PRODUCTION CONTROL ASPECTS IN A SMALL MANUFACTURING ENTERPRISE

by

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ABSTRACT

CERES LTD. management felt something was running out of control in the operations of its industrial plant and decided to analyze its present organization and operations to develop a production control system.

A study was conducted in the factory, department by department, and several problems that would affect any production control system were detected which would require a solution previous to the development of the control system itself.

Selected topics of the theory compatible with the complexity of the factory, and solution to the basic problems are presented.

Finally a proposal of the organization for CERES LTD. is presented along with a list of future tactics to accomplish the goal of improving the production control system.

SUMMARY

CERES LTD. had the feeling that it was possible to improve its present performance in the factory and decided to develop a production control system. To achieve this objective CERES LTD. asked the Mechanical Engineering Department, Industrial Engineering group, to assist it in the preparation of a suitable system.

To get a knowledge of the present system at the factory to a degree that enabled the author to decide about its advantages and disadvantages, and to propose improvements in this topic, he had to spend some time in the factory itself.

Characteristics of the products of CERES LTD. suggested the development of a Line of Balance for each one of its products because this control system is especially suited to control production when assembly is an important percentage of the total added value. The implementation of this system, besides being time consuming, was not possible immediately because the present productive system showed several inefficiencies that made the development of the needed activities difficult.

Improvements had to be studied in several areas which led to analyzing first the organization of CERES LTD., the

plant layout of its inductrial plant, and the planning system in use, applying methods study and work measurement techniques afterwards.

The theoretical basis and results in plant layout, planning and methods study and work measurement are presented in detail. Proposals for the improvement of some aspects of the productive activity at CERES LTD., are shown as well as preliminary steps to establish a production control system.

Achievements in the developing of such a system might be obtained only after working out a Chart of Accounts, a Departments Code, and a Nomendature of Materials. These assignments, which demand careful work, are easily developed but are very time consuming, hence a special effort of the CERES LTD. management will be needed.

LIST OF SYMBOLS

LOWER CASE LETTERS	: Any physical or geometical characteristic, unless otherwise indicated.
UPPER CASE LETTERS	: Any name, unless otherwise indicated.
GREEK LETTERS	: Any constant, unless otherwise indicated.
Yi ; X	: Known or unknown variables
V ; X	: Vectors related to known or unknown variables.
ϕ ; ψ	: Functions expressing dependency between variables.
(N , X)	: Finite non empty sets
$f(\alpha,Q)$	: Expected total yearly inventory cost function.
$g(\alpha,Q)$	: Average inventory on hand function.
$h(\alpha,Q)$	: Average shortage hours per year function.
n(2)	: Average shortage hours per cycle.
b(t)	: Total cost function.
p(t)	: Price when a unit is withdrawn from inventory.
E	: Expected number of occurrences.
H	: Holding costs.
I	: Net inventory when new shipments arrive.
M	: Idle machine (men) costs.
O	: Ordering costs
P	: Probability
Q	: Optimum amount of goods to be ordered
R	: Reorder level
S	: Shortage costs
T_L	: Lead time.
T_R	: Time to complete R units of output.
W	: Number of working hours per year.
Z	: Standard normal deviation.
n	: Any real number.
r	: Correlation coefficient.
S_y	: Sample Standard Deviation.
S_{yx}	: Standard error of estimate.
δ	: Any increment.
σ	: Standard deviation.
μ	: Mean value.
τ	: A time interval.

LIST OF FIGURES

TABLE OF CONTENTS

PAGE

1. INTRODUCTION

1.1. Short History of Production Studies.

No one can say when man first studied production. If we rely on written proof, the date must be set well along in recorded history, but surely some early "managers" pondered better ways to produce crude wheels, utensils, and building blocks.

Awaiting documentary evidence, we must pass by the construction of Moais in Easter Island, Pyramids in Egypt, construction marvel of the Greeks or the Roman Empire, the artistic masterpieces of the Dark Ages, and the craftsmanship of the Middle Age guilds. During the last period, production was characterized by individual activities and muscle power instead of mechanical power.

In the eighteenth century conditions changed rapidly with the introduction of steam power, machine tools and a factory system emphasizing interchangeability of manufactured parts. These conditions heralded the industrial revolution and initiated many modern management headaches.

At the beginning of the nineteenth century, typical factory conditions were grim by today's standards. Children put in 12 to 13 hours six times a week. The work place was dismal and unsafe. Management attitudes were to equate the sensibilities of men to that of machines and to implement cost-reduction policies by brute force. Despite the lack of social concern, production concepts inaugurated in the period included departmentalized plant layouts, division of labor for training and work study, more orderly material flow, improved cost-recording procedures, and incentive wage plans.

By the end of this century Henri Fayol, a French metalurgical engineer, published his monograph, which when translated into English had a great impact on the North American management thought. The "Industrial and General Administration" contains many of the general principles in texts on this subject.

At the beginning of the twentieth century significant experiments by Frederick Taylor characterized the new scientific approach. He, from empirical observations, designed work methods where man and machine were one - an operating unit of a man inspired by an incentive wage to service a machine efficiently according to exact instructions. He segregated the planning of activities from their implementation and place it in the field of professional management. His concepts, under the title of Scientific Management were criticized because they would completely dehumanize industry. Critics or not, his beliefs strongly stimulated industrial management.

Henry L. Gantt, an associate of Taylor, developed methods of sequencing production activities and Frank and Lillian Gilbreth showed the basic human motion patterns that are common to many different work situations.

By the twenties and thirties it became clear that the carrot of better wages or working conditions did not always lead to proportional increases in output; psychological factors such as morale and attention were also influential. During this period mass production techniques were introduced into the industrial activities and using statistical controls it became apparent that all the interacting factors of product design, plant layout, worker capacity, environmental conditions, materials and customers attitudes had to be considered, deriving to the study of entire production systems rather than isolated parts.

An interdisciplinary approach to system studies appeared with the forties, first in Great Britain in the form of operational research teams. Experts in different areas of studies applied accepted scientific methodologies to problems from different areas and favorable results did not surprise because analogs are found throughout nature and the works of man.

Electronic Computer also appears in 1940 and today its influence is apparent throughout the industry. At the top and bottom of the organizational pyramid, the input has been gentle, often just the pride of having a computer.

Some emotional fog about the computer issue is removed by concentrating on what has been done and what has to be done. To use the machine problems must be "programmable" so it can be visualized as a sort of man-machine partnership.

1.2. Generalities.

Every company has an information system to control and plan its business. For example, in a two-man partnership in which one man handles production and the other handles sales, each informs the other of developments affecting his own side of the operation. Hence, without formalization an information system exists, even if the vehicle is only oral communication.

Should the company grow or desire more precise data about its performance, a more complex system of information will be required. The design of a system suited to the users' real needs is a very critical and complex task. Meeting the information needs of management with a poorly conceived system, which is either too weak for proper response or too powerful and thus too costly, can spell disaster for the user. On the other hand, the use of an appropriate, advanced information system may determine management's ability to survive in a dynamic, growing and competitive environment.

The design and implementation of a proper information system is a monumental effort because rules which guarantee success do not exist except for two major guidelines:

1 - A comprehensible, viable plan should be created even if the number of variables is large, and -

2 - The environment should be studied conscientiously to identify, quantify and effectively deal with all the variables.

Planning an overall systems effort is one of the most difficult, frustrating and tedious tasks. A plan for a system effort must be flexible but definitive, must facilitate control and direction but not engulf it in paperwork, must provide a basic picture but retain sufficient detail to be meaningful, and must provide for change as a natural function of the system effort (1). Such information systems are developed to control and plan other systems, generally of an industrial-business (i.e., Production) nature.

Systems can be said generally to consist of inputs (flow of resources), structures within which flows occur, and procedures or processes which transform flows into some kind of system outputs. A typical organization consists of physical production and distribution systems, programmed information processes for controlling routine physical systems operations, and non-programmed information decision systems for making higher-level decisions.

The parameters of a system, then are flows, structures, and procedures or processes. Systems, in essence, consist of operations of flows. Systems outputs are the results of operating upon inputs by means of processes or procedures.

The concepts of programmed and unprogrammed information/ control/ decision processes are in tune with the "management by exception principle" where the programmed process represents the delegated authority in accordance with basic principles of the organization.

A system has been defined as a "complex unity formed of many often diverse parts subject to a common plan serving a common purpose" (2). Similarly, production is defined as "the process by which goods and services are created" (3). The components of such a system contribute to the production of a set of outputs from given inputs which may or may not be optimal with respect to some appropriate measure of effectiveness, on a continuous or batch basis with or without profit as a primary objective.

A General Model for a Production System has been developed (4), (5), (Fig. 1), in terms of flows and operations for which six distinct types of flows have been defined (6), (7), (8).

1 - Flow of orders,

2 - Flow of material and energy,

3 - Flow of money,

4 - Flow of personnel,

5 - Flow of capital equipment, and

6 - Flow of information.

This model assumes the existence of pools external to the system that interact with it. Those pools are systems which provide the production system with personnel, material and energy, equipment, and services or financial assistance when they are required.

Mathematically, when confronted with a system, one observes a number of variables, Y_i, which are assumed to be related to another series of known or unknown variables, X_k. The first group we can think of as the OUTPUT VECTOR, $\bar{Y}$, and the second as the INPUT VECTOR, $\bar{X}$. Thus, the functional dependency may be expressed as:

$$\bar{Y} = \Psi\ (\bar{X})$$

where Ψ, in general, is non-linear. The $\bar{X}$ and $\bar{Y}$ quantities are also called "independent" and "dependent" variables respectively. In addition, a system is also generally described by means of its "geometry" or "structural parameters" and by its "properties" or "material parameters".

Using the Method of Potentials (9), (Appendix A), to show sequential relationships between interacting systems, it is possible to build up a kind of network with the systems, as nodes. At any node of this network one can derive a relationship that is a detailed statement of the universal principle of conservation of entities, in accordance with the vectors already shown. The logical process of deriving this principle is deductive in nature.

Σ Rates of flow in = Σ Rates of flow out + Σ Rates of accumulation - Σ Rates of generation.

or

Σ Net rate of flow = Σ Rates of flow in - Σ Rates of flow out.

or

Σ Net rate of flow = Σ Rates of accumulation - (Σ Losses into sinks + Σ gains from sources).

According to the general model for a production system already presented, a control system is sufficient if it controls every one of the flows of our concern at every one of the nodes of the network.

The system concept, as it has been defined, is general enough to be thought of as composed of systems (subsystems) in which each system could be a subsystem of some other system.

In fact, a Production System, with its primary purpose of converting a customer's order into a finished product, can be divided into subsystems in order to make this conversion in a simple, easily understood and practical manner.

Preferably, each subsystem should be relatively independent of the others so that any changes or perturbations within it will have a minimal impact on the total system. The activities carried out within each subsystem should be of the same general type, and the number of interfaces between the subsystems should be kept to a minimum. When an interface is required, however, it should be capable of being clearly defined.

Traditionally a Production System has been divided into five basic subsystems:

1 - Planning,

2 - Operations,

3 - Control,

4 - Financial, and

5 - Information.

These basic subsystems are included in the schematic diagram of a General Model for a Production System shown in Fig. 1.

Each subsystem can be decomposed into basic units until each Activity Centre has been defined. With the activity centre as a basic unit for the network it will be possible to control the net rate of flow for every one of the flows shown to an accuracy controllable by the definition of these activity centres. If an activity centre has been properly defined, one must know clearly the amount of energy it is using, how many man-hours it needs to operate, the amount of output it is producing, and the amount of waste it is sending to a sink. In other words one must know the amount of money it is expending to produce one unit of output.

The data obtained from the information system can be used directly to control the production of goods or services, or to be stored for future needs in planning, financing or producing.

Until now one has developed a concept of an activity which begins with the identification of the human needs and the conceptual and logical design of a system to satisfy these needs and follow through to its integrated physical development and use, taking into account all its environmental constraints. This activity, adding further evolutionary development and economic soundness, is the basis of the Systems Engineering and includes the elements of synthesis, analysis, management and technology.

For an Industrial System Engineer control must contain a condition or characteristic to be controlled, a procedure for measuring the thing to be controlled, a procedure for comparing the actual result with the desired result and produce a signal to initiate control action, and a controller which in response to the control signal is capable of bringing a change in the operative system. For management, on the other hand, control consists of standards, tangible or intangible, vague or specific, that represent desired performance; of a comparison of actual results against the standards which evaluation must be reported to the people that can do something about it; and of a corrective action that must be taken when it is discovered that current activities are not leading to the desired results. It is clear that until everyone concerned understands what results are required, control will create confusion.

To accomplish the stated goals policies must exist, that is, rules by which the input information streams are converted into decisions to control activity.

Although there are no exact rules to develop efficient information systems, there exist several methodologies to control the production of goods or services. These are available under Operations Research and Management in the literature. The most widely used methods are based on the Critical Path Scheduling Systems (10), (11), PERT (Performance Evaluation and Review Techniques) and CPM (Critical Path Methods). These are used as a basis for a great variety of other Production Control Methods such as Inventory Control, Preventive Maintenance, etc., and recent attempts have conducted to use them in a computational way.

Management often feels that the cost of implementation of such information/control systems is more than it is worth. Because this is a mistaken attitude the development, application and benefits of such control systems must be clearly explained to management in terms that they can understand. Of course in certain cases the simplicity of the operation of a company does not warrant the full complexity of a general, methodological control system.