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ON THE COMPARISON OF MODERN PRODUCTION MANAGEMENT PHILOSOPHIES

M. Sinclair
Department of Industrial Engineering
University of Stellenbosch
Private Bag X5018
7600 STELLENBOSCH

ABSTRACT

A variety of production management philosophies are discussed in the literature and implemented in industry. This paper will present a framework for the comparison of such management approaches. Each of the modern production management systems MRP I, MRP II, OPT and JIT will be discussed within this framework. A comparison of these approaches will then be made.

OPSOMMING

Verskeie bestuursfilosofieë vir produksiestelsels word in die literatuur bespreek en in die industrie gevolg. Hierdie artikel stel 'n raamwerk voor waarbinne sulke bestuursbenaderings met mekaar vergelyk kan word. Elkeen van die moderne produksiebestuursbenaderings MRP I, MRP II, OPT en JIT word binne hierdie raamwerk bespreek. 'n Vergelyking word dan tussen hierdie benaderings getref.

1. INTRODUCTION

The Japanese success in manufacturing has drawn a lot of attention lately. Refer for instance to the many books and articles on the Japanese production management approach, e.g. Sohal, et al [1]. Many articles on comparisons between the Japanese approach and other approaches have also appeared, e.g. Plenert, et al [2]. This paper has two aims:

1. To provide a framework within which production management philosophies can be compared.

2. To compare the most important modern production management approaches within this framework.

Notice that reference is made to "management approaches" or "management philosophies", not specific implementations of these approaches or philosophies. The fact that the different approaches are to be compared also means that hybrid approaches will be ignored, however successful their implementation in industry may be (see e.g., Belt [3] and Bose, et al [4]). Furthermore, the discussion will emphasise production management in industries other than the process industries. In the process industries such as steel, glass, petrochemicals, etc., capital investment is the key to high productivity. Management systems seem less important, since processes are highly automated and employ little labour. The use of computerized process control equipment minimizes problems stemming from worker inconsistencies. This discussion will emphasise industries in which management itself is critical. This includes any industry in which the products can be counted in discrete units, and which thus have the following properties:

(a) They can be made, inspected, stored and counted one at a time or in batches of any size.

(b) While in process, individual units can form queues and jostle, or be jostled, for priority.

In order to attain the first goal set out above, a few concepts from optimization theory are borrowed to construct the necessary framework. Other optimization frameworks for operations management do exist. For example, in the context of Just-In-Time (JIT), see Haynsworth [5, p2] and Lubben [6]. The framework constructed in section 2 of this paper is, however, the only one the author is aware of which can be used to explain existing approaches to production management and to compare them.

Section 3 of this paper is devoted to the exposition of JIT, as well as Material Requirements Planning (MRP I), Manufacturing Resource Planning (MRP II) and Optimized Production Scheduling (OPT), within the framework constructed in section 2. In section 4 a comparison of these systems will be made on the basis of the exposition of section 3. The final section will be devoted to some conclusions.

2. OPTIMIZATION FRAMEWORK FOR PRODUCTION MANAGEMENT SYSTEMS

Any operational system has as its main objective the most efficient use of resources. In a manufacturing environment, these resources are:

1. Machines (including tools and vehicles).
2. Materials (the input to the operation).
3. Time (that of workers and machines).
4. Space (i.e. the production area or building).
5. Skills (i.e. labour).

The word "efficient" implies the use of resources to meet some criteria. These are:

1. Customer service.
2. Low cost.
3. High quality.
4. Wide variety of products.
5. Product innovation.
6. Responsiveness to change (or flexibility).

It is therefore possible to interpret the goals and objectives of production management as some kind of optimization approach. For instance, minimize cost, maximize quality, maximize responsiveness, etc. The optimization must, of course, be done under certain constraints, such as limited funds or limited raw materials. The main point is that many, usually conflicting, objectives exist in production management. Similar arguments appear in Funk [7] and Sushill, et al [8].

Thus, production management can be modeled as a multicriteria decision making problem. There are many approaches to the solution of such problems (e.g., see Goicoechea, et al [9]). Since we want to use the model only as an aid to understanding the reasoning behind some of the existing production management philosophies, we shall not try to go into the merits of all these solution strategies. There is one approach which we have found to be suitable for the type of analysis which must be done in the rest of this paper, namely the goal programming approach (see for example, Lee [10]).

Many examples exist in the literature of such a goal programming approach to operations management. Consider the following few examples:

1. Quality control by formulating a goal programming model in which quality specifications form the goals (Sengupta [11] and Lawrence, et al [12]).

2. Linear goal models for multi-product production planning (Kendall, et al [13] and Sushill, et al [8]).

3. Linear goal programming model for quality control circles (Ebrahimpour, et al [14]).

Note that these examples illustrate the feasibilty of the approach and not the application to JIT, MRP, OPT or any other production management system. They also illustrate the existence of functional relationships to model the multiple objectives referred to above. Another illustration of such a relationship appears in Matta [15].

In general, suppose we can model the criteria to be optimized by the functions $f_i(\underline{x})$, where $\underline{x}$ denotes the vector of decision variables and i the index of the specific criterion. Then the multicriteria decision making problem discussed above can be solved by solving the following goal programming problem:

$$\text{Minimize } \Sigma_i(w_i^+ s_i^+ + w_i^- s_i^-)$$

Subject to:

$$f_i(\underline{x}) - s_i^+ + s_i^- = b_i \text{ , for all } i \quad . \; . \; . \; . \; . \; . \quad (1)$$

$$\underline{x} \text{ in } X,$$

where X is a set indicating the constraints on the decision variables, b_i denote the goal set for criterion i and s_i^+, s_i^- respectively denote the over- and underachievement of goal i. For instance, if criterion i indicates minimum inventory, b_i would be 0. If, on the other hand, criterion i indicates maximum quality, b_i would be 100 (%). The weights w_i^+ and w_i^- can be chosen by the decision maker to indicate the priority he/she attaches to the over- and underachievement of criterion i respectively. This can be done by ignoring some objectives (i.e. setting its weights equal to zero) or setting some priorities on some goals (i.e. attaching a larger weight to the criteria which is most important).

In order to evaluate existing production management approaches in terms of the goal programming model above, some criterion should be formulated whereby the suitability of each approach can be measured. That is, given the goal programming model for each of the approaches, how do we decide which model is best? Without much fear of contradiction it can be stated that the system which leaves the decision maker (i.e. the manager) the most leeway to set his own targets (i.e. the values for the weights) without being constrained to ignore some of them, would be the best. Thus, the criterion used in the rest of this paper to evaluate production management approaches, is that the best approach will allow the most objectives such as (1) into the goal programming model of the approach.

3. MODERN PRODUCTION MANAGEMENT PHILOSOPHIES WITHIN THE GOAL FRAMEWORK.

In order to compare the production management systems identified in the introduction, each of them will be discussed within the framework presented in the previous section.

3.1 Just-In-Time in the goal framework:

A whole new field of study, called World Class Manufacturing (WCM), has developed around the Japanese approach to manufacturing. WCP has three basic pillars, namely (Schonberger [16]):

1. Just-in-Time (JIT).
2. Total Quality Control (TQC).
3. Total Productive Maintenance (TPM).

These pillars do not exists in isolation. Therefore our outline of JIT will contain many references to the other two pillars.

Just-in-Time (JIT) is meant to convey the idea that the three major elements of manufacturing - capital, equipment and labour - are made available only in the amounts required and at the time required to do the job most effectively. Because the development of high-quality processes and products is the responsibility of the entire company, the word manufacturing includes all responsible functions in the company (i.e., engineering, production, sales, finance, quality, etc.), not just production. Thus JIT is a total systems approach (Lubben [6, p 3] and thus the goal programming model describing the approach would have an expression such as (1) for every possible criterion.

JIT is often presented as a philosophy for the elimination of <u>all</u> waste. The definition of waste most universally accepted in this context, is the one used by the quality control fraternity: "Quality is value added; all the rest is waste". (Schonberger [16, p 27]) This definition, over and above the fact that it establishes the close relationship between JIT and quality, provides us with the (complementary) positive and negative aims of the JIT approach. The positive aim is to maximize value added. The negative aim is to eliminate anything not needed for the first aim.

In using the goal programming model to explain JIT, it is necessary to differentiate between goals (expressions (1)) and decisions (or strategies for achieving the goals, the vector $\underline{x}$).

In formulating the goals of JIT, it is possible to differentiate between goals and sub-goals, or objectives. Since we want to explain JIT in as much detail as possible, we shall present both goals and objectives. It should be understood that both goals and objectives generate the type of expressions (1) in the model of the previous section.

The goals of JIT can be summarized as follows:

GOALS OF JIT

1. Produce at minimum cost.
2. Ensure maximum quality.
3. Ensure maximum flexibility.
4. Ensure maximum responsiveness to customer needs.
5. Ensure maximum commitment to continual improvement of the manufacturing system.

Note that these goals are all consequences of the commitment to the elimination of waste, as defined above.

The secondary goals, or objectives, of JIT can be summarized as follows:

OBJECTIVES OF JIT

1. Simplify product design and production process as far as possible.
2. Eliminate every kind of inventory.
3. Eliminate every kind of time waste.
4. Eliminate every kind of rework and scrap.
5. Eliminate handling and transportation of materials and products as far as possible.

The goals and objectives of JIT as set out by Lubben [6], and the elimination of the "seven wastes" as summarized by Suzaki [17], can all be found in one form or another in our goals and objectives.

Given these sets of goals and objectives, it is obvious that JIT takes all the goals mentioned in the introduction into account.

3.2 MRP I in the goal framework:

Material Requirements Planning (MRP I) integrates the scheduling and the control of materials for manufacturing. MRP I uses a computer to perform thousands of simple calculations in transforming a master schedule of end products into parts requirements. It is thus based on calculated needs, the so-called look-ahead principle. (De Toni, et al [18]). However, it shares one weakness with earlier approaches such as Reorder-Point (ROP): It is lot-oriented. That is, in the MRP process the computer collects all demands for a given part number in a given time period and recommends production or purchase of the part number in one sizeable lot. Thus MRP correctly calculates parts requirements by precisely associating them with the master schedule of end products. It is thus obvious why MRP has been labeled a "push" system. But the schedule is subject to error. Since the lot is sizable, and the lead times thus long, it is virtually impossible to adjust the lot sizes to take into account any delays and schedule changes during the lead time. MRP thus falls short in flexibility (goals 3 and 4 of JIT), as well as ignoring the goal of low inventories (objective 2 of JIT). Manufacturing in lot sizes also leads to more scrap if something goes wrong with the production process (objective 4 of JIT).

3.3 MRP II in the goal framework:

Manufacturing Resource Planning (MRP II) is an integrated computer-based information system that steps beyond first-generation MRP II to synchronize all aspects (not just manufacturing) of the business. One unified data base is used to plan and update the activities in all the systems. It is no longer easy to classify MRP II as either a "push" or a "pull" system (see De Toni et al [18]). The basic lot size based approach is, however still used. Furthermore, MRP II needs much more paper work and computer facilities in order to function efficiently. This may tie up capital, time and other resources which could be used more productively.

Finally, to emphasise the last point, consider the following quote from Plenert, et al [2, p 23]:

"MRP production scheduling systems sequence tasks as if the plant has infinite resources available."

Many of the goals identified in the introduction are thus ignored in the MRP II approach. In particular, objectives 2, 3 and 4 of JIT are ignored.

3.4 OPT in the goal framework:

In OPT (Optimized Production Scheduling) production is not scheduled with either a "push" or "pull" technique, but on a "bottleneck" basis. (Plenert, et al [2]). The bottleneck areas in a facility are analyzed and then emphasized. Production is planned so that the bottleneck work centers will be utilized to the maximum and all other departments which are not bottlenecks will be planned to keep the bottleneck departments working at full production at all times. Like MRP II, OPT requires sophisticated computer systems to generate production schedules, but OPT is typically faster. Less flexibility in production, higher data accuracy requirements and greater complexity are some of the disadvantages of OPT in contrast with JIT. Thus, some of the more subtle forms of waste are ignored in OPT (e.g. goals 3 and 4, objectives 3 and 5 of JIT).

4. CONCLUSIONS.

If everything in the previous two sections are considered carefully, it is obvious that JIT allows all possible management objectives to be considered in any production system. Some are given more emphasis than others, but nevertheless, they are all considered. The weight attached to a specific goal in a specific implementation will of course depend on the management of the facility. The other philosophies, however, each emphasise only some goals while ignoring others. This means that JIT leaves the manager of the factory more leeway to set his own targets, without being constrained to ignore some. In terms of the criterion formulated in section 2, JIT must thus be considerd the best approach to production management.

Please note that this discussion is not an attempt to paint JIT as the solution to all production management problems. The aim is to provide an objective measure of the suitability of different production management approaches, and to illustrate its use for some well-known approaches for a certain class of manufacturing problem.

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