45.30	42.56	161.5	28.0	0.105E 08	0.03222	8.65	7.96	8.55	8.42	8.43	8.42
21	463.3	45.14	45.27	44.32	44.76	42.69	162.1	27.9	0.106E 08	0.03367	9.37	8.89	14.09	11.08	11.61	11.34
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	45.14	35.64	44.91	42.65	42.25	160.0	28.3	0.105E 08	0.02849	8.00	6.69	8.66	6.63	8.00	7.32

******************* 8 *********************

INPUT ELECTRIC POWER = 60.3 W
MASS FLOW RATE = 23.4938 G/S

HEAT RATE GAINED BY WATER = 58.0 W
PRESSURE DROP = 0.891 MM H2O

HEAT BALANCE ERROR = 3.66%
FRICTION FACTOR = 0.049693 FREM = 9.8588

REM = 198.4 GRM+ = 0.13158E 06 UPSTREAM BULK TEMPERATURE = 41.39 DEG C DOWNSTREAM BULK TEMPERATURE = 42.21 DEG C
PRM = 28.62 RAM+ = 0.37656E 07 INLET BULK TEMPERATURE = 41.39 DEG C OUTLET BULK TEMPERATURE = 42.21 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	B	T+B
0	0.0	40.96	40.96	40.94	40.95	41.39	195.8	29.0	0.370E 07	0.00000	*****	*****	*****	*****	*****	*****
1	1.5	41.04	41.05	41.03	41.04	41.40	195.8	29.0	0.370E 07	0.00009	*****	*****	*****	*****	*****	*****
2	2.5	41.10	41.11	41.10	41.10	41.40	195.8	29.0	0.370E 07	0.00015	*****	*****	*****	*****	*****	*****
3	5.5	41.28	41.29	41.29	41.29	41.40	195.8	29.0	0.371E 07	0.00032	*****	*****	*****	*****	*****	*****
4	15.5	41.66	41.79	41.81	41.77	41.42	195.9	28.9	0.371E 07	0.00090	35.36	22.65	21.39	24.11	25.20	24.65
5	25.5	41.96	42.03	41.95	41.97	41.44	196.0	28.9	0.371E 07	0.00148	16.09	14.15	16.33	15.67	15.72	15.70
6	45.5	42.41	42.34	42.17	42.27	41.47	196.3	28.9	0.372E 07	0.00264	8.91	9.62	11.87	10.40	10.57	10.48
7	75.5	42.74	42.55	42.57	42.61	41.52	196.6	28.9	0.372E 07	0.00438	6.85	8.17	8.01	7.72	7.76	7.74
8	105.5	42.87	42.81	42.73	42.78	41.58	196.9	28.8	0.373E 07	0.00612	6.48	6.76	7.25	6.92	6.94	6.93
9	135.5	42.88	43.05	42.59	42.78	41.63	197.3	28.8	0.374E 07	0.00786	6.69	5.87	8.64	7.25	7.46	7.36
10	165.2	43.00	42.82	42.71	42.81	41.68	197.6	28.7	0.375E 07	0.00958	6.34	7.30	8.10	7.39	7.46	7.42
11	205.2	42.88	43.10	42.86	42.92	41.75	198.1	28.7	0.376E 07	0.01189	7.39	6.20	7.53	7.11	7.16	7.14
12	245.2	43.30	42.75	43.18	43.10	41.82	198.5	28.6	0.377E 07	0.01421	5.65	8.99	6.14	6.52	6.73	6.62
13	275.2	43.11	43.39	43.26	43.26	41.87	198.8	28.6	0.377E 07	0.01594	6.75	5.50	6.01	6.03	6.07	6.05
14	305.2	43.71	43.69	43.48	43.59	41.92	199.2	28.5	0.378E 07	0.01768	4.68	4.73	5.36	5.01	5.03	5.02
15	333.3	43.92	43.88	43.65	43.77	41.97	199.4	28.5	0.378E 07	0.01930	4.30	4.39	4.99	4.64	4.67	4.66
16	363.3	44.01	43.91	43.78	43.87	42.02	199.8	28.4	0.379E 07	0.02104	4.21	4.43	4.77	4.53	4.54	4.54
17	383.3	44.44	44.19	43.95	44.14	42.06	200.0	28.4	0.379E 07	0.02219	3.51	3.91	4.41	4.02	4.06	4.04
18	403.3	44.34	44.21	44.06	44.17	42.09	200.2	28.4	0.379E 07	0.02335	3.73	3.94	4.26	4.03	4.05	4.04
19	423.3	44.37	44.33	44.15	44.25	42.13	200.4	28.4	0.379E 07	0.02450	3.73	3.80	4.14	3.94	3.95	3.95
20	443.3	44.27	44.49	43.78	44.08	42.16	200.6	28.3	0.380E 07	0.02566	3.97	3.59	5.16	4.36	4.47	4.41
21	463.3	44.19	44.30	43.28	43.76	42.20	200.8	28.3	0.380E 07	0.02681	4.20	3.98	7.73	5.35	5.91	5.63
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	44.22	44.17	43.89	44.05	42.07	200.1	28.4	0.379E 07	0.02267	3.91	4.01	4.62	4.26	4.29	4.27

******************** 9 ************************

INPUT ELECTRIC POWER = 240.1 W   HEAT RATE GAINED BY WATER = 234.0 W   HEAT BALANCE ERROR = 2.55%
MASS FLOW RATE = 14.6731 G/S   PRESSURE DROP = 0.481 MM H2O   FRICTION FACTOR = 0.068763   FREM = 8.4454

REM = 122.8   GRM+ = 0.52053E 06   UPSTREAM BULK TEMPERATURE = 38.89 DEG C   DOWNSTREAM BULK TEMPERATURE = 44.17 DEG C
PRM = 28.84   RAM+ = 0.15014E 08   INLET BULK TEMPERATURE = 38.90 DEG C   OUTLET BULK TEMPERATURE = 44.17 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	41.22	41.24	41.17	41.20	38.90	113.1	31.1	0.136E 08	0.00000	14.49	14.32	14.76	14.58	14.58	14.58
1	1.5	41.38	41.42	41.36	41.38	38.92	113.1	31.1	0.136E 08	0.00014	13.60	13.39	13.72	13.61	13.61	13.61
2	2.5	41.50	41.54	41.49	41.51	38.93	113.1	31.0	0.136E 08	0.00023	13.04	12.82	13.08	13.01	13.01	13.01
3	5.5	41.85	41.91	41.88	41.88	38.96	113.3	31.0	0.136E 08	0.00052	11.63	11.36	11.49	11.49	11.49	11.49
4	15.5	42.39	42.52	42.32	42.39	39.07	113.6	30.9	0.136E 08	0.00145	10.11	9.73	10.34	10.12	10.13	10.13
5	25.5	42.80	42.82	42.62	42.72	39.19	114.0	30.8	0.137E 08	0.00239	9.28	9.23	9.76	9.50	9.51	9.51
6	45.5	43.37	43.35	42.91	43.14	39.41	114.8	30.6	0.138E 08	0.00425	8.49	8.51	9.59	9.01	9.04	9.03
7	75.5	43.76	43.56	43.36	43.51	39.75	116.0	30.4	0.140E 08	0.00705	8.37	8.82	9.31	8.93	8.95	8.94
8	105.5	43.99	43.88	43.64	43.79	40.08	117.2	30.1	0.142E 08	0.00984	8.60	8.86	9.44	9.07	9.09	9.08
9	135.5	44.12	44.41	43.78	44.02	40.42	118.5	29.8	0.144E 08	0.01263	9.09	8.43	10.02	9.34	9.39	9.36
10	165.2	44.46	44.29	44.02	44.19	40.76	119.8	29.5	0.146E 08	0.01538	9.09	9.52	10.31	9.78	9.81	9.79
11	205.2	44.63	44.95	44.54	44.67	41.20	121.5	29.1	0.148E 08	0.01908	9.83	8.98	10.07	9.72	9.74	9.73
12	245.2	45.40	45.43	45.24	45.33	41.65	123.3	28.7	0.151E 08	0.02276	8.99	8.91	9.39	9.17	9.17	9.17
13	275.2	45.47	45.69	45.48	45.53	41.99	124.6	28.5	0.153E 08	0.02552	9.68	9.10	9.65	9.51	9.52	9.52
14	305.2	46.24	46.33	45.97	46.13	42.33	125.9	28.2	0.154E 08	0.02827	8.62	8.43	9.25	8.87	8.89	8.88
15	333.3	46.61	46.58	46.26	46.43	42.64	127.1	28.0	0.154E 08	0.03085	8.49	8.56	9.31	8.90	8.92	8.91
16	363.3	47.07	47.03	46.70	46.88	42.98	128.4	27.7	0.156E 08	0.03359	8.25	8.33	9.06	8.66	8.68	8.67
17	383.3	47.57	47.29	46.92	47.18	43.20	129.3	27.5	0.156E 08	0.03542	7.74	8.26	9.07	8.50	8.53	8.51
18	403.3	47.61	47.41	47.18	47.35	43.43	130.2	27.3	0.157E 08	0.03725	8.07	8.48	9.00	8.62	8.64	8.63
19	423.3	47.75	47.75	47.34	47.54	43.65	131.2	27.2	0.158E 08	0.03907	8.25	8.25	9.17	8.69	8.71	8.70
20	443.3	47.77	47.95	47.63	47.75	43.88	132.1	27.0	0.158E 08	0.04089	8.69	8.30	8.99	8.73	8.74	8.74
21	463.3	47.61	47.85	46.51	47.12	44.10	133.0	26.8	0.159E 08	0.04270	9.63	9.02	14.02	11.19	11.67	11.43
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	47.40	47.33	47.01	47.19	43.30	129.7	27.5	0.157E 08	0.03618	8.25	8.36	9.10	8.68	8.70	8.69

******************** 10 ************************

INPUT ELECTRIC POWER = 300.2 W HEAT RATE GAINED BY WATER = 288.6 W HEAT BALANCE ERROR = 3.88%
MASS FLOW RATE = 30.7875 G/S PRESSURE DROP = 0.877 MM H2O FRICTION FACTOR = 0.028504 FREM = 7.0307

REM = 246.7 GRM+ = 0.58485E 06 UPSTREAM BULK TEMPERATURE = 38.61 DEG C DOWNSTREAM BULK TEMPERATURE = 41.72 DEG C
PRM = 30.00 RAM+ = 0.17544E 08 INLET BULK TEMPERATURE = 38.62 DEG C OUTLET BULK TEMPERATURE = 41.72 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	41.67	41.69	41.66	41.67	38.62	235.2	31.3	0.165E 08	0.00000	13.56	13.45	13.59	13.55	13.55	13.55
1	1.5	41.83	41.87	41.84	41.85	38.63	235.3	31.3	0.165E 08	0.00007	12.89	12.74	12.88	12.85	12.85	12.85
2	2.5	41.95	42.00	41.96	41.97	38.63	235.3	31.3	0.166E 08	0.00011	12.47	12.30	12.42	12.40	12.40	12.40
3	5.5	42.30	42.37	42.33	42.33	38.65	235.4	31.3	0.166E 08	0.00025	11.34	11.14	11.24	11.24	11.24	11.24
4	15.5	42.85	42.97	42.94	42.93	38.72	235.9	31.2	0.166E 08	0.00069	10.02	9.72	9.79	9.83	9.83	9.83
5	25.5	43.31	43.22	43.07	43.17	38.78	236.4	31.2	0.166E 08	0.00114	9.15	9.33	9.64	9.44	9.44	9.44
6	45.5	43.76	43.69	43.42	43.57	38.92	237.3	31.1	0.167E 08	0.00203	8.54	8.66	9.19	8.89	8.90	8.89
7	75.5	44.16	44.00	43.81	43.94	39.12	238.8	30.9	0.169E 08	0.00337	8.21	8.46	8.82	8.57	8.58	8.58
8	105.5	44.27	44.27	44.04	44.16	39.31	240.2	30.7	0.170E 08	0.00470	8.35	8.36	8.75	8.55	8.55	8.55
9	135.5	44.35	44.52	44.00	44.22	39.51	241.7	30.6	0.171E 08	0.00604	8.57	8.26	9.22	8.80	8.82	8.81
10	165.2	44.57	44.40	44.13	44.31	39.71	243.2	30.4	0.172E 08	0.00736	8.52	8.83	9.37	9.01	9.02	9.01
11	205.2	44.57	44.73	44.43	44.54	39.97	245.2	30.2	0.174E 08	0.00913	9.01	8.72	9.29	9.07	9.08	9.07
12	245.2	45.17	45.21	44.95	45.07	40.24	247.2	29.9	0.176E 08	0.01090	8.40	8.34	8.79	8.58	8.58	8.58
13	275.2	45.19	45.47	45.14	45.23	40.44	248.8	29.8	0.177E 08	0.01222	8.73	8.24	8.82	8.64	8.65	8.65
14	305.2	45.84	45.71	45.46	45.62	40.64	250.3	29.6	0.179E 08	0.01355	7.96	8.17	8.59	8.32	8.33	8.33
15	333.3	45.99	46.02	45.70	45.85	40.82	251.8	29.4	0.180E 08	0.01479	8.02	7.98	8.51	8.25	8.25	8.25
16	363.3	46.33	46.29	45.92	46.11	41.02	253.4	29.3	0.181E 08	0.01611	7.81	7.87	8.47	8.14	8.16	8.15
17	383.3	46.83	46.50	46.08	46.37	41.15	254.5	29.2	0.182E 08	0.01699	7.31	7.76	8.41	7.95	7.97	7.96
18	403.3	46.71	46.51	46.27	46.44	41.29	255.6	29.1	0.183E 08	0.01786	7.65	7.94	8.32	8.05	8.06	8.05
19	423.3	46.79	46.63	46.33	46.52	41.42	256.7	28.9	0.184E 08	0.01874	7.73	7.97	8.45	8.14	8.15	8.14
20	443.3	46.69	46.93	46.62	46.71	41.55	257.9	28.8	0.185E 08	0.01962	8.07	7.72	8.19	8.04	8.04	8.04
21	463.3	46.66	46.76	45.65	46.18	41.68	259.0	28.7	0.186E 08	0.02049	8.34	8.18	10.47	9.23	9.37	9.30
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	46.56	46.48	46.15	46.34	41.21	255.0	29.1	0.183E 08	0.01735	7.76	7.87	8.39	8.09	8.11	8.10

********************* 11 *********************

INPUT ELECTRIC POWER = 335.2 W HEAT RATE GAINED BY WATER = 312.2 W HEAT BALANCE ERROR = 6.88%
MASS FLOW RATE = 16.7875 G/S PRESSURE DROP = 0.557 MM H2O FRICTION FACTOR = 0.060684 FREM = 9.0982

REM = 149.9 GRM+ = 0.77318E 06 UPSTREAM BULK TEMPERATURE = 40.56 DEG C DOWNSTREAM BULK TEMPERATURE = 46.69 DEG C
PRM = 27.20 RAM+ = 0.21027E 08 INLET BULK TEMPERATURE = 40.57 DEG C OUTLET BULK TEMPERATURE = 46.69 DEG C

STA- TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER- AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	B	T+B
0	0.0	42.89	42.92	42.89	42.89	40.57	136.2	29.7	0.193E 08	0.00000	19.31	19.10	19.35	19.28	19.28	19.28
1	1.5	43.12	43.16	43.13	43.14	40.59	136.3	29.6	0.193E 08	0.00012	17.68	17.43	17.64	17.60	17.60	17.60
2	2.5	43.29	43.33	43.30	43.30	40.60	136.3	29.6	0.193E 08	0.00020	16.70	16.44	16.63	16.60	16.60	16.60
3	5.5	43.77	43.83	43.80	43.80	40.64	136.5	29.6	0.193E 08	0.00045	14.33	14.04	14.19	14.19	14.19	14.19
4	15.5	44.49	44.61	44.47	44.51	40.77	137.1	29.5	0.194E 08	0.00126	12.05	11.69	12.13	12.00	12.00	12.00
5	25.5	45.05	45.03	44.76	44.90	40.90	137.7	29.4	0.195E 08	0.00207	10.80	10.87	11.62	11.21	11.23	11.22
6	45.5	45.67	45.50	45.17	45.38	41.16	138.8	29.2	0.197E 08	0.00370	9.95	10.35	11.19	10.64	10.67	10.66
7	75.5	46.13	45.97	45.66	45.86	41.55	140.6	28.8	0.200E 08	0.00613	9.81	10.17	10.92	10.44	10.46	10.45
8	105.5	46.46	46.39	45.99	46.21	41.94	142.4	28.5	0.203E 08	0.00855	9.94	10.10	11.11	10.54	10.57	10.55
9	135.5	46.61	46.90	46.20	46.48	42.34	144.1	28.2	0.205E 08	0.01097	10.52	9.85	11.65	10.86	10.92	10.89
10	165.2	46.98	46.93	46.46	46.71	42.72	145.8	27.9	0.206E 08	0.01336	10.57	10.70	12.04	11.29	11.34	11.32
11	205.2	47.34	47.26	47.19	47.24	43.25	148.2	27.5	0.209E 08	0.01657	11.01	11.22	11.43	11.27	11.27	11.27
12	245.2	48.24	47.89	48.04	48.05	43.77	150.6	27.1	0.211E 08	0.01977	10.08	10.93	10.55	10.52	10.53	10.52
13	275.2	48.39	48.28	48.33	48.33	44.16	152.5	26.8	0.213E 08	0.02217	10.65	10.94	10.82	10.81	10.81	10.81
14	305.2	49.38	49.41	49.03	49.21	44.55	154.4	26.5	0.214E 08	0.02456	9.34	9.28	10.07	9.68	9.69	9.69
15	333.3	49.87	49.91	49.34	49.61	44.92	156.3	26.2	0.216E 08	0.02679	9.11	9.04	10.21	9.61	9.65	9.63
16	363.3	50.41	50.43	49.97	50.19	45.31	158.3	25.9	0.218E 08	0.02916	8.85	8.82	9.69	9.25	9.27	9.26
17	383.3	51.15	50.72	50.29	50.61	45.57	159.7	25.7	0.219E 08	0.03074	8.10	8.77	9.57	8.96	9.00	8.98
18	403.3	51.06	50.95	50.64	50.82	45.83	161.1	25.5	0.221E 08	0.03232	8.65	8.84	9.40	9.06	9.07	9.06
19	423.3	51.29	51.22	50.81	51.03	46.09	162.5	25.3	0.222E 08	0.03389	8.70	8.82	9.59	9.16	9.17	9.16
20	443.3	51.38	51.63	51.26	51.38	46.35	164.0	25.1	0.223E 08	0.03546	9.00	8.57	9.22	9.00	9.00	9.00
21	463.3	51.32	51.51	49.98	50.70	46.61	165.5	24.9	0.225E 08	0.03703	9.61	9.24	13.45	11.08	11.44	11.26
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	50.86	50.81	50.38	50.61	45.68	160.3	25.6	0.220E 08	0.03139	8.74	8.81	9.61	9.17	9.19	9.18

****************** 12 *****************

INPUT ELECTRIC POWER = 321.2 W HEAT RATE GAINED BY WATER = 319.4 W HEAT BALANCE ERROR = 0.56%
MASS FLOW RATE = 24.6603 G/S PRESSURE DROP = 0.701 MM H2O FRICTION FACTOR = 0.035393 FREM = 8.1971

REM = 231.6 GRM+ = 0.85663E 06 UPSTREAM BULK TEMPERATURE = 43.06 DEG C DOWNSTREAM BULK TEMPERATURE = 47.32 DEG C
PRM = 25.98 RAM+ = 0.22258E 08 INLET BULK TEMPERATURE = 43.06 DEG C OUTLET BULK TEMPERATURE = 47.31 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	44.69	44.67	44.60	44.64	43.06	216.4	27.6	0.213E 08	0.00000	28.31	28.67	29.99	29.22	29.24	29.23
1	1.5	44.93	44.90	44.85	44.88	43.08	216.5	27.6	0.213E 08	0.00008	24.90	25.28	25.93	25.50	25.51	25.50
2	2.5	45.09	45.06	45.03	45.05	43.09	216.6	27.6	0.213E 08	0.00014	22.98	23.38	23.71	23.44	23.45	23.45
3	5.5	45.58	45.53	45.55	45.55	43.11	216.7	27.6	0.213E 08	0.00030	18.68	19.08	18.88	18.88	18.88	18.88
4	15.5	46.25	46.07	45.94	46.05	43.20	217.3	27.5	0.213E 08	0.00085	15.10	16.05	16.83	16.17	16.21	16.19
5	25.5	46.80	46.84	46.51	46.66	43.30	218.0	27.5	0.214E 08	0.00140	13.14	12.98	14.34	13.67	13.70	13.69
6	45.5	47.36	47.30	46.87	47.10	43.48	219.2	27.3	0.214E 08	0.00250	11.87	12.05	13.58	12.71	12.77	12.74
7	75.5	47.82	47.48	47.35	47.50	43.75	221.1	27.1	0.216E 08	0.00415	11.31	12.35	12.79	12.28	12.31	12.29
8	105.5	48.09	48.02	47.93	48.00	44.02	223.0	26.9	0.217E 08	0.00579	11.32	11.54	11.78	11.60	11.61	11.60
9	135.5	48.19	48.32	47.66	47.96	44.29	224.9	26.7	0.218E 08	0.00743	11.83	11.47	13.71	12.59	12.68	12.64
10	165.2	48.44	48.28	47.88	48.12	44.56	226.9	26.5	0.220E 08	0.00905	11.91	12.42	13.91	12.97	13.04	13.00
11	205.2	48.52	48.44	48.25	48.37	44.92	229.6	26.2	0.221E 08	0.01123	12.84	13.14	13.87	13.42	13.43	13.42
12	245.2	49.14	48.84	48.84	48.92	45.29	232.4	25.9	0.223E 08	0.01340	11.98	13.00	13.00	12.73	12.75	12.74
13	275.2	49.18	49.12	49.07	49.11	45.56	234.5	25.7	0.224E 08	0.01503	12.78	12.98	13.18	13.03	13.03	13.03
14	305.2	50.11	50.08	49.59	49.85	45.83	236.6	25.5	0.226E 08	0.01665	10.81	10.88	12.29	11.52	11.57	11.54
15	333.3	50.32	50.30	49.74	50.02	46.09	238.7	25.3	0.227E 08	0.01817	10.93	10.97	12.67	11.75	11.81	11.78
16	363.3	50.86	50.77	50.25	50.53	46.36	240.9	25.1	0.229E 08	0.01978	10.28	10.49	11.89	11.09	11.14	11.11
17	383.3	51.37	51.01	50.51	50.85	46.54	242.4	24.9	0.230E 08	0.02086	9.58	10.36	11.65	10.74	10.81	10.77
18	403.3	51.28	51.06	50.70	50.93	46.72	243.9	24.8	0.231E 08	0.02193	10.15	10.68	11.64	10.99	11.03	11.01
19	423.3	51.35	51.28	50.81	51.06	46.90	245.4	24.7	0.232E 08	0.02301	10.42	10.59	11.86	11.14	11.18	11.16
20	443.3	51.38	51.63	51.14	51.32	47.08	246.7	24.5	0.233E 08	0.02408	10.79	10.19	11.41	10.92	10.95	10.93
21	463.3	51.32	51.51	50.04	50.73	47.26	248.0	24.4	0.234E 08	0.02516	11.42	10.92	16.72	13.39	13.95	13.67
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	51.09	51.01	50.52	50.79	46.61	243.0	24.9	0.230E 08	0.02131	10.36	10.55	11.85	11.10	11.15	11.13

INPUT ELECTRIC POWER = 51.9 W   HEAT RATE GAINED BY WATER = 49.3 W   HEAT BALANCE ERROR = 5.05%
MASS FLOW RATE = 4.4340 G/S   PRESSURE DROP = 0.0541 MM H2O   FRICTION FACTOR = 0.078813   FREM = 12.9301

REM = 164.1   GRM+ = 0.43873E 06   UPSTREAM BULK TEMPERATURE = 26.08 DEG C   DOWNSTREAM BULK TEMPERATURE = 28.78 DEG C
PRM = 5.757   RAM+ = 0.25258E 07   INLET BULK TEMPERATURE = 26.10 DEG C   OUTLET BULK TEMPERATURE = 28.76 DEG C

STA- TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER- AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.51	25.52	25.49	25.50	26.10	159.2	5.95	0.236E 07	0.00002	-6.89	-7.07	-6.65	-6.81	-6.81	-6.81
1	1.5	25.63	25.65	25.62	25.63	26.11	159.3	5.95	0.236E 07	0.00052	-8.46	-8.85	-8.28	-8.46	-8.47	-8.47
2	2.5	25.71	25.73	25.71	25.71	26.11	159.3	5.95	0.236E 07	0.00087	*****	*****	-9.97	*****	*****	*****
3	5.5	25.95	25.99	25.97	25.97	26.13	159.4	5.94	0.236E 07	0.00191	*****	*****	*****	*****	*****	*****
4	15.5	26.61	26.56	26.59	26.59	26.19	159.6	5.93	0.237E 07	0.00538	9.71	10.91	10.20	10.24	10.26	10.25
5	25.5	26.92	27.01	26.92	26.94	26.25	159.8	5.93	0.238E 07	0.00886	6.08	5.33	6.08	5.87	5.89	5.88
6	45.5	27.44	27.40	27.41	27.41	26.36	160.2	5.91	0.239E 07	0.01581	3.76	3.93	3.88	3.86	3.86	3.86
7	75.5	27.95	27.74	27.76	27.80	26.53	160.9	5.88	0.241E 07	0.02625	2.86	3.38	3.32	3.21	3.22	3.21
8	105.5	28.14	28.03	28.08	28.08	26.70	161.6	5.85	0.244E 07	0.03670	2.84	3.06	2.95	2.95	2.95	2.95
9	135.5	28.34	28.28	27.85	28.08	26.87	162.2	5.83	0.246E 07	0.04715	2.76	2.88	4.14	3.36	3.48	3.42
10	165.2	28.30	28.26	28.17	28.22	27.04	162.8	5.81	0.248E 07	0.05750	3.21	3.33	3.61	3.43	3.44	3.43
11	205.2	28.33	28.30	28.08	28.20	27.26	163.5	5.78	0.251E 07	0.07145	3.81	3.92	4.99	4.36	4.43	4.39
12	245.2	28.54	28.66	28.37	28.48	27.49	164.3	5.75	0.253E 07	0.08541	3.90	3.48	4.62	4.09	4.15	4.12
13	275.2	28.72	28.61	28.41	28.54	27.66	164.8	5.73	0.255E 07	0.09588	3.82	4.27	5.43	4.63	4.74	4.68
14	305.2	28.83	28.77	28.59	28.70	27.83	165.4	5.71	0.257E 07	0.10636	4.05	4.33	5.33	4.69	4.76	4.72
15	333.3	28.92	28.94	28.74	28.83	27.99	166.0	5.69	0.259E 07	0.11618	4.36	4.29	5.45	4.82	4.89	4.86
16	363.3	29.12	29.12	28.75	28.94	28.16	166.5	5.66	0.261E 07	0.12668	4.23	4.24	6.87	5.24	5.55	5.39
17	383.3	29.22	29.17	28.81	29.00	28.27	166.9	5.65	0.263E 07	0.13367	4.31	4.56	7.54	5.58	5.99	5.78
18	403.3	29.26	29.12	28.90	29.04	28.39	167.3	5.64	0.264E 07	0.14067	4.68	5.53	7.92	6.18	6.51	6.35
19	423.3	29.06	29.04	28.70	28.88	28.50	167.7	5.62	0.266E 07	0.14768	7.20	7.56	20.15	10.80	13.77	12.28
20	443.3	29.26	29.31	28.84	29.06	28.61	168.1	5.61	0.267E 07	0.15468	6.32	5.81	18.14	9.08	12.10	10.59
21	463.3	28.91	28.97	28.50	28.72	28.73	168.5	5.59	0.268E 07	0.16169	22.23	16.85	*****	*****	1.03	*****
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	29.14	29.12	28.79	28.96	28.32	167.1	5.64	0.263E 07	0.13659	5.18	5.33	11.01	6.95	8.14	7.54

INPUT ELECTRIC POWER = 120.1 W   HEAT RATE GAINED BY WATER = 116.6 W   HEAT BALANCE ERROR = 2.95%
MASS FLOW RATE = 6.7122 G/S   PRESSURE DROP = 0.0865 MM H2O   FRICTION FACTOR = 0.055013   FREM = 12.8868

REM = 234.3   GRM+ = 0.45995E 06   UPSTREAM BULK TEMPERATURE = 22.80 DEG C   DOWNSTREAM BULK TEMPERATURE = 26.97 DEG C
PRM = 6.141   RAM+ = 0.52193E 07   INLET BULK TEMPERATURE = 22.81 DEG C   OUTLET BULK TEMPERATURE = 26.96 DEG C

STA-TION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.30	25.31	25.24	25.27	22.81	223.5	6.47	0.464E 07	0.00001	3.91	3.89	4.00	3.95	3.95	3.95
1	1.5	25.40	25.42	25.36	25.38	22.82	223.5	6.47	0.464E 07	0.00034	3.78	3.75	3.83	3.80	3.80	3.80
2	2.5	25.46	25.49	25.44	25.46	22.83	223.6	6.47	0.464E 07	0.00057	3.69	3.66	3.72	3.70	3.70	3.70
3	5.5	25.67	25.71	25.69	25.69	22.86	223.7	6.46	0.465E 07	0.00125	3.46	3.41	3.43	3.43	3.43	3.43
4	15.5	26.21	26.17	26.14	26.16	22.94	224.2	6.45	0.467E 07	0.00353	2.98	3.02	3.05	3.02	3.02	3.02
5	25.5	26.41	26.50	26.47	26.46	23.03	224.6	6.43	0.470E 07	0.00581	2.88	2.80	2.83	2.84	2.84	2.84
6	45.5	26.94	26.95	26.84	26.89	23.21	225.5	6.41	0.475E 07	0.01036	2.61	2.60	2.68	2.64	2.64	2.64
7	75.5	27.44	27.29	27.31	27.34	23.48	226.8	6.36	0.482E 07	0.01721	2.45	2.55	2.54	2.52	2.52	2.52
8	105.5	27.74	27.69	27.68	27.70	23.74	228.2	6.32	0.489E 07	0.02406	2.43	2.46	2.47	2.45	2.45	2.45
9	135.5	27.95	28.00	27.68	27.83	24.01	229.6	6.28	0.497E 07	0.03092	2.46	2.43	2.64	2.54	2.54	2.54
10	165.2	28.02	27.92	27.83	27.90	24.27	231.0	6.24	0.504E 07	0.03772	2.58	2.65	2.73	2.67	2.67	2.67
11	205.2	27.99	28.02	27.80	27.90	24.63	232.9	6.18	0.514E 07	0.04689	2.88	2.85	3.05	2.96	2.96	2.96
12	245.2	28.25	28.33	28.03	28.16	24.98	234.8	6.13	0.525E 07	0.05609	2.96	2.89	3.18	3.05	3.05	3.05
13	275.2	28.33	28.28	28.13	28.21	25.25	236.2	6.08	0.533E 07	0.06299	3.13	3.19	3.36	3.26	3.26	3.26
14	305.2	28.50	28.49	28.25	28.37	25.51	237.7	6.04	0.540E 07	0.06990	3.24	3.25	3.53	3.38	3.38	3.38
15	333.3	28.64	28.54	28.39	28.49	25.76	239.1	6.00	0.548E 07	0.07639	3.35	3.47	3.67	3.54	3.54	3.54
16	363.3	28.72	28.67	28.41	28.55	26.03	240.6	5.96	0.556E 07	0.08332	3.58	3.66	4.04	3.82	3.83	3.82
17	383.3	28.76	28.72	28.48	28.61	26.20	241.7	5.93	0.561E 07	0.08795	3.77	3.84	4.25	4.02	4.03	4.02
18	403.3	28.80	28.78	28.50	28.65	26.38	242.7	5.90	0.567E 07	0.09259	3.98	4.01	4.55	4.25	4.27	4.26
19	423.3	28.61	28.59	28.31	28.46	26.56	243.7	5.80	0.572E 07	0.09723	4.69	4.75	5.50	5.08	5.11	5.10
20	443.3	28.75	28.92	28.44	28.64	26.74	244.8	5.85	0.578E 07	0.10187	4.79	4.42	5.65	5.07	5.13	5.10
21	463.3	28.63	28.57	28.03	28.32	26.91	245.8	5.82	0.583E 07	0.10651	5.61	5.82	8.59	6.86	7.16	7.01
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	28.72	28.70	28.42	28.57	26.28	242.1	5.92	0.564E 07	0.08989	4.03	4.03	4.61	4.30	4.32	4.31

INPUT ELECTRIC POWER = 120.1 W HEAT RATE GAINED BY WATER = 118.2 W HEAT BALANCE ERROR = 1.65%
MASS FLOW RATE = 4.2586 G/S PRESSURE DROP = 0.0534 MM H2O FRICTION FACTOR = 0.084327 FREM = 13.3455

REM = 158.3 GRM+ = 0.10682E 07 UPSTREAM BULK TEMPERATURE = 24.29 DEG C DOWNSTREAM BULK TEMPERATURE = 31.00 DEG C
PRM = 5.730 RAM+ = 0.61205E 07 INLET BULK TEMPERATURE = 24.32 DEG C OUTLET BULK TEMPERATURE = 30.96 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	26.27	26.29	26.18	26.23	24.33	146.7	6.23	0.513E 07	0.00002	5.05	5.01	5.29	5.16	5.16	5.16
1	1.5	26.52	26.54	26.46	26.49	24.35	146.8	6.23	0.513E 07	0.00054	4.52	4.48	4.65	4.58	4.58	4.58
2	2.5	26.69	26.71	26.65	26.67	24.36	146.8	6.22	0.514E 07	0.00090	4.22	4.18	4.30	4.25	4.25	4.25
3	5.5	27.20	27.23	27.22	27.22	24.40	147.0	6.22	0.515E 07	0.00198	3.51	3.47	3.49	3.49	3.49	3.49
4	15.5	28.31	28.20	28.23	28.24	24.54	147.5	6.19	0.519E 07	0.00558	2.61	2.69	2.67	2.66	2.66	2.66
5	25.5	28.94	28.99	28.72	28.84	24.69	147.9	6.17	0.523E 07	0.00919	2.31	2.28	2.44	2.36	2.36	2.36
6	45.5	29.69	29.65	29.39	29.53	24.97	148.9	6.13	0.532E 07	0.01640	2.08	2.10	2.22	2.15	2.15	2.15
7	75.5	30.38	30.20	29.90	30.09	25.39	150.4	6.06	0.544E 07	0.02725	1.97	2.04	2.18	2.09	2.09	2.09
8	105.5	30.67	30.61	30.31	30.47	25.82	151.9	5.99	0.557E 07	0.03812	2.02	2.05	2.18	2.10	2.11	2.11
9	135.5	30.89	30.83	30.16	30.51	26.24	153.5	5.93	0.570E 07	0.04901	2.11	2.13	2.50	2.29	2.31	2.30
10	165.2	30.94	30.85	30.50	30.70	26.66	155.0	5.86	0.583E 07	0.05982	2.29	2.34	2.55	2.42	2.43	2.43
11	205.2	30.93	30.95	30.44	30.69	27.23	156.9	5.78	0.600E 07	0.07439	2.64	2.63	3.04	2.82	2.84	2.83
12	245.2	31.43	31.46	30.94	31.19	27.80	158.8	5.71	0.616E 07	0.08897	2.68	2.66	3.10	2.87	2.89	2.88
13	275.2	31.48	31.42	31.26	31.35	28.22	160.2	5.66	0.629E 07	0.09992	2.99	3.04	3.21	3.11	3.11	3.11
14	305.2	31.75	31.74	31.20	31.47	28.65	161.6	5.60	0.642E 07	0.11089	3.13	3.14	3.81	3.44	3.48	3.46
15	333.3	31.96	31.98	31.35	31.66	29.04	162.9	5.55	0.654E 07	0.12117	3.34	3.31	4.21	3.72	3.77	3.74
16	363.3	32.24	32.24	31.57	31.90	29.47	164.4	5.50	0.667E 07	0.13217	3.51	3.51	4.63	3.99	4.07	4.03
17	383.3	32.40	32.26	31.56	31.94	29.75	165.4	5.46	0.675E 07	0.13952	3.67	3.87	5.37	4.43	4.57	4.50
18	403.3	32.42	32.32	31.68	32.03	30.04	166.4	5.43	0.684E 07	0.14687	4.07	4.25	5.89	4.88	5.03	4.95
19	423.3	32.27	32.29	31.56	31.92	30.32	167.4	5.39	0.693E 07	0.15423	4.96	4.93	7.84	6.06	6.39	6.23
20	443.3	32.59	32.82	31.95	32.33	30.60	168.4	5.36	0.702E 07	0.16159	4.89	4.36	7.18	5.61	5.90	5.76
21	463.3	32.11	32.17	31.27	31.70	30.89	169.5	5.32	0.711E 07	0.16897	7.90	7.52	25.35	11.82	16.53	14.17
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	32.31	32.32	31.61	31.96	29.87	165.8	5.45	0.679E 07	0.14259	4.07	4.04	5.85	4.78	4.95	4.87

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INPUT ELECTRIC POWER = 170.8 W HEAT RATE GAINED BY WATER = 167.9 W HEAT BALANCE ERROR = 1.70%
MASS FLOW RATE = 7.5233 G/S PRESSURE DROP = 0.0954 MM H2O FRICTION FACTOR = 0.048229 FREM = 13.3473

REM = 276.7 GRM+ = 0.14663E 07 UPSTREAM BULK TEMPERATURE = 24.45 DEG C DOWNSTREAM BULK TEMPERATURE = 29.83 DEG C
PRM = 5.793 RAM+ = 0.84943E 07 INLET BULK TEMPERATURE = 24.47 DEG C OUTLET BULK TEMPERATURE = 29.81 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.95	25.98	25.94	25.95	24.47	260.1	6.21	0.735E 07	0.00001	9.49	9.25	9.55	9.46	9.46	9.46
1	1.5	26.17	26.23	26.18	26.19	24.49	260.2	6.20	0.735E 07	0.00031	8.29	8.05	8.27	8.22	8.22	8.22
2	2.5	26.33	26.39	26.35	26.35	24.50	260.2	6.20	0.736E 07	0.00051	7.63	7.38	7.57	7.54	7.54	7.54
3	5.5	26.80	26.90	26.85	26.85	24.54	260.5	6.20	0.737E 07	0.00112	6.16	5.92	6.04	6.04	6.04	6.04
4	15.5	27.80	27.75	27.78	27.78	24.65	261.1	6.18	0.742E 07	0.00316	4.43	4.51	4.46	4.46	4.46	4.46
5	25.5	28.44	28.48	28.32	28.39	24.76	261.8	6.16	0.747E 07	0.00520	3.80	3.75	3.92	3.84	3.85	3.85
6	45.5	29.13	29.14	28.94	29.04	24.99	263.2	6.12	0.756E 07	0.00929	3.37	3.36	3.53	3.45	3.45	3.45
7	75.5	29.87	29.70	29.56	29.67	25.33	265.3	6.07	0.771E 07	0.01542	3.07	3.19	3.30	3.21	3.21	3.21
8	105.5	30.27	30.21	30.08	30.16	25.67	267.5	6.02	0.786E 07	0.02157	3.03	3.07	3.16	3.10	3.10	3.10
9	135.5	30.55	30.55	29.99	30.27	26.02	269.6	5.96	0.800E 07	0.02773	3.07	3.07	3.50	3.27	3.29	3.28
10	165.2	30.72	30.68	30.33	30.51	26.35	271.8	5.91	0.815E 07	0.03383	3.19	3.21	3.50	3.34	3.35	3.35
11	205.2	30.81	30.72	30.27	30.52	26.81	274.9	5.84	0.836E 07	0.04208	3.47	3.55	4.01	3.74	3.76	3.75
12	245.2	31.09	31.12	30.66	30.88	27.27	277.4	5.78	0.854E 07	0.05032	3.63	3.60	4.09	3.84	3.85	3.84
13	275.2	31.20	31.08	30.63	30.89	27.61	279.4	5.73	0.868E 07	0.05651	3.86	3.99	4.59	4.23	4.26	4.24
14	305.2	31.36	31.35	30.86	31.11	27.95	281.3	5.69	0.882E 07	0.06270	4.06	4.07	4.76	4.39	4.42	4.40
15	333.3	31.56	31.53	31.01	31.28	28.27	283.2	5.65	0.896E 07	0.06851	4.20	4.25	5.05	4.60	4.64	4.62
16	363.3	31.78	31.84	31.17	31.49	28.61	285.2	5.61	0.910E 07	0.07471	4.36	4.28	5.40	4.80	4.86	4.83
17	383.3	31.89	31.75	31.17	31.49	28.84	286.6	5.58	0.920E 07	0.07885	4.54	4.74	5.94	5.21	5.29	5.25
18	403.3	31.97	31.87	31.28	31.60	29.07	288.0	5.55	0.930E 07	0.08300	4.77	4.93	6.23	5.45	5.54	5.50
19	423.3	31.77	31.78	31.22	31.50	29.30	289.4	5.52	0.940E 07	0.08715	5.59	5.55	7.17	6.27	6.37	6.32
20	443.3	32.08	32.32	31.44	31.82	29.52	290.8	5.49	0.950E 07	0.09130	5.40	4.94	7.19	6.01	6.18	6.10
21	463.3	31.72	31.71	30.86	31.29	29.75	292.2	5.46	0.960E 07	0.09546	7.01	7.02	12.40	8.96	9.71	9.34
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	31.84	31.85	31.22	31.53	28.93	287.2	5.57	0.924E 07	0.08059	4.81	4.78	6.16	5.39	5.48	5.44

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INPUT ELECTRIC POWER = 230.1 W
MASS FLOW RATE = 3.3132 G/S

HEAT RATE GAINED BY WATER = 217.7 W
PRESSURE DROP = 0.0364 MM H2O

HEAT BALANCE ERROR = 5.38%
FRICTION FACTOR = 0.094576
FREM = 13.4773

REM = 142.5
PRM = 4.870

GRM+ = 0.31317E 07
RAM+ = 0.15253E 08

UPSTREAM BULK TEMPERATURE = 26.69 DEG C
INLET BULK TEMPERATURE = 26.83 DEG C

DOWNSTREAM BULK TEMPERATURE = 42.67 DEG C
OUTLET BULK TEMPERATURE = 42.55 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	31.23	31.29	31.01	31.13	26.83	121.1	5.83	0.108E 08	0.00002	4.09	4.04	4.31	4.18	4.19	4.19
1	1.5	31.95	32.03	31.80	31.90	26.88	121.2	5.83	0.109E 08	0.00070	3.55	3.50	3.66	3.59	3.59	3.59
2	2.5	32.45	32.54	32.35	32.42	26.91	121.3	5.82	0.109E 08	0.00116	3.25	3.20	3.31	3.27	3.27	3.27
3	5.5	33.93	34.07	34.00	34.00	27.01	121.6	5.81	0.109E 08	0.00256	2.60	2.55	2.58	2.58	2.58	2.58
4	15.5	36.43	36.21	36.04	36.18	27.35	122.4	5.77	0.111E 08	0.00722	1.98	2.03	2.07	2.04	2.04	2.04
5	25.5	37.90	38.00	37.16	37.56	27.68	123.2	5.72	0.113E 08	0.01189	1.76	1.74	1.90	1.82	1.82	1.82
6	45.5	39.31	39.07	38.21	38.70	28.36	124.9	5.64	0.117E 08	0.02124	1.64	1.67	1.82	1.73	1.74	1.74
7	75.5	40.37	40.02	38.96	39.58	29.36	127.6	5.51	0.122E 08	0.03530	1.63	1.68	1.86	1.75	1.76	1.75
8	105.5	40.95	40.74	39.81	40.33	30.37	130.4	5.39	0.128E 08	0.04941	1.69	1.72	1.89	1.79	1.80	1.80
9	135.5	41.35	41.13	39.50	40.37	31.37	133.3	5.26	0.134E 08	0.06357	1.79	1.81	2.19	1.98	2.00	1.99
10	165.2	41.65	41.36	40.21	40.86	32.37	136.1	5.14	0.140E 08	0.07770	1.92	1.98	2.27	2.09	2.11	2.10
11	205.2	41.81	41.63	39.99	40.86	33.71	139.7	4.98	0.147E 08	0.09693	2.19	2.24	2.82	2.48	2.52	2.50
12	245.2	42.67	42.52	41.24	41.92	35.05	143.6	4.83	0.155E 08	0.11636	2.32	2.36	2.86	2.57	2.60	2.58
13	275.2	42.77	42.49	41.10	41.87	36.06	146.6	4.71	0.161E 08	0.13107	2.62	2.74	3.49	3.03	3.09	3.06
14	305.2	43.43	43.35	41.95	42.67	37.07	149.6	4.60	0.167E 08	0.14584	2.76	2.79	3.59	3.13	3.19	3.16
15	333.3	43.64	43.76	41.77	42.73	38.01	152.3	4.51	0.172E 08	0.15950	3.12	3.05	4.66	3.71	3.87	3.79
16	363.3	44.35	44.42	42.20	43.29	39.02	155.2	4.42	0.178E 08	0.17413	3.28	3.24	5.49	4.09	4.38	4.23
17	383.3	44.78	44.48	42.55	43.59	39.69	157.3	4.36	0.183E 08	0.18392	3.43	3.65	6.10	4.48	4.82	4.65
18	403.3	45.07	44.72	42.75	43.82	40.36	159.3	4.30	0.187E 08	0.19374	3.70	4.00	7.29	5.04	5.57	5.30
19	423.3	44.88	44.50	42.69	43.69	41.03	161.5	4.24	0.191E 08	0.20358	4.53	5.02	10.48	6.55	7.63	7.09
20	443.3	45.62	45.91	43.56	44.66	41.70	163.7	4.17	0.196E 08	0.21346	4.44	4.13	9.36	5.88	6.82	6.35
21	463.3	44.41	44.64	42.12	43.33	42.37	165.6	4.12	0.200E 08	0.22334	8.51	7.64	*****	18.18	*****	-6.62
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	44.72	44.63	42.59	43.63	39.97	158.2	4.33	0.185E 08	0.18805	3.75	3.85	7.23	4.96	5.51	5.24

INPUT ELECTRIC POWER = 245.8 W HEAT RATE GAINED BY WATER = 231.9 W HEAT BALANCE ERROR = 5.66%
MASS FLOW RATE = 6.0483 G/S PRESSURE DROP = 0.0678 MM H2O FRICTION FACTOR = 0.052880 FREM = 13.9042

REM = 262.9 GRM+ = 0.34455E 07 UPSTREAM BULK TEMPERATURE = 30.56 DEG C DOWNSTREAM BULK TEMPERATURE = 39.86 DEG C
PRM = 4.810 RAM+ = 0.16572E 08 INLET BULK TEMPERATURE = 30.63 DEG C OUTLET BULK TEMPERATURE = 39.80 DEG C

STATION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	29.82	29.87	29.65	29.75	30.63	239.4	5.35	0.138E 08	0.00001	*****	*****	*****	*****	*****	*****
1	1.5	30.50	30.58	30.40	30.47	30.65	239.5	5.35	0.138E 08	0.00039	*****	*****	*****	*****	*****	*****
2	2.5	30.98	31.07	30.92	30.97	30.67	239.6	5.35	0.138E 08	0.00064	62.36	47.71	77.21	63.59	66.12	64.86
3	5.5	32.40	32.54	32.47	32.47	30.73	239.9	5.34	0.139E 08	0.00141	11.39	10.51	10.93	10.93	10.94	10.94
4	15.5	34.84	34.63	34.51	34.62	30.93	240.9	5.32	0.140E 08	0.00398	4.86	5.14	5.31	5.14	5.15	5.15
5	25.5	36.32	36.47	35.76	36.08	31.12	242.0	5.29	0.141E 08	0.00655	3.65	3.55	4.10	3.84	3.85	3.84
6	45.5	37.91	37.72	36.86	37.33	31.52	244.1	5.24	0.144E 08	0.01170	2.97	3.06	3.55	3.26	3.28	3.27
7	75.5	39.13	38.84	37.89	38.44	32.10	247.1	5.17	0.147E 08	0.01944	2.70	2.81	3.27	2.99	3.01	3.00
8	105.5	39.83	39.56	38.72	39.21	32.69	250.0	5.10	0.151E 08	0.02721	2.65	2.75	3.14	2.90	2.92	2.91
9	135.5	40.16	40.00	38.43	39.25	33.28	252.9	5.03	0.154E 08	0.03501	2.74	2.81	3.67	3.16	3.22	3.19
10	165.2	40.47	40.18	39.25	39.79	33.86	255.8	4.97	0.157E 08	0.04277	2.85	2.98	3.50	3.18	3.21	3.20
11	205.2	40.68	40.40	38.98	39.76	34.64	259.9	4.88	0.162E 08	0.05327	3.12	3.27	4.34	3.68	3.77	3.72
12	245.2	41.31	41.18	40.09	40.67	35.43	264.1	4.79	0.167E 08	0.06383	3.19	3.26	4.03	3.58	3.63	3.61
13	275.2	41.42	41.20	39.85	40.58	36.01	267.3	4.72	0.171E 08	0.07179	3.47	3.62	4.89	4.11	4.22	4.16
14	305.2	42.03	41.95	40.59	41.29	36.60	270.7	4.65	0.174E 08	0.07979	3.45	3.50	4.69	3.99	4.08	4.04
15	333.3	42.34	42.41	40.57	41.48	37.15	273.6	4.59	0.178E 08	0.08725	3.60	3.56	5.47	4.33	4.52	4.42
16	363.3	42.99	43.00	40.91	41.95	37.74	276.6	4.54	0.182E 08	0.09519	3.56	3.55	5.90	4.43	4.72	4.58
17	383.3	43.08	42.73	40.92	41.91	38.13	278.7	4.50	0.184E 08	0.10050	3.77	4.06	6.68	4.93	5.30	5.12
18	403.3	43.32	42.92	41.10	42.11	38.52	280.7	4.47	0.187E 08	0.10581	3.89	4.24	7.22	5.19	5.64	5.42
19	423.3	43.07	42.59	40.90	41.87	38.91	282.8	4.43	0.189E 08	0.11112	4.48	5.06	9.37	6.31	7.07	6.69
20	443.3	43.82	43.98	41.63	42.77	39.30	285.0	4.39	0.192E 08	0.11645	4.13	3.98	8.00	5.38	6.03	5.70
21	463.3	42.56	42.76	40.33	41.50	39.70	287.1	4.36	0.195E 08	0.12178	6.50	6.08	29.14	10.34	17.72	14.03
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	43.10	42.94	41.01	42.02	38.29	279.6	4.49	0.185E 08	0.10272	3.90	4.07	7.11	5.10	5.55	5.32

******************** 7 ********************

INPUT ELECTRIC POWER = 87.3 W HEAT RATE GAINED BY WATER = 82.8 W HEAT BALANCE ERROR = 5.12%
MASS FLOW RATE = 2.8863 G/S PRESSURE DROP = 0.0261 MM H2O FRICTION FACTOR = 0.089177 FREM = 12.6624

REM = 142.0 GRM+ = 0.17654E 07 UPSTREAM BULK TEMPERATURE = 38.04 DEG C DOWNSTREAM BULK TEMPERATURE = 44.94 DEG C
PRM = 4.193 RAM+ = 0.74020E 07 INLET BULK TEMPERATURE = 38.06 DEG C OUTLET BULK TEMPERATURE = 44.93 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	AVERAGE H	AVERAGE T+H
0	0.0	41.04	41.11	41.09	41.08	38.06	132.8	4.51	0.656E 07	0.00003	2.24	2.19	2.21	2.21	2.21	2.21
1	1.5	41.13	41.23	41.19	41.19	38.08	132.9	4.51	0.657E 07	0.00082	2.19	2.12	2.15	2.15	2.15	2.15
2	2.5	41.20	41.32	41.26	41.26	38.10	132.9	4.51	0.657E 07	0.00137	2.15	2.07	2.11	2.11	2.11	2.11
3	5.5	41.39	41.58	41.48	41.48	38.14	133.0	4.50	0.658E 07	0.00302	2.05	1.94	1.99	1.99	2.00	2.00
4	15.5	41.83	41.96	41.92	41.91	38.29	133.4	4.49	0.661E 07	0.00852	1.88	1.82	1.83	1.84	1.84	1.84
5	25.5	42.12	42.20	42.12	42.14	38.44	133.8	4.47	0.665E 07	0.01402	1.81	1.77	1.81	1.80	1.80	1.80
6	45.5	42.63	42.56	42.29	42.44	38.73	134.5	4.45	0.672E 07	0.02502	1.70	1.74	1.87	1.79	1.80	1.79
7	75.5	42.86	42.66	42.74	42.75	39.17	135.6	4.41	0.682E 07	0.04155	1.80	1.91	1.86	1.86	1.86	1.86
8	105.5	43.09	43.04	43.01	43.04	39.61	136.8	4.37	0.693E 07	0.05810	1.91	1.94	1.95	1.94	1.94	1.94
9	135.5	43.10	43.39	42.93	43.09	40.05	138.0	4.33	0.704E 07	0.07468	2.17	1.99	2.30	2.18	2.19	2.19
10	165.2	43.39	43.22	42.99	43.15	40.48	139.2	4.29	0.714E 07	0.09112	2.28	2.42	2.64	2.49	2.50	2.49
11	205.2	43.33	43.49	43.36	43.39	41.07	140.8	4.23	0.729E 07	0.11329	2.93	2.74	2.88	2.86	2.86	2.86
12	245.2	43.86	43.87	43.75	43.81	41.65	142.4	4.18	0.744E 07	0.13552	2.99	2.99	3.15	3.07	3.07	3.07
13	275.2	43.84	43.56	43.94	43.82	42.09	143.6	4.14	0.755E 07	0.15222	3.78	4.51	3.57	3.82	3.86	3.84
14	305.2	44.44	44.47	44.27	44.37	42.53	144.7	4.11	0.765E 07	0.16893	3.46	3.40	3.79	3.60	3.61	3.61
15	333.3	44.70	44.67	44.50	44.59	42.94	145.7	4.07	0.775E 07	0.18462	3.75	3.83	4.24	4.00	4.02	4.01
16	363.3	44.92	44.87	44.68	44.79	43.38	146.9	4.04	0.786E 07	0.20138	4.30	4.42	5.09	4.70	4.72	4.71
17	383.3	45.41	45.04	44.85	45.04	43.67	147.6	4.02	0.793E 07	0.21258	3.80	4.83	5.61	4.84	4.96	4.90
18	403.3	45.24	45.11	45.02	45.10	43.97	148.4	3.99	0.800E 07	0.22379	5.17	5.76	6.25	5.82	5.86	5.84
19	423.3	45.33	45.34	45.15	45.24	44.26	149.2	3.97	0.807E 07	0.23501	6.18	6.11	7.37	6.70	6.75	6.73
20	443.3	45.23	45.46	45.26	45.30	44.55	150.0	3.95	0.815E 07	0.24624	9.78	7.28	9.35	8.82	8.94	8.88
21	463.3	45.14	45.27	44.32	44.76	44.85	150.7	3.93	0.822E 07	0.25748	22.14	15.37	*****	*****	3.12	*****
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	45.14	45.08	44.91	45.01	43.80	148.0	4.01	0.796E 07	0.21727	5.50	5.37	6.32	5.81	5.88	5.84

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INPUT ELECTRIC POWER = 200.5 W
MASS FLOW RATE = 6.5169 G/S

HEAT RATE GAINED BY WATER = 190.5 W
PRESSURE DROP = 0.0753 MM H2O

HEAT BALANCE ERROR = 4.97%
FRICTION FACTOR = 0.050649
FREM = 13.3438

REM = 263.5
PRM = 5.232

GRM+ = 0.22639E 07
RAM+ = 0.11845E 08

UPSTREAM BULK TEMPERATURE = 28.06 DEG C
INLET BULK TEMPERATURE = 28.10 DEG C

DOWNSTREAM BULK TEMPERATURE = 35.13 DEG C
OUTLET BULK TEMPERATURE = 35.09 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	28.16	28.17	28.04	28.10	28.10	244.4	5.67	0.101E 08	0.00001	*****	*****	*****	*****	*****	*****
1	1.5	28.58	28.60	28.50	28.54	28.12	244.6	5.67	0.101E 08	0.00036	34.02	32.76	41.55	37.02	37.47	37.24
2	2.5	28.87	28.89	28.81	28.85	28.13	244.6	5.67	0.101E 08	0.00059	21.30	20.70	23.14	22.01	22.07	22.04
3	5.5	29.74	29.77	29.76	29.76	28.18	244.9	5.66	0.101E 08	0.00130	10.03	9.83	9.93	9.93	9.93	9.93
4	15.5	31.32	31.24	31.17	31.23	28.33	245.6	5.64	0.102E 08	0.00368	5.24	5.38	5.52	5.41	5.42	5.42
5	25.5	32.38	32.45	31.98	32.20	28.48	246.4	5.63	0.103E 08	0.00605	4.02	3.95	4.48	4.22	4.23	4.22
6	45.5	33.46	33.37	32.90	33.16	28.77	247.9	5.59	0.104E 08	0.01080	3.35	3.41	3.81	3.58	3.59	3.59
7	75.5	34.45	34.19	33.73	34.02	29.22	250.3	5.53	0.106E 08	0.01794	3.00	3.16	3.48	3.27	3.28	3.27
8	105.5	34.88	34.75	34.43	34.62	29.67	252.6	5.47	0.108E 08	0.02509	3.00	3.08	3.29	3.16	3.17	3.16
9	135.5	35.19	35.13	34.10	34.63	30.12	255.1	5.42	0.111E 08	0.03225	3.09	3.12	3.93	3.47	3.52	3.49
10	165.2	35.37	35.23	34.64	34.97	30.56	257.5	5.36	0.113E 08	0.03935	3.25	3.34	3.83	3.54	3.56	3.55
11	205.2	35.44	35.39	34.54	34.98	31.16	260.9	5.29	0.116E 08	0.04893	3.65	3.69	4.61	4.09	4.14	4.11
12	245.2	36.03	36.04	35.35	35.69	31.76	264.4	5.21	0.119E 08	0.05853	3.65	3.64	4.34	3.96	3.99	3.97
13	275.2	36.09	35.92	35.18	35.59	32.20	266.8	5.16	0.121E 08	0.06577	4.01	4.19	5.23	4.59	4.66	4.63
14	305.2	36.47	36.45	35.61	36.04	32.65	269.1	5.11	0.124E 08	0.07305	4.07	4.09	5.25	4.59	4.66	4.63
15	333.3	36.67	36.77	35.79	36.26	33.07	271.3	5.06	0.126E 08	0.07988	4.31	4.19	5.70	4.87	4.98	4.93
16	363.3	37.10	37.17	35.96	36.55	33.52	273.8	5.01	0.128E 08	0.08720	4.33	4.25	6.37	5.12	5.33	5.23
17	383.3	37.23	37.05	35.88	36.51	33.82	275.4	4.97	0.129E 08	0.09209	4.55	4.80	7.52	5.76	6.10	5.93
18	403.3	37.39	37.09	36.05	36.65	34.12	277.0	4.94	0.131E 08	0.09699	4.73	5.21	7.99	6.12	6.48	6.30
19	423.3	37.17	36.94	35.87	36.46	34.41	278.7	4.90	0.132E 08	0.10190	5.62	6.14	10.66	7.57	8.27	7.92
20	443.3	37.61	37.81	36.37	37.04	34.71	280.4	4.87	0.134E 08	0.10683	5.34	4.99	9.34	6.65	7.25	6.95
21	463.3	36.83	36.98	35.54	36.22	35.01	282.1	4.83	0.135E 08	0.11176	8.50	7.86	29.15	12.75	18.66	15.71
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	37.19	37.14	35.99	36.58	33.94	276.1	4.96	0.130E 08	0.09415	4.81	4.93	7.93	6.02	6.40	6.21

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INPUT ELECTRIC POWER = 200.3 W
HEAT RATE GAINED BY WATER = 81.5 W
HEAT BALANCE ERROR - 59.30%

MASS FLOW RATE = 4.6790 G/S
PRESSURE DROP = 0.0575 MM H2O
FRICTION FACTOR = 0.075259
FREM - 12.7444

REM = 169.3
GRM+ = 0.67382E 06
UPSTREAM BULK TEMPERATURE = 24.32 DEG C
DOWNSTREAM BULK TEMPERATURE = 28.52 DEG C

PRM = 5.898
RAM+ = 0.39739E 07
INLET BULK TEMPERATURE = 24.34 DEG C
OUTLET BULK TEMPERATURE = 28.51 DEG C

STA-TION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	26.34	26.33	26.31	26.32	24.34	161.2	6.23	0.354E 07	0.00002	3.38	3.40	3.44	3.41	3.41	3.41
1	1.5	26.43	26.42	26.41	26.42	24.35	161.3	6.22	0.354E 07	0.00049	3.25	3.27	3.29	3.28	3.28	3.28
2	2.5	26.50	26.49	26.48	26.48	24.36	161.3	6.22	0.355E 07	0.00082	3.17	3.19	3.20	3.19	3.19	3.19
3	5.5	26.69	26.67	26.68	26.68	24.39	161.4	6.22	0.355E 07	0.00180	2.94	2.97	2.96	2.96	2.96	2.96
4	15.5	27.23	27.13	27.15	27.17	24.47	161.8	6.21	0.357E 07	0.00508	2.46	2.56	2.53	2.52	2.52	2.52
5	25.5	27.54	27.58	27.42	27.49	24.56	162.1	6.19	0.359E 07	0.00836	2.28	2.25	2.37	2.32	2.32	2.32
6	45.5	27.89	28.52	27.80	28.01	24.74	162.8	6.16	0.362E 07	0.01492	2.15	1.79	2.21	2.08	2.09	2.08
7	75.5	28.29	28.13	28.21	28.21	25.01	163.8	6.12	0.368E 07	0.02478	2.06	2.17	2.12	2.12	2.12	2.12
8	105.5	28.53	28.48	28.54	28.52	25.28	164.8	6.08	0.373E 07	0.03464	2.08	2.11	2.08	2.09	2.09	2.09
9	135.5	28.68	28.68	28.30	28.49	25.54	165.8	6.04	0.379E 07	0.04453	2.15	2.16	2.45	2.29	2.30	2.30
10	165.2	28.70	28.60	28.51	28.58	25.81	166.9	5.99	0.384E 07	0.05432	2.34	2.42	2.50	2.44	2.44	2.44
11	205.2	28.61	28.70	28.42	28.54	26.16	168.3	5.94	0.392E 07	0.06754	2.76	2.67	2.99	2.84	2.85	2.85
12	245.2	28.88	29.00	28.71	28.83	26.52	169.7	5.88	0.399E 07	0.08078	2.86	2.72	3.07	2.92	2.93	2.93
13	275.2	28.95	28.95	28.75	28.85	26.78	170.8	5.84	0.405E 07	0.09073	3.12	3.12	3.43	3.26	3.27	3.27
14	305.2	29.06	29.00	28.82	28.92	27.05	171.8	5.80	0.411E 07	0.10067	3.36	3.47	3.81	3.60	3.61	3.61
15	333.3	29.15	29.22	28.96	29.07	27.30	172.7	5.77	0.416E 07	0.10998	3.65	3.51	4.05	3.80	3.82	3.81
16	363.3	29.35	29.29	29.09	29.20	27.57	173.6	5.74	0.421E 07	0.11993	3.78	3.91	4.42	4.12	4.14	4.13
17	383.3	29.44	29.33	29.09	29.24	27.75	174.2	5.72	0.424E 07	0.12657	3.96	4.24	5.00	4.50	4.55	4.53
18	403.3	29.43	29.40	29.18	29.30	27.92	174.9	5.69	0.428E 07	0.13321	4.48	4.55	5.34	4.89	4.93	4.91
19	423.3	29.35	29.37	29.09	29.23	28.10	175.5	5.67	0.432E 07	0.13985	5.41	5.29	6.78	5.98	6.06	6.02
20	443.3	29.48	29.65	29.18	29.37	28.28	176.2	5.65	0.435E 07	0.14650	5.59	4.90	7.49	6.15	6.36	6.26
21	463.3	29.30	29.31	28.84	29.07	28.46	176.8	5.63	0.439E 07	0.15316	7.94	7.87	17.48	10.89	12.69	11.79
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	29.37	29.38	29.10	29.24	27.82	174.5	5.71	0.426E 07	0.12934	4.48	4.40	5.51	4.91	4.98	4.94

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INPUT ELECTRIC POWER = 108.0 W   HEAT RATE GAINED BY WATER = 101.7 W   HEAT BALANCE ERROR = 5.85%
MASS FLOW RATE = 7.9505 G/S   PRESSURE DROP = 0.1002 MM H2O   FRICTION FACTOR = 0.045401   FREH = 12.8585

REM = 283.2   GRM+ = 0.79659E 06   UPSTREAM BULK TEMPERATURE = 24.22 DEG C   DOWNSTREAM BULK TEMPERATURE = 27.30 DEG C
PRM = 6.002   RAM+ = 0.47814E 07   INLET BULK TEMPERATURE = 24.23 DEG C   OUTLET BULK TEMPERATURE = 27.29 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	25.79	25.78	25.73	25.76	24.23	273.3	6.24	0.439E 07	0.00001	5.42	5.44	5.66	5.54	5.54	5.54
1	1.5	25.86	25.85	25.81	25.84	24.24	273.4	6.24	0.439E 07	0.00029	5.21	5.24	5.37	5.30	5.30	5.30
2	2.5	25.91	25.90	25.87	25.89	24.25	273.4	6.24	0.439E 07	0.00048	5.07	5.11	5.19	5.14	5.14	5.14
3	5.5	26.07	26.05	26.06	26.06	24.26	273.5	6.24	0.440E 07	0.00106	4.70	4.74	4.72	4.72	4.72	4.72
4	15.5	26.55	26.51	26.53	26.53	24.33	273.9	6.23	0.442E 07	0.00299	3.81	3.89	3.84	3.84	3.85	3.84
5	25.5	26.75	26.78	26.69	26.73	24.40	274.4	6.22	0.443E 07	0.00492	3.60	3.54	3.68	3.63	3.63	3.63
6	45.5	27.05	27.06	27.01	27.03	24.53	275.2	6.20	0.446E 07	0.00878	3.35	3.34	3.40	3.37	3.37	3.37
7	75.5	27.50	27.34	27.36	27.39	24.72	276.4	6.17	0.451E 07	0.01457	3.04	3.22	3.20	3.17	3.17	3.17
8	105.5	27.69	27.64	27.68	27.67	24.92	277.7	6.14	0.456E 07	0.02037	3.05	3.11	3.06	3.07	3.07	3.07
9	135.5	27.89	27.89	27.51	27.70	25.11	279.0	6.10	0.461E 07	0.02618	3.04	3.05	3.52	3.26	3.28	3.27
10	165.2	27.86	27.81	27.71	27.77	25.31	280.2	6.07	0.466E 07	0.03193	3.31	3.37	3.51	3.42	3.43	3.43
11	205.2	27.88	27.91	27.63	27.76	25.57	282.0	6.03	0.473E 07	0.03969	3.65	3.61	4.09	3.85	3.86	3.85
12	245.2	28.19	28.27	28.03	28.13	25.83	283.7	5.99	0.480E 07	0.04745	3.57	3.46	3.84	3.67	3.67	3.67
13	275.2	28.22	28.16	28.13	28.16	26.03	285.0	5.96	0.485E 07	0.05329	3.84	3.94	4.01	3.95	3.95	3.95
14	305.2	28.33	28.27	28.14	28.22	26.22	286.4	5.93	0.490E 07	0.05913	4.00	4.12	4.39	4.22	4.22	4.22
15	333.3	28.42	28.43	28.28	28.35	26.41	287.6	5.90	0.495E 07	0.06460	4.18	4.16	4.49	4.33	4.33	4.33
16	363.3	28.61	28.55	28.30	28.44	26.60	289.0	5.87	0.501E 07	0.07046	4.19	4.31	4.95	4.57	4.60	4.59
17	383.3	28.65	28.60	28.31	28.47	26.73	289.9	5.85	0.504E 07	0.07436	4.39	4.50	5.34	4.85	4.89	4.87
18	403.3	28.58	28.56	28.45	28.51	26.86	290.8	5.83	0.508E 07	0.07827	4.90	4.95	5.31	5.11	5.12	5.12
19	423.3	28.50	28.53	28.31	28.41	26.99	291.6	5.81	0.511E 07	0.08217	5.57	5.46	6.38	5.92	5.95	5.93
20	443.3	28.69	28.86	28.39	28.58	27.12	292.3	5.80	0.514E 07	0.08607	5.36	4.84	6.66	5.77	5.88	5.83
21	463.3	28.52	28.51	28.21	28.36	27.25	293.1	5.78	0.517E 07	0.08997	6.65	6.69	8.82	7.60	7.75	7.67
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	28.57	28.59	28.34	28.46	26.79	290.2	5.84	0.505E 07	0.07599	4.77	4.70	5.52	5.09	5.13	5.11

INPUT ELECTRIC POWER = 118.6 W
MASS FLOW RATE = 3.5871 G/S

HEAT RATE GAINED BY WATER = 110.3 W
PRESSURE DROP = 0.0390 MM H2O

HEAT BALANCE ERROR - 6.98%
FRICTION FACTOR - 0.086581
FREM - 12.7291

REM = 147.0
PRM = 5.152

GRM+ = 0.13682E 07
RAM+ = 0.70485E 07

UPSTREAM BULK TEMPERATURE = 28.53 DEG C
INLET BULK TEMPERATURE = 28.59 DEG C

DOWNSTREAM BULK TEMPERATURE = 36.00 DEG C
OUTLET BULK TEMPERATURE - 35.95 DEG C

STATION NO.	Z CM	WALL TEMPERATURE (DEG C) A	B	C	AVERAGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	29.25	29.26	29.13	29.20	28.59	135.9	5.61	0.597E 07	0.00002	13.69	13.44	16.60	14.93	15.08	15.01
1	1.5	29.59	29.61	29.51	29.56	28.61	136.0	5.61	0.598E 07	0.00065	9.25	9.09	10.08	9.60	9.62	9.61
2	2.5	29.83	29.85	29.77	29.80	28.63	136.0	5.61	0.598E 07	0.00108	7.55	7.43	7.93	7.71	7.71	7.71
3	5.5	30.53	30.57	30.55	30.55	28.67	136.2	5.60	0.600E 07	0.00237	4.88	4.80	4.84	4.84	4.84	4.84
4	15.5	31.89	31.75	31.79	31.81	28.83	136.6	5.58	0.604E 07	0.00669	2.97	3.11	3.06	3.05	3.05	3.05
5	25.5	32.77	32.79	32.49	32.64	28.99	137.1	5.56	0.608E 07	0.01101	2.40	2.39	2.59	2.49	2.49	2.49
6	45.5	33.69	33.66	33.35	33.51	29.30	138.0	5.52	0.617E 07	0.01965	2.07	2.08	2.24	2.15	2.16	2.16
7	75.5	34.61	34.36	34.06	34.27	29.77	139.4	5.46	0.631E 07	0.03263	1.87	1.98	2.11	2.01	2.02	2.01
8	105.5	34.99	34.92	34.66	34.81	30.24	140.8	5.40	0.645E 07	0.04563	1.90	1.94	2.05	1.98	1.98	1.98
9	135.5	35.36	35.24	34.38	34.84	30.71	142.2	5.34	0.659E 07	0.05865	1.95	2.00	2.47	2.19	2.22	2.21
10	165.2	35.48	35.40	34.93	35.18	31.18	143.7	5.28	0.673E 07	0.07157	2.10	2.14	2.41	2.25	2.26	2.26
11	205.2	35.66	35.50	34.77	35.17	31.81	145.7	5.21	0.692E 07	0.08900	2.34	2.44	3.05	2.68	2.72	2.70
12	245.2	35.97	35.93	35.40	35.68	32.44	147.5	5.13	0.709E 07	0.10655	2.55	2.58	3.03	2.78	2.80	2.79
13	275.2	36.03	35.86	35.30	35.62	32.91	148.9	5.08	0.722E 07	0.11976	2.88	3.04	3.76	3.31	3.36	3.34
14	305.2	36.30	36.23	35.73	36.00	33.38	150.3	5.02	0.735E 07	0.13302	3.07	3.15	3.82	3.43	3.47	3.45
15	333.3	36.50	36.55	35.85	36.19	33.82	151.6	4.97	0.748E 07	0.14548	3.34	3.29	4.42	3.79	3.87	3.83
16	363.3	36.88	36.88	35.96	36.42	34.29	153.0	4.92	0.761E 07	0.15882	3.46	3.45	5.38	4.21	4.42	4.31
17	383.3	37.06	36.88	35.93	36.45	34.60	154.0	4.88	0.770E 07	0.16775	3.65	3.94	6.73	4.85	5.26	5.05
18	403.3	37.11	36.98	36.11	36.58	34.92	155.0	4.84	0.779E 07	0.17669	4.09	4.35	7.51	5.40	5.86	5.63
19	423.3	36.94	36.77	35.87	36.36	35.23	156.0	4.81	0.789E 07	0.18566	5.23	5.82	14.10	7.92	9.81	8.87
20	443.3	37.33	37.53	36.37	36.90	35.55	157.0	4.77	0.798E 07	0.19465	5.02	4.51	10.86	6.61	7.81	7.21
21	463.3	36.61	36.81	35.54	36.12	35.86	158.0	4.73	0.807E 07	0.20366	11.97	9.42	*****	33.79	8.68	12.55
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	36.97	36.93	36.01	36.48	34.73	154.4	4.87	0.774E 07	0.17151	4.13	4.23	8.17	5.46	6.17	5.82

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INPUT ELECTRIC POWER = 130.6 W HEAT RATE GAINED BY WATER = 129.1 W HEAT BALANCE ERROR - 1.16%
MASS FLOW RATE = 6.3410 G/S PRESSURE DROP = 0.0689 MM H2O FRICTION FACTOR - 0.048968 FREM 12.9502

REM = 264.5 GRM+ = 0.16912E 07 UPSTREAM BULK TEMPERATURE = 30.69 DEG C DOWNSTREAM BULK TEMPERATURE = 35.62 DEG C
PRM = 5.048 RAM+ = 0.85380E 07 INLET BULK TEMPERATURE = 30.72 DEG C OUTLET BULK TEMPERATURE = 35.59 DEG C

STA-TION NO.	Z CM	-WALL TEMPERATURE (DEG C)- A	B	C	AVER-AGE	TB (C)	RE	PR	RA+	Z+	NUSSELT NUMBER A	B	C	AVERAGE T	H	T+H
0	0.0	29.41	29.40	29.31	29.36	30.72	251.5	5.34	0.771E 07	0.00001	-8.07	8.01	-7.53	-7.78	-7.79	-7.78
1	1.5	29.77	29.75	29.70	29.73	30.73	251.5	5.34	0.772E 07	0.00037	*****	*****	*****	*****	*****	*****
2	2.5	30.02	30.00	29.96	29.98	30.75	251.6	5.34	0.772E 07	0.00061	*****	*****	*****	*****	*****	*****
3	5.5	30.76	30.73	30.75	30.75	30.78	251.8	5.34	0.773E 07	0.00135	*****	*****	*****	*****	*****	*****
4	15.5	32.06	31.98	31.91	31.96	30.88	252.3	5.32	0.777E 07	0.00380	8.97	9.66	10.30	9.78	9.81	9.79
5	25.5	32.89	33.02	32.60	32.78	30.98	252.9	5.31	0.781E 07	0.00625	5.56	5.20	6.54	5.90	5.96	5.93
6	45.5	33.86	33.82	33.46	33.65	31.19	254.1	5.28	0.788E 07	0.01115	3.97	4.02	4.66	4.30	4.33	4.31
7	75.5	34.73	34.52	34.23	34.43	31.50	255.8	5.24	0.800E 07	0.01851	3.28	3.50	3.87	3.61	3.63	3.62
8	105.5	35.22	35.14	34.83	35.01	31.82	257.6	5.20	0.811E 07	0.02588	3.10	3.18	3.50	3.31	3.32	3.32
9	135.5	35.52	35.47	34.66	35.08	32.13	259.2	5.17	0.821E 07	0.03328	3.11	3.16	4.17	3.58	3.65	3.61
10	165.2	35.65	35.57	35.15	35.38	32.44	260.8	5.13	0.831E 07	0.04061	3.28	3.36	3.88	3.58	3.60	3.59
11	205.2	35.78	35.73	35.05	35.40	32.85	262.9	5.08	0.844E 07	0.05051	3.60	3.66	4.80	4.13	4.22	4.17
12	245.2	36.20	36.21	35.63	35.92	33.27	265.1	5.04	0.857E 07	0.06043	3.59	3.58	4.45	3.97	4.02	3.99
13	275.2	36.25	36.14	35.52	35.86	33.58	266.7	5.00	0.868E 07	0.06790	3.93	4.10	5.41	4.61	4.71	4.66
14	305.2	36.58	36.45	35.90	36.21	33.89	268.4	4.96	0.878E 07	0.07538	3.91	4.10	5.24	4.54	4.62	4.58
15	333.3	36.73	36.83	36.08	36.43	34.18	269.9	4.93	0.888E 07	0.08240	4.12	3.97	5.55	4.68	4.80	4.74
16	363.3	37.10	37.11	36.12	36.62	34.50	271.7	4.89	0.898E 07	0.08991	4.02	4.01	6.44	4.95	5.23	5.09
17	383.3	37.28	37.05	36.16	36.66	34.70	272.8	4.87	0.905E 07	0.09493	4.06	4.48	7.21	5.36	5.74	5.55
18	403.3	37.33	37.09	36.28	36.75	34.91	274.0	4.84	0.912E 07	0.09995	4.33	4.81	7.66	5.72	6.12	5.92
19	423.3	37.05	36.94	36.09	36.54	35.12	275.1	4.82	0.919E 07	0.10499	5.41	5.77	10.81	7.36	8.20	7.78
20	443.3	37.49	37.70	36.54	37.07	35.33	276.3	4.80	0.927E 07	0.11003	4.83	4.42	8.65	6.02	6.64	6.33
21	463.3	36.94	37.04	35.77	36.38	35.54	277.5	4.77	0.934E 07	0.11508	7.44	6.98	44.35	12.39	25.78	19.08
AVERAGE VALUES THROUGH STATIONS 15 TO 20:	391.6	37.17	37.12	36.21	36.68	34.79	273.3	4.86	0.908E 07	0.09703	4.46	4.58	7.72	5.68	6.12	5.90