The Efficient Management of Manufacturing Systems for the Realization of Mechanical Products

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Abstract: Today's competitive world leads to fierce industrial competition in launching new, cheaper and better products. In order to meet increasingly severe demands, manufacturers are forced to continuously improve the design and manufacturing methods of their products, to permanently modernize their organizational structure, so as to create a fluent connection between study, design, preparation, manufacturing, marketing and monitoring in operation. The method proposed in this paper facilitates the connection between the technical and sales departments by achieving an optimal control of the manufacturing systems based on the efficiency evaluation (E), considered as a technical-economic evaluation criterion of the manufacturing systems that execute, on order, small series pieces.

Key-Words: - competition, efficiency, management of the manufacturing system, order efficiency, optimal control of the processing regime, order, market.

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1 Introduction

Currently, worldwide the competition requires the realization of new products in a very short time, reducing the time between the demand for the product and its delivery to the market. The dynamic evolution of society has also determined major changes in the objectives of the economy. The market economy, with its rigors and demands, makes it necessary now, more than ever, to move from quantity to quality, and the emphasis must be placed on approaching the leading fields of science, on advanced technology and on efficient management methods. The production methods and means of the mechanical industry are being disrupted by the presence of computers, robots and numerical control. After the appearance of numerically controlled machine tools, evolutions were mainly marked by the accelerated development of computing technology, geometric modeling and graphic data processing techniques, of simulations, CAD/CAM systems, diagnostic systems and techniques, high-level programming languages and artificial intelligence [1], [2], [3].

The production function can be considered the main function of an enterprise, consisting of producing, at the desired time, in the quantities requested by customers, at a determined cost and quality, optimizing the enterprise's resources in such a way as to ensure its sustainability, development and competitiveness.

In the life cycle of a product, the design and industrialization stages have a great responsibility, influencing costs, quality and deadlines. During the creation of a product, most manufacturing companies apply a linear approach. This approach was imposed by the way the company is organized and by the flow of information between the different services [1], [4], [5].

2 Manufacturing System Management

We understand by manufacturing system an assembly of workstations selected from a workshop and used to execute an order. The workstations are interconnected, operate integratedly, as a unitary whole, with a unique management and dedicated to the manufacturing of a class of products.

The structure of the manufacturing system is established starting from the existing machine tools in the workshop and selecting those that will be used to execute an order.

By managing the manufacturing system is meant: a) assigning the operations by which a product is manufactured to the machine tools existing in the workshop, thus configuring the manufacturing system; b) programming the work cycles of the machine tools that form the manufacturing system so that, under market conditions, maximum efficiency is achieved at the manufacturing system level. Consequently, the management of manufacturing systems is a management according to the program and consists of developing the program of evolution over time of the reference values of the control variables (i.e. the variables whose values are controlled by the control loops of the workstations), followed by the execution of the respective program, respecting these values of the control variables. Therefore, in case of the management after the program , the only action that keeps the way the system works under control is to modify the program, as soon as reasons arise that require changing the way the system currently functions.

In the programming of the functioning of a manufacturing system, the basic structural component is the part program related to a technological operation. The ensemble of part programs, which are designed in such a way as to make it possible to execute a certain order received from a certain customer, and which are correlated, both in terms of the values of the process parameters and in terms of the schedule of their execution in time by the workstations that make up the manufacturing system, is called the order program. An ensemble of command programs specifically structured , as well as their execution schedule, is called a system program.

Manufacturing system management means the permanent re-elaboration of the system program, so that a certain objective is achieved and certain restrictions are respected.

On the other hand, developing the system program, corresponding to a certain manufacturing system, considered as a unitary whole, means carrying out the following actions:

a) Among the orders coming from the customer, those that the system will execute and then deliver to the customer should be accepted, the rest being rejected;

b) Among the components that have to be manufactured in order to execute the accepted orders, those that the system workstations will manufacture should be established, the rest being purchased by third parties;

c) Simultaneously, for all operations performed by the system workstations during the manufacturing of these components, to be establish, on the one hand, the values of the process parameters which be entered into the part programs by means of which the workstations will perform these operations and, on the other hand, the schedule for the execution of these operations in time. The values of the process parameters are not independent, as is currently the case, but correlated with each other in such a way as to achieve the management objective.

The development of these three actions have to take place in such a way as to ensure both the achievement of a certain objective and the satisfaction of certain requirements for the production of mechanical products.

3 Modeling Manufacturing System Efficiency

In practice, order acceptance decisions and production planning are usually made separately. The sales department makes decisions regarding order acceptance, while the production department is responsible for production planning to fulfill accepted orders. Most of the time, the decision to accept the order is made without the involvement of the production department or with incomplete information about the planning of available production capacities. The method proposed in this paper facilitates the connection between the two departments and the achievement of optimal control of manufacturing systems based on the efficiency evaluation (E), considered as a technical-economic evaluation criterion of manufacturing systems that execute, on order, small series works.

The proposed criterion is both synthetic (because it reflects the essential motivation for which the manufacturing process takes place) and compliant with the five most important aspects of performance, namely: profitability, specification compliance, customer satisfaction, return on investment and material costs, which the researchers selected in order of importance.

Efficiency modeling, E, is a solid strategy for selecting those orders that bring profit to companies. Thus, this method provides the company manager with a model with which he can interact with the economic environment in order to be able to make an offer of price so that the company is competitive.

This criterion is analyzed at the operation level of the manufacturing, the component level, and finally at the order level.

Depending on the maximum value of the order efficiency, the manager can decide whether to perform all the operations necessary to fulfill the order or not within his company. The manager can opt to outsource those operations for which efficiency does not have a favorable economic effect. Through the efficiency of the manufacturing system, E_i , is understood to be the ratio between the profit rate and the investment value, calculated at the level of the order-manufacturing system couple. It is considered that the order that the manufacturing system has to execute is made up of j components and each component, in turn, is made up of k operations. The efficiency of the manufacturing system will be relation (1):

$$E_{i} = \frac{P_{i} - \sum_{j} \sum_{k} c_{ijk}(p_{jkn})}{\sum_{j} \sum_{k} A_{ijk} \cdot t_{ijk}(p_{jkn})} \qquad \left[\frac{Euros}{Euros \cdot min}\right]$$
(1)
where:

 P_i is the price of order *i* [Euro];

 $\sum_{j} \sum_{k} c_{ijk}(p_{jkn})$ represents the expenses for achieve of order *i*, depending on the parameters *n*, of the work regime of operation *k* for the execution of component *j* [Euro];

 A_{ijk} - represents the investment value necessary to achieve operation k from component j in order i [Euros];

 $t_{ijk}(p_{jkn})$ - time for workstation's process when make the operation k from component j [min].

Efficiency can be defined at the level of operation, component or manufacturing system.

The essential attribute of the manufacturing systems management method is given by the optimal nature of the proposed method. The optimal character of management consists in the fact that: a) the structure of the manufacturing system is optimal; b) the functioning of all machine tools that make up the manufacturing system is optimal.

Currently, the structuring of the manufacturing system is done without any analysis, but only based on the availability of machine tools at a given time. The assignment of the operation to a machine tool is not optimal but just random. The work regime and the programming of the work regime on the machine tool are done based on general data that do not take into account how efficient the execution of the respective order is.

The disadvantages of current methods of managing manufacturing systems are:

- The analysis of the methods, presented in the specialized literature, for making the decision to accept or reject an order has as its main drawback the fact that this decision is made based on the time factor and the capacity factor and takes far too little account of the efficiency that could be obtained if a certain order were accepted.

- The efficiency of each operation is not evaluated so that its efficiency is maximized. In addition, alternatives are not established for situations where the technological flow is affected by production congestion.

- These methods have a poor ability to adapt to different concrete situations because the information used for estimation is general and not adapted to the specific case.

- Currently, machine tool control is performed independently of order characteristics, such as price. For this reason, although local the machine control is optimal, at the order level the efficiency obtained is not maximum.

The manufacturing systems efficiency modeling method has the following advantages:

- achieving an optimal management method for manufacturing systems in accordance with current market dynamics;

- developing a method for managing the manufacturing system taking into account the entire manufacturing-market system, this being no longer reported in the specialized literature, where there are separate approaches: technical or economical;

- the obtained model is simple to use and offers the company manager the possibility of selecting orders with a favorable economic effect;

- based on the obtained model, an optimal control of the processing regime is achieved;

- in addition to achieving an integrated control at the manufacturing system level, this method develops a strategic and tactical control of investments;

- the proposed method has a high degree of efficiency because a mathematical model is built for each series of input data. Moreover, following the practical verification of the solution resulting from the negotiation with the client, it will be added to the initial experimental data table, thus enriching the database with new experience.

4 The Algorithm of the Proposed Method

The following steps are taken within the algorithm:

1) it is decomposed the current order into operations, resulting in the network of alternative technological processes composed of manufacturing, commercial and administrative operations;

2) the characterization of the network components, that is, the determination of the network characteristics, resulting in the characteristics of the operations and of the machine tools that will execute them;

3) modeling of the operation-machine tool assemblies, existing within the technological process network, resulting in cost, time and efficiency models of all operation-machine tool associations in the technological process network;

4) simulation of the implementation of the technological processes of the network using models resulting from the previous step. The simulation is applied to the group of orders that appeared over a period of time in order to make possible the competitive evaluation of the orders. The orders are

selected for which the efficiency of the manufacturing system is maximum and the restrictions specific to the orders are satisfied (time and price constraints);

5) programming the work cycle of the machine tool that executes the operation that has been associated with it and to which the working regime is established in such a way that the efficiency of the manufacturing system is maximum, and in that the techniques used in modeling the efficiency are adaptable to the specific processing case.

4 Conclusion

The method of managing manufacturing systems using the efficiency modeling aligns the system's operation with market dynamics.

This method offers the enterprise manager the possibility of selecting orders with a favorable economic effect.

The technical problem that this method solves is to optimally manage the functioning of manufacturing systems by controlling, throughout the technological path of manufacturing a product, all combinations between technological operations and the machine tools that execute them, on the one hand, and on the other hand, by controlling all processes through which the machine tools execute the operations with which they have been associated.

Modelling Manufacturing System Efficiency will help the manager of company to accept or not an order and it will enable to perform an optimal control of the manufacturing system.

Through the efficiency production lines, this approach lowers costs of manufacturing, improves product quality and reduces waste. These efficiencies prove essential in a competitive world, enabling manufacturers to deliver value to customers while managing tight margins.

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Conflict of Interest

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