

# METHOD FLOWCHART OF MAKE TO ORDER MANUFACTURING SYSTEMS

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## ABSTRACT

*Decisions on acceptance of order and production planning in the manufacturing system are often considered separately. Sales Department is responsible for accepting orders, while the production department deals with production planning for implementation of orders accepted. Sales department will tend to accept all orders no matter the capacity available for the department because this department's target is turn over. Production department will try to maximize the use of workstations and minimize the number of late deliveries. Order acceptance decisions are often made without involving the production department or incomplete information on the basis of available production capacity.*

*The authors have developed a new method for integrated control of the manufacturing system and this paper presents the method flowchart.*

KEYWORDS: manufacturing system, order acceptance, control, earning power (EP)

## 1. INTRODUCTION

In this paper, we propose a method to control the entire production process, starting with customer enquiry up to product delivery, for the make-to-order (MTO) manufacturing system. Control achieved with the proposed method is based on modelling the relationship between cost and time, two very important elements of manufacturing process performance evaluation.

In order to better represent the specified goal of the manufacturing process we propose (as a novelty) as a criterion the Earning Power (EP). It is both synthetic (because it reflects the essential motivation of 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, these aspects are selected by researchers in order of importance.

## 2. EARNING POWER

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:

$$EP = \text{Sales revenue} - (\text{Cost of sales} + \text{Operating expenses}). \quad (1)$$

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 the element's different features that are closely related to cost. With few exceptions, estimation methods lead to cost estimation without a mathematic model describing the relation between cost and the 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.

Cost and time will be estimated by techniques that are based on analytical modeling, neuronal modeling, or k-nearest neighbor regression. Each of these techniques covers a range of specific cases, namely: analytical technique covers process cases with all known regularities. The technique based on neuronal modeling covers cases when a large number of similar products are manufactured, slightly differently. Moreover, k-NN regression technique covers cases when there is little data to produce a model (production is diverse and manufactured series are few).

It is not difficult to estimate the asset because in the balance sheet there are quite accurate and updated data.

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.

At present, machine control is made independently to from 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 the 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 decision criterion when accepting and rejecting the

order.

### 3. METHOD FLOWCHART

In order to make feasible decisions on the arriving orders, all affected parties of the supply chain, whose decisions and performances have significant effect on prices and delivery times of the new arriving orders, are considered in the structure. These parties consist of customers, the MTO company, suppliers and subcontractors.

#### - Order breakdown (jobs, operations)

The order is a group of products structured by the customer for a product it solicits to manufacture. During order entry, all product components are analyzed. If some product components are related from a technological and commercial point of view forming a family, they will be manufactured simultaneously to several workstations,  $M$ . As a result, the number of copies that are released into production will increase and workstation adjustment under goes only minor changes when moving from one product to another in the same family. Each family is launched as a job in manufacturing. The operation is an operation cycle of a workstation when having a job.

For example, in the case of the hydraulic cylinders, by job we understand execution of cylinder rod, piston, body, bearing, etc. to implement one of these jobs are needed more operations such as cutting, drilling, boring, etc.

#### - Manufacturing system configuration

Each order has a manufacturing system specific, including all the workstations covered by the order.

Figure 1 presents MTO manufacturing system configuration. Out of the order entry pool the  $i$  order is launched. This order is formed from manufacturing jobs, deposited in a manufacturing jobs pool, and non-manufacturing jobs, deposited in a non-manufacturing jobs pool. Manufacturing jobs are released into production from the manufacturing jobs pool to different workstations  $M$  (job  $ij$ , job  $i(j-1)$ ).

Supposed that  $ij$  job includes  $ij1$ ,  $ij2$  and  $ij3$  operations. For an  $ij1$  operation, the  $ij$  job will wait for its workstation  $M$ . After processing this  $M$  workstation goes  $ij2$  operation to another  $M$  workstation.  $ij3$  operation is a  $ij$ ,  $i(j-1)$  parts assembling operation and  $i(j+1)$  non-manufacturing part on  $A$  workstation. The  $i(j-1)$  job is of from  $i(j-1)1$  operation performed on  $M$  workstation. After processing, part  $i(j-1)$  will result. We supposed that a non-manufacturing jobs pool is a supply pool of parts unsuitable to be processed, as an example, the  $i(j+1)$  part.

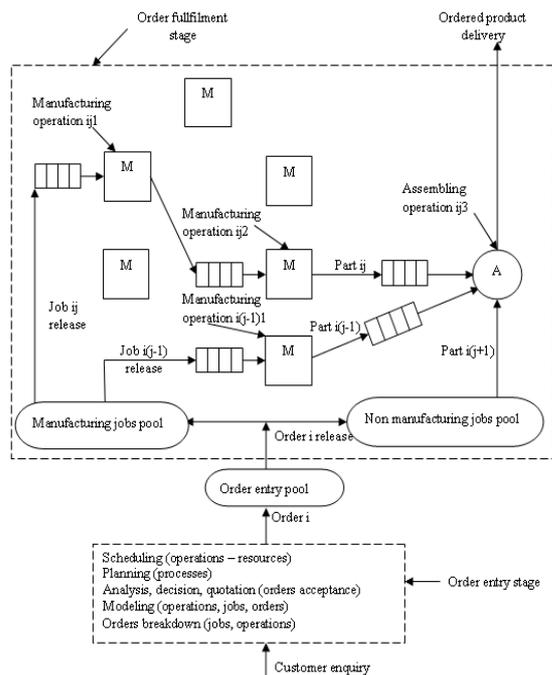


Fig.1 Scheme of the job shop manufacturing

#### - Operation, job, and order characterization (features and parameters)

Operation, job, order have six specific features: earning power, cost, time, price, asset, number of samples.

At operation level by *EP* we understand the relation between the difference of price operation and cost of operation and product from product asset and operation time. By operation asset it is understood the capital invested in workstations necessary to process orders (machine tools, tools, devices, workers, buildings, land, etc).

At job level *EP* we understand the relation between price difference and cost for job processing and the amount of products from job asset and operation time to accomplish the job. Costs necessary to accomplish the job are the sum of costs for the transactions that make the job. Thus, the cost for *ij* job from Fig.1 is the sum of costs for *ij1*, *ij2* and *ij3* operations.

At order level, *EP* is the ration between price difference and order cost and product from order asset and order time. Necessary costs to achieve the order is the sum of costs for carrying out jobs that form the order. Thus, the cost for order *i* in fig.1 is the sum of costs *ij* jobs,  $j=1...J$ .

Operation, job and order are characterized by the following parameters: part parameters (part length, part width, etc), process parameters (cutting speed  $v$ , advance  $s$ , cutting

depth  $t$ ), tooling parameters (tool material, devices, etc) and workstation parameters.

#### - Manufacturing system integrated control

In practice, decisions on acceptance of order and production planning are often considered separately. Sales Department is responsible for accepting orders, while the production department deals with production planning for implementation of the orders accepted. Sales department will tend to accept all orders whatever the capacity available for the department because this department's target is turn over. Production department will try to maximize the use of workstations and minimize the number of late deliveries. Order acceptance decisions are often made without involving of the production department or incomplete information on the basis of available production capacity.

The 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 job shop type manufacturing system on the basis of earning power evaluation.

The method we propose is described in Fig.2.

Each customer enquiry is included in an enquiries pool. Periodically, these enquiries pool are downloaded in orders 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 decision 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 the accepted orders. The next step is production scheduling developing production documents for all orders accepted. They go to order entry pool waiting for order release.

For job level control it is established which of the jobs are going to be manufactured and non-manufactured. This selection is made by evaluating job *EP*. All manufactured jobs go to manufacturing jobs pool waiting for order release.

The next step is manufacturing operations level control, resulting manufactured parts. Here are established the optimal work parameters when 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.

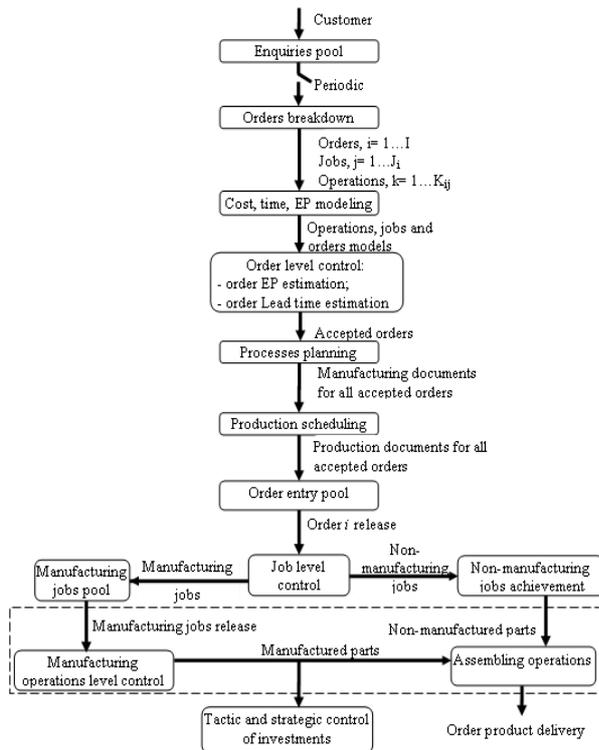


Fig. 2 Method flowchart

#### 4. CONCLUSION

A key requirement for MTO companies to remain competitive is the ability to assess incoming orders in terms of their technical and economic efficiency and determine the best orders that they should accept. To make an appropriate response to customer enquires, managers need a better understanding of the links between marketing and production departments.

In this paper, we propose a method to control the entire production process, starting with customer enquiry up to product delivery, for MTO manufacturing systems.

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