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# METHOD ALGORITHM FOR ORDER ACCEPTANCE IN MAKE-TO-ORDER MANUFACTURING

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## ABSTRACT

*In practice, decisions on order acceptance and on production planning are often made separately. Sales department is responsible for accepting orders, while production department is in charge of production planning for implementation of accepted orders. The method proposed in this paper aims to facilitate the connection between the two departments by an integrated control based on the earning power (EP) evaluation.*

KEYWORDS: manufacturing system control, order acceptance, MTO manufacturing system, process monitoring and control

## 1. INTRODUCTION

Frequently, the performance measurement systems of manufacturing companies are based on cost evaluation. In present manufacturing environment, these systems do not capture the relevant performances issues. Assessment results are used for monitoring, control and improvement of manufacturing operations. So, many researchers suggested new performance measurement approaches in order to provide to managers and operators with relevant information to support daily activities. However, there are few papers referring to measurement of manufacturing systems performance, most researchers being focused on financial and managerial accounting measures in order to determine organization performance.

For example, in [1] a new performance measurement model is proposed. It includes four indicators, each one with a given weight. Haskose et al. [2] take as consistent for make-to-order environment the following performance measures: work in progress, manufacturing lead time, and utilization of workstations. Chi-Wen J. Lee et al. [3] studied the relationship between the managed earnings (defined as the illegal practice when a company projects a higher profit margin to attract investors) and firms earnings performance and proposes a new performance measure, namely earnings quality, defined as the proportion of true economic earnings in total reported earnings. Ratore et al. [4] take into consideration the total productivity as an important measure of performance.

In this paper, we propose a method to control the entire production process performed by a MTO manufacturing system, from customer enquiry up to product delivery.

*Firstly*, the control achieved by implementing the proposed method includes the modeling of cost and time, two very important elements of manufacturing process performance criteria.

Current methods for estimating the cost and time are based on decomposing the product into elements, followed by cost estimation of each element and summing of the other costs. As element, we can consider a product component, a manufacturing process component or an activity component. To estimate the cost for each element, its features that are closely related to cost or time are used. With a few exceptions, the estimation methods lead to estimation without a mathematic model describing the relation between cost or time and the element’s features. Moreover, these methods have a slight adaptation capacity to different specific situations because the information that is provided in order to make estimations is general and does not adapt to a specific case.


43

Therefore, in this paper, cost and time will be estimated by a set of appropriate techniques which are based on analytical modeling, neural modeling, or k-nearest neighbour regression. Each of these techniques cover a range of specific cases. Thus the analytical technique covers the cases with known regularities. The technique based on neural modeling regards the cases when a large number of similar products are manufactured, slightly different. The k-NN regression technique is appliable in the cases when there is too little data to produce a model.

*Secondly,* the order acceptance problem is usually treated in literature by considering the single resource case with deterministic processing time. In addition, the acceptance is based on capacity-driven approach. This is why we cannot take into consideration that company performance is essentially dependent on the measure in which the accepted orders are appropriate to the characteristics of manufacturing system components. In accordance with to the method proposed in this paper, the order acceptance is earning power - driven, while workload, due date and price are considered as restrictions.

*Thirdly,* the machine control is conceived as independent to order features, such as the price of performed operation, for example. This is why, although the machine local control is optimal, the order performance level is not maximum. The method proposed in this paper removes this disadvantage in that the machine control is based on simultaneous optimization of all manufacturing processes performed for order fulfillment.

*Finally,* nowadays, the problems of *i)* order acceptance, *ii)* planning and scheduling of the production process, and *iii)* machine control are solved separately. In this paper, we propose an integrated control method for all three aspects where earning power is used as decision criterion [5].

## 2. METHOD ALGORITHM

The eight steps of the method algorithm, along with its linkage tree are shown in Fig. 2.

***I.*** *Breakdown of the current enquiry*

In this first step, each enquiry is considered as a potential order, even if a decision regarding its acceptance was not made yet. To make such a decision, this potential order is processed for enabling to generate its network routings.

Processing consists in identifying all the alternatives regarding order decomposition in jobs and operations. Each operation is defined so that it can be accomplished by using one of the manufacturing system resources. Definition includes the resource that will be used and the product status before and after the operation execution. The result is the routings network diagram of the order, associated with the definitions of all operations.

***II.*** *Featuring the order routings network operations*

For every manufacturing system resource, a set of features was a priori and definitively established. These features represent the potential input variables of the model, which describes every operation that such a resource will perform. During this stage, for each operation that appears in the routings network diagram of the current order, the values of the corresponding set of features are established, based on the operation definition.

***III.*** *Modeling the network operations*

This step consists in modeling the order routings operations, by using a proper technique (such as for example neural modeling). For every manufacturing system resource, one of these modeling techniques was a priori and definitively selected. Each operation is modeled by using the resource of the previous by selected technique. As model output variables are considered the cost, the time, the earning power, and the asset (the same for all the operations) while the input variables are selected from the resource’s set of features, in order to obtain the best operation model.

In addition, a resource-dedicated dataset containing the resource past experience is permanently updated by registering the actual data resulted after completion of the current performed operation. Depending on the modeling technique, some data are extracted from this dataset. Finally, the order routings network, associated with the cost, time, earning power, and asset models of all operations, are obtained and placed in a portfolio.

***IV.*** *Batching the orders flow*

For concurrent order processing, the orders existing in portfolio are grouped periodically, this way forming the current batch of orders. Only the enquiries found in the portfolio are considered for batching. They are either newcomers or returnees. Batching rule can be *i)* first $N_e$ enquiries, while the others are postponed, or *ii)* all enquiries found in portfolio. Period size is set according to orders flow and the due dates. Depending on company policy, the batching can take place either at certain dates or at regular intervals.

***V.*** *Orders fullfilment simulation*

The current batch of orders is analyzed in order to divide the orders in three groups: accepted, rejected, and returned to portfolio. In this purpose, for each order, the earning power is firstly evaluated by using the operations

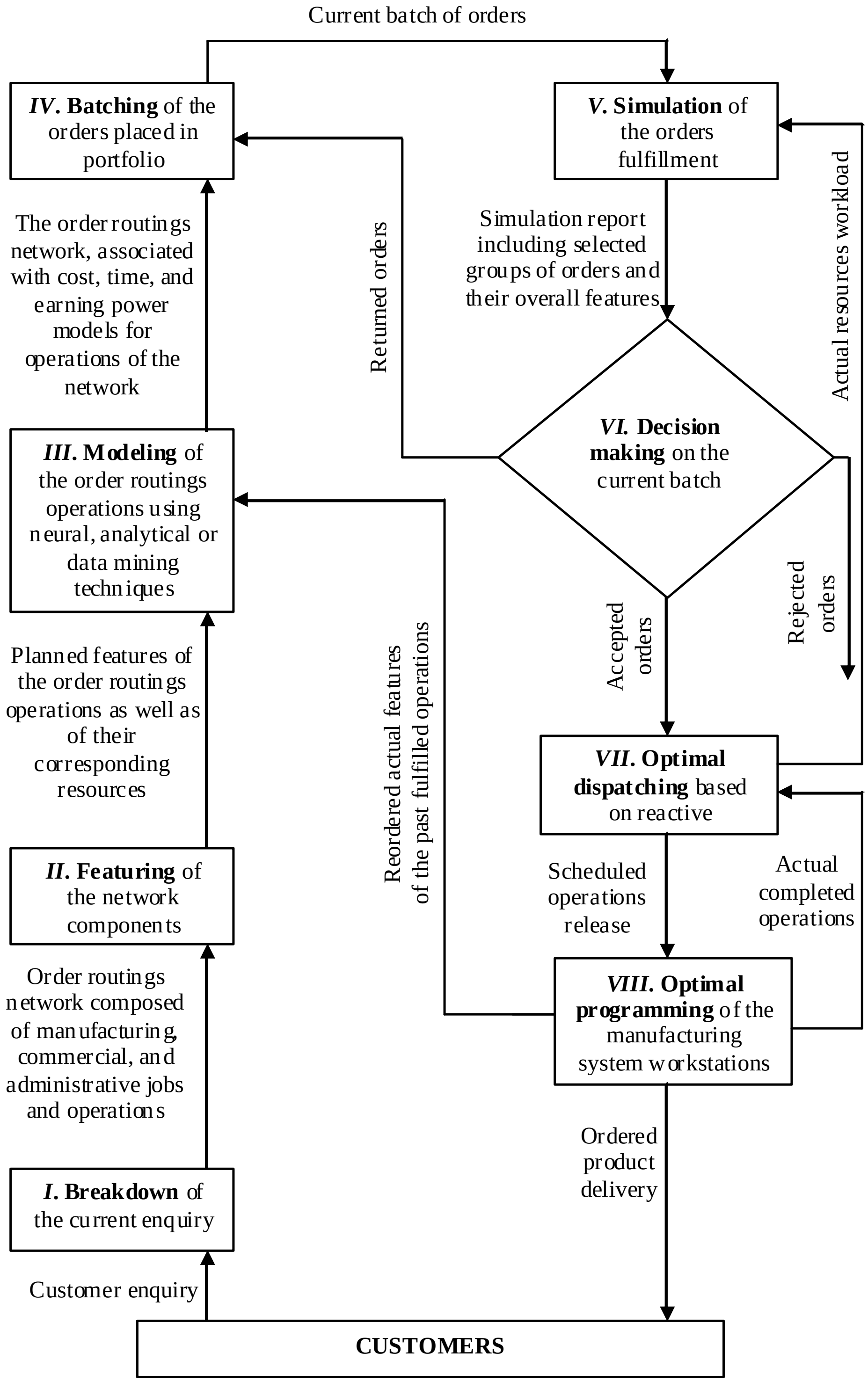


**Fig. 2** Method flowchart

models prepared at step *III*. The orders belonging to current batch are further ranked according to their earning power values. Then, one or several order groups are prepared. Such a group order contains those orders which could be accepted; the orders that are not included in the group will be either rejected or returned back to portfolio.

Orders grouping algorithm contains two generic actions, namely the group making up and the performance evaluation. For making up a group, successively, in decreasing order of the earning power value, the acceptance of each order is simulated, by taking into account the resources available workload and the due date of each included order. The performance criterion is the earning power, evaluated at the level of the entire manufacturing system and for the whole current period. Restrictions are the orders due dates.

The prepared orders groups (i.e. their content and performance) are finally transmitted to the management, for making a decision at the next step.

***VI.*** *Decision making on current batch*

During this stage some orders are accepted and some other orders are rejected.

***VII.*** *Optimal dispatching of the orders fulfillment*

The pool of orders consists in the accepted orders as consequence of the previous step. Their operations should be fulfilled according to the scheduling diagram. If a deviation from this diagram appears, during actual production process, at a given moment, then a new scheduling diagram is elaborated. The start point is the state at the given moment while the scheduling technique is the same as in simulation. In this way, the optimal dispatching is implemented on the base of reactive scheduling.

***VIII.*** *Optimal programming of the manufacturing system’s workstations*

For many system’s workstations, the cost and time depend on the process intensity. The latter is set during the workstation programming. On the other hand, let us consider that the tradeoff between cost and time will result by considering *EP* as criterion for performance evaluation. Finally, we may observe that *EP* depends on the product price.

These aspects lead to the opportunity of *EP* maximization through such a workstation programming that would be adequate to level of the product price. The action developed in this last step of the proposed method is to elaborate on these bases the workstation work program.

For example, let us consider the case of a workstation that performs a certain machining operation. The development of the part-program dedicated to this operation includes determining those values of the cutting parameters that, taking into account the price of product, lead to maximum value for earning power.

## 3. CONCLUSIONS

*Order routing networking* is an action performed by specialists knowing the manufacturing system capabilities. Currently, there are no adequate solutions for performing this action automatically. However, the facilities offered by current CAPP systems can be considered as support.

Conversely, *online modeling* can be performed automatically if a software would implement the modeling algorithm. The algorithm should be specific to each resource. In addition, it should include the data obtained from monitoring and management of the resources operation.

*Reactive scheduling* is an action with a strong general nature. It appears in two of the eight steps of the method, namely steps *VI* and *VII*. In addition, this action appears many times. Therefore, despite it could be performed manually, when the number of operations is small, however, it is preferable to use an appropriate software.

*Optimal programming of the manufacturing system resources* is performed mainly when issuing the part-program for each operation. In particular, when a CAM system is used, the subroutine for calculating the cutting parameters can implement the algorithm of this action.

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