Manufacturing System Integrated Control

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Abstract: In this paper, we propose a method to control the entire production process, starting with customer enquiry up to product delivery, for the MTO (make-to-order) manufacturing system. In practice, decisions on acceptance of order and production planning are often considered separately. The sales Department is responsible for accepting orders, while the production department is in charge of production planning for implementation of orders accepted. Acceptance decisions are often made without involving the control of the production department or incomplete information on the basis of available production capacity. Method for integrated control of the job shop type manufacturing system proposed in this paper aims to facilitate the connection between the two departments and to achieve integrated control of the job shop type manufacturing system on the basis of Earning Power (EP) evaluation. It gives a more accurate picture of a firm's profitability than gross income.

Key-Words: - earning power, manufacturing system control, order acceptance, MTO manufacturing system, process monitoring and control

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1 Introduction

Manufacturing companies differ in how they respond to customs demands. Some, called make-to-stock (MTS) companies, anticipate customer needs by producing a series of standard products, and deliver the products when customer orders occur. At these companies, all given products are usually used for general purpose, and therefore they do not cover the exact customer needs. The estimated delivery periods required by customers can be easily observed. On the other hand, as there is repetitive production, the products can be manufactured on manufacturing systems as a single production line. Therefore, manufacturing systems (and even workstations forming these manufacturing systems), are product-dedicated. Changing a product that one MTS manufacturing system performs is time consuming. In addition, inventory costs are high.

Others, called make-to-order (MTO) companies, start the manufacturing process only after the order content is acknowledged and accepted. Compared to MTS companies, these have a better responsiveness, because they can deliver products more varied and even customized. As a result, customer’s requirements are fully satisfied and inventory costs are low. However, these advantages can be realized only if the lead times can be reduced enough to respect the delivery period required by the customers. In addition, MTO manufacturing must be a job shop and its workstations must be process-dedicated.

That is why the problem of developing a system encompassing the advantages of these two kinds of companies has occured.

A first approach to this problem is reported by [1], who propose a hybrid MTS/MTO production system. In this case, a portion of the production system operates as an MTS system and makes certain products, and the other operates as an MTO system and makes other products. Moreover, some products will be firstly, partially manufactured in MTS mode, reaching the semi-finished product stage. In this state, the products are kept in stock until the arrival of customer order. Product manufacturing continues then in MTO mode, until its delivery. The point where there is a shift from a mode to another is called order penetration point in the production line. A proper combination of MTO and MTS can exploit the advantages of the lower inventory, short delivery time, and good responsiveness. The authors present a decision-making procedure to determine the appropriate position of the order penetration point for different products in a manufacturing system. In this way, we can use with a greater extension the advantages of both types of manufacturing systems. However, the disadvantages remain unchanged.

The second approach consists in solving the problem by improving one of the two kinds of company. Since the high inventory and low responsiveness of the MTS manufacturing system are hard to improve, most researchers propose improvement of the MTO manufacturing system, by considering that it is easier to reduce its disadvantages.

In this paper, the second approach will be considered.

Regardless of how researchers have approached this problem, they decomposed the production process in the following generic activities: a) cost and time estimation, b) price and due date quotation, c) order acceptance and scheduling, d) manufacturing process planning (where manufacturing operations are established, including workstation which will perform each of them), e) production activities scheduling, and f) performance measurement. Moreover, they have grouped these activities into two stages, namely order entry stage, which is followed or not by an order acceptance, and order fulfillment stage, ending with product delivery.

By analyzing the results reported in the literature we proposed solutions for the improvement of MTO manufacturing system control, in order to increase its performance.

2 Order Acceptance and Scheduling

Today, the procedure of responding to an enquiry is approached as a multistage-multicriteria decision-making process. The most common support for this process is to develop an appropriate decision support system (DSS). In this kind of decision-making structure, the initial decision is to determine whether to accept or not the order based on a pre screening process.

In [2] present a comprehensive decision-making structure composed of two phases and dedicated to manage the incoming orders. The incoming orders are checked in the first phase for acceptance on the base of their due dates. For this purpose, they apply the backward method proposed by [3] and calculate the completion date, the earliest release date and the latest release date of the orders. In the second phase, the accepted orders are ranked according to a multiple criteria decision-making (MCDM) methodology, which combines two techniques, the analytical hierarchy process (AHP) and the technique for order performance by similarity to ideal solution (TOPSIS). The ranked orders are then finally accepted based on manufacturing system capacity. In [4] showed that none of the existing decision support systems had the capability to instantly relate customer enquiries, during the enquiry stage, with capacity, process capability, inventory, potential profit to be derived and material requirement planning. In [5] propose a new comprehensive decision structure for the order entry stage in order to improve the production planning framework in MTO environments, by taking into account all affected parties of the supply chain: customers, the MTO company, suppliers and subcontractors. In [6] investigated the importance of the workload based order acceptance method in over-demanded job shop environments. Their approaches integrate order acceptance and resource capacity loading. In [7] investigate dynamic order acceptance and capacity planning under limited regular and non-regular resources aiming to maximize the profits of the accepted projects within a finite planning horizon. In [8] investigated the selectivity property of two acceptance policies. The first uses simulated annealing techniques and an empirically determined slack to estimate the realized makespan of an order set. The second uses regression techniques to estimate the realized makespan. In [9], [10] present a literature overview on research regarding order acceptance and scheduling. The author considers that taxonomy of research in order acceptance and scheduling includes single/multiple machines and deterministic/stochastic approach. The objectives are maximum profit, maximum throughput, maximum value of accepted orders, minimum cost, maximum percent of time utilization, and net present value.

3 Method Proposed

In order to better represent the specified goal of the manufacturing process we propose (as a novelty) as a criteria the Earning Power (EP). It is both synthetic (because it reflects the essential motivation of the manufacturing process) as compliant with the most important five performance aspects, namely: profitability, conformance to specifications, customer satisfaction, return on investment and materials/overhead cost, selected by researchers in order of importance.

By definition, Earning Power is an operating income divided by total assets. Here, operating income is an income resulting from a firm's primary business operations, excluding extraordinary income and expenses. It gives a more accurate picture of a firm's profitability than gross income. It is calculated by the formula:

EP=Sales revenue - (Cost of sales + Operating expenses). (1)

Asset is something that an entity has acquired or purchased, and that has money value (its cost, book value, market value, or residual value). An asset can be: something physical, such as cash, machinery, inventory, land and building; an enforceable claim against others, such as accounts receivable; right, such as copyright, patent, trademark or an assumption, such as goodwill.

For determination of EP it must be estimated: cost, time, asset, and price.

Current methods for estimating the cost and time are based on breakdown of the product into elements, cost estimation of each element and summing of other costs. As an element, we can consider one product component, one manufacturing component or one activity component. To estimate the cost for each element there are used element's different features that are closely related to cost. With few exceptions, estimation methods lead to cost estimation without a mathematical model describing relation between cost and element's different features. As a plus, those methods have a slight adaptation capacity to different specific situations because the information that is provided in order to estimate is general and does not adapt to specific cases.

Price estimation goes from costs and represents the company mission in relation to the market.

Order acceptance problem is usually treated in the literature considering the single resource case with deterministic processing time. The acceptance criterion is based mostly on capacity-driven approach. We cannot take into consideration that company performance is essentially dependent on the manner in which accepted orders are appropriate to all characteristic elements of the manufacturing system. In accordance with the method proposed in this paper, order acceptance is Earning Power-driven, while work-load, due-date and price are considered as restrictions.

In the present, machine control is made independent to order features, such as price. This is why, although the local control of the machine is optimal, the order performance level is not maximum. The method presented in this paper removes the disadvantage in that the machine control is based on simultaneous optimization of all manufacturing processes caused by order fulfillment.

Finally, in present order acceptance, planning and scheduling of the production process, and machine control can be solved separately. In this paper, we propose an integrated control method for the three aspects where Earning Power is used as a decision criterion when accepting and rejecting the order.

4. Method Flowchart

Method for integrated control of the job shop type manufacturing system proposed in this paper aims to facilitate the connection between the two departments and to achieve integrated control of the job shop type manufacturing system on the basis of earning power evaluation.

The method proposed by us is described in figure 1.

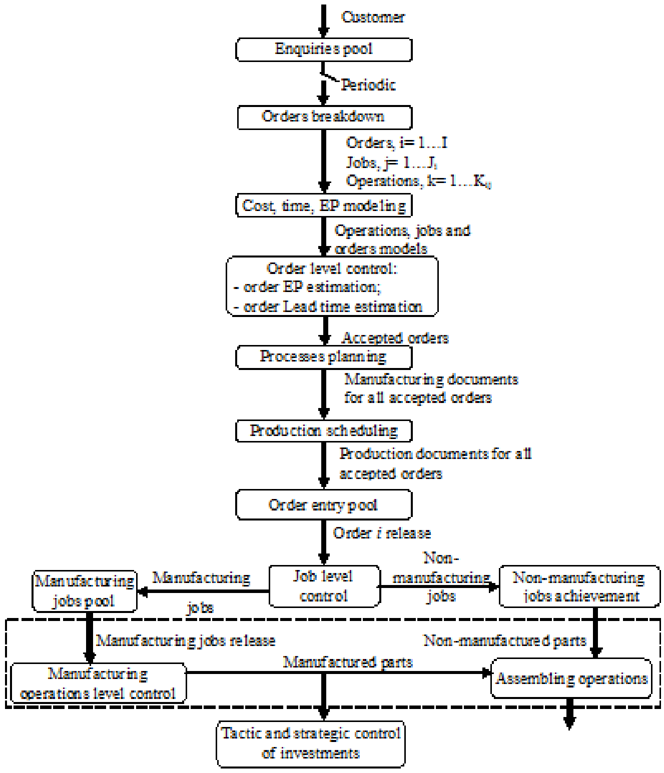

Fig.1: Method flowchart

Each customer enquiry is included in an enquiries pool. Periodically, these enquiry pools are downloaded in order of breakdown. Here, each order breaks in jobs and each job in operations in order to evaluate the *EP* of the order. In order to evaluate the *EP* of the order we need time and cost models at job level and operation level. Order acceptance decisions will be made after *EP* and lead time estimation for each order. The order acceptance is in descending EP order. This is actually an order level control. Thus, all accepted orders go to processes planning from where resulting manufacturing documents for accepted orders. Next step is production scheduling, developing production documents for all orders accepted. They go to the order entry pool waiting order release. For job level control it is established which of the jobs are going to be manufactured and unmanufactured. This selection is made by evaluating job EP. All manufactured jobs go to manufacturing jobs pool waiting for an order.

Next step is in manufacturing operations level control with manufactured parts resulting. Here it is established that the optimal work parameters for operation EP is maximum. Manufacturing parts will be assembled with non-manufactured parts in assembling operation level resulting order product delivery.

In addition to achieving an integrated control of a job shop, this method develops a tactic and strategic control of investments.

5 Conclusion

This paper targets the manufacturing systems issue for MTO in order to develop a method for control in accordance with present market dynamics.
In order to survive in the present environment, a complex and unpredictable environment, MTO manufacturing systems must be able to react rapidly in terms of favorable market position. Acquiring and maintaining this capacity is the most difficult because it involves many endogenous and exogenous factors and the process is continuous, dynamic, and difficult to predict.

Manufacturing system performance depends on how it is run. In several specialized papers, reference is made to the relationships between processing parameters and technical performance of manufacturing system (i.e. purely technical aspects), and in others, as many are referred to the relationship between product made by the system manufacturing and market (i.e. economical relations) and requiring an intervention in the manufacturing system to achieve favorable economic effects. There were not reported in the literature any attempts to address the whole system of manufacturing-market as a result, there are significant performance improvement resources that are not used, because it addresses the technical and economic aspect separately. In addition, there is no known algorithm for management of the entire manufacturing system-market, but there are technical management algorithms that make manufacturing systems and economical management tools in the overall relationship with the market.

The authors propose a new method of management of the MTO manufacturing system. The method is based on earning power used as an evaluation criterion for accepting and rejecting orders that have favorable economic effect. Thus, for each order there are accepted those orders for which the EP has the maximum value. The order acceptance is in descending EP order. For each job, a job selection takes place, meaning that those jobs with a favorable economical effect are kept and the others are outsourced to other processing companies. For an operation, optimal parameters for a process system will be made according to the maximum value of EP. Thus, a manufacturing process control will be performed.

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