Behavioral Relationship of the Market qnd Manufacturing System

GHELASE DANIELA, DASCHIEVICI LUIZA
Faculty of Engineering and Agronomy
"Dunarea de Jos" University of Galati
Calea Calarasilor, nr. 29, 810017, Braila, ROMANIA
luiza.tomulescu@ugal.ro

Abstract: - In order to progress in the present-day complex and unpredictable environment, the company must feature abilities of quick response and favorable reposition itself on the market. Acquisition and preservation of this capacity is the most difficult step for companies as it involves many endogenous and exogenous factors and the process is continuous, dynamic and hardly predictable. The paper goal is a new approach of the manufacturing systems - market assembly, with a view to finding the quantities that characterizes it, the laws that govern it, the relationships that describe it, and on this basis, to design a competitive management system of the assembly as a whole. The approach is general, but the application is focused on the manufacture of mechanical products, in small and medium series, always taking into account the dynamics of the interaction factors.

Key-Words: - behavioral modeling, cost estimation, product time, manufacturing system

1 Introduction

The system environment provides on-line data on the actions undertaken which, properly analysed and correlated, will further generate solutions in order to develop said system and make it competitive.

The paper aims, in the field of manufacturing technologies, at approaching issues of manufacturing systems, in order to develop a new concept of management, which is in line with the current market dynamics.

The dynamic changes and the overall progress of society are reflected at company level by many orders in number, small in volume, very diverse, obtained through frequent auctions with short - term response, which leaves no time for a relevant analysis of said orders [1].

To be competitive, enterprise should be able to produce a variety of components at law costs and in a short time.

In order to achieve this goal, during the negotiation process, the manager based on the product time and cost estimation has to decide quickly and correctly if the order is competitive.

It is very important in winning an order if the response time requested by the client is short.

A slow response can determine losing the order because the client may choose the offer from another competitor that submits a quotation faster.

The cost estimation is used in price determination. If the price estimation is less than product cost then can be financial losses for the enterprise.

On the other hand, if the price estimation is much higher than the product cost it is possible that the client to place his order with another company that offers a better price.

The product time estimation is used to determine the date of the delivery. It is known that any delays in the product delivery can lead to financial loss.

The classification of the different methods and estimation models used to obtain a reliable quotation is presented in [2] as follows:

1) qualitative estimation methods;

2) quantitative estimation methods.

The study [2], that is a review of the different types of the product cost estimation, concludes that qualitative estimation methods are based on the analysis of the new product as compared to products developed previously. On the other hand, quantitative estimation methods are based on the analysis of detailed product design, its features and manufacturing process.

Qualitative estimation methods include:

a) Intuitive methods- based on the use of previous experience. Of them can be observed: Case-based methodology; Decision support systems;

b) Analogical methods- based on the similarity between the new product and past cases. These methods can be classified as: Regression analysis; Artificial neural networks.

Qualitative estimation methods include:

a) Parametric methods- derived from the application of statistical methods to define the cost as a function of different product variables. These methods provide fast estimation;

b) Analytical methods- based on the breakdown of the product into elements. Product cost is calculated as a sum of all of the components. Of these methods that are amongst the most reliable can be cited: Operation-based; Breakdown-based; Tolerance-based; Based on the product feature; ABC method (activity-based-costing).

Note that there is a classification of the traditional estimation methods as:

- Detailed breakdown methods;
- Simplified breakdown method (designed for estimation during the initial design phases);
- Methods based on the technological group (based on similarity);
- ABC method.

Manny researchers [3] consider that the use of a single estimation method is not enough to generate a estimation in the case of the initial phases because of the detailed information they require.

In this paper it is proposed a product time and cost estimation method taking account the market dynamics and manufacturing system competitiveness, based on the behavioral modeling (term introduced by the authors).

In the literature no attempt to approach the whole manufacturing system – market assembly is reported; therefore, there are significant resources to improve performance which are not used because the technical and economic aspects are dealt with separately.

Also, it is not known an algorithm for the management of the manufacturing system – market assembly, but only algorithms for the technical control of the technological systems-components of the manufacturing system and tools of economic management of the relationship between the enterprise as a whole and the market.

The interaction between the economic environment and the manufacturing system is a major source of knowledge about the economic environment and the manufacturing system themselves.

The manager of an enterprise is in the situation that has to make a quotation of price for elaborate an offer in order to negotiate.

Thus, the question that occurs is: how competitive is the product on the market?

To answer at this question, the manager is obliged to establish a link between task and performance or profit of manufacturing system in order to negotiate the contract.

The link between task and performance is built on a mathematical relationship, using datasets, created by the manufacturing system, in situations similar but not identical.

In other words, knowing this relationship, the manager will make control based on competitiveness (performance) of manufacturing system and will negotiate the contract in effective terms.

Adaptive control of the manufacturing system occurs when must be obtained a batch of parts in certain circumstances: time, cost, etc. In this case, the mathematical model have to be modified, so to respect the requirements and will be modify process parameters.

Well, another set of data known, is a new mathematical model (another relationship task-performance) with other process parameters in order to see how to change the behaviour of manufacturing system

The problem is the following: giving a batch of parts to be manufactured, in terms of working time required and a minimum cost, to evaluate the process parameters to assure compliance (achievement) of these conditions.

However, approaches are of economic and managerial nature, while the relationship with the technical aspects of competitiveness is less noticeable. At this point there is no defined algorithm to evaluate the technical and economic competitiveness, moreover, the technical factors are not considered at a practical level, when defining competitiveness, although consumption and costs incurred by the technological processes are generated by technical actions.

In this context, the notion of competitiveness gains new valences, including factors and policies that determine the ability of the enterprise to get a favorable place on the market, to hold that place and to continuously improve its position. Only in this way can competitiveness fully and synthetically characterize the enterprise viability.

In concordance of the specialty literature, an enterprise is competitive on a certain market when it obtains, at an acceptable level, certain economic indicators: cipher of business, profit, market segment comparable or superior with one have another competitors on the same market.

In the paper, competitiveness will be understood as the capacity (potential) to provide performance (compared with other similar elements), in a very punctual way, within a macroeconomic concrete context and at a certain time.

Moreover, according to a meter of competitiveness (considered as an essential performance indicator) it will be assessed the extent to which the company achieves the purpose for which it has been created.

Therefore the paper aims at making a numerical and on-line evaluation of the technical- economic competitiveness and the management of the manufacturing system is performed to obtain maximum competitiveness. Thence, it follows at the current level the competitiveness is definite by the economical factors and indicators obtained.

In this moment the algorithm for technical-economical competitiveness evaluation is not defined and, more the technical factors are not taken into account, also consumptions and expenses caused by the technological processes are generated by the technical actions.

In this context, competitiveness notion has new valences, because it's assembles the factors and politics which determine the enterprise capacity to occupy a favourable place on market, to keep that place and to improve the position.

The competitiveness characterizes synthetically and completely the viability of the enterprise. It isn't reported in the special literature a approach of the ensemble manufacturing system-market.

It isn't known an algorithm of management of ensemble manufacturing system - market, but just algorithm of technical management of the manufacturing system and economical of the relation with the market [5].

Today the manufacturing systems are managed through the programs of the machines tools with numerical program.

Management is exclusive technique because doesn't exist an economic variable which in fact is an ultimate consequence.

Dynamic changes and the general progress of society translated to the level of the enterprise through many orders as the small volume, very varied, obtained through frequent auctions with answers in short terms, carry it doesn't offer the times for analysis pertinence statements.

Consequence, it can not be managed for a long time. It is enforced a method of the fluctuant on-line, prompt reaction, speeder management [3], [6]. The dynamism from the market is transmitted into the management.

The rest of the paper is structured as follows: section 2 presents problem formulation, section 3 describes behavioral modeling method, section 4 contains a case study and section and 5 summarizes the main conclusions.

2 Problem Formulation

The interaction between the economic environment and the manufacturing system is a major source of knowledge about the economic environment and the manufacturing system themselves. Product prices have a strong informational load.

They inform producers about the economic profit margin that they may receive by producing the products they offer. In determining a price of the product have to know the necessary costs of the product production.

In market economy conditions, a product cost estimation and time for achieving it are problems of concern to any enterprise manager.

The manager of an enterprise is in the situation that has to make a quotation of price for elaborate an offer in order to negotiate.

Thus, the question that occurs is: What price must have product to win the auction? For this, manager is obliged to establish a link between task and market in terms of customer requirements.

Manager develops an action of exploiting already knows and an action of exploration in order to choose the better in the future.

In order to face these situations, the manager has set specific goals, can realize the different aspects of the economic environment and can make choices after which selects the efficient actions.

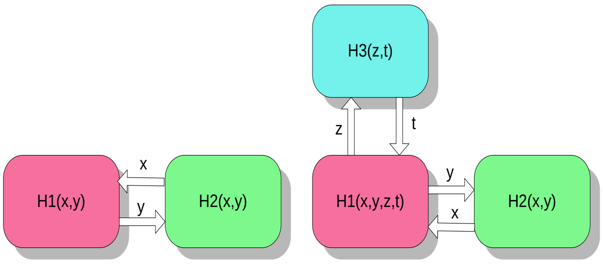
Result of the actions of an exhibition provides information about how effective was the action.

Consequently, the aim of this paper is the achievement behavioral modeling of the market-manufacturing system relationship to develop the strategic component of the competitive management, thus ensuring extension in time of the current performance.

3 Behavioral Modeling Method

By competitive management adaptation takes place of the manufacturing system for the purpose of profit maximization. To achieve adaptation, it is necessary to achieve modeling of the interaction between all elements of manufacturing system - market assembly, which shall be called behavioral modeling from now on.

The term of behavioral modeling is introduced by the authors of this paper and, for presenting this notion, we shall consider two elements H1 and H2, which interact with each other (Fig. 1. a). Model H1 of the first element establishes a connection between the input x and output y). If x and y are at the same time input and output of another element, whose model is H2, then the two elements interact with each other.



a b
Fig. 1. Behavioral modeling

Modeling their interaction (behavioral modeling) means setting the pairs of values (x, y) which satisfy the transfer functions H1 and H2. The multitude of solutions which satisfy both transfer functions H1 and H2 represent the behavioral model because they describe the behavior of the elements during their interaction.

For instance, under the theme concerned, H1 could stand for the manufacturing system while H2, for the market.

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For instance, under the theme concerned, H1 could stand for the machining system while H2, for the market .

Behavioral modeling becomes increasingly complex as the number of interacting elements is growing too.

For example, in case of Fig. 1.b, thr elements interact and behavioral model represen the relationship between the values of *x*, *y*, *z* and for which the three elements can interact.

Considering elements H1 and H2 with the following transfer functions:

$$\begin{cases} H1(x,y)=0 \\ H2(x,y)=0 \end{cases} \quad (1)$$

then, the solutions of the system (1) represent the behavior model of H1-H2 assembly. If the solution is unique, then the behavioral model is reduced at one operational point.

Considering H1(x,y) and H2(x,y) as being two lines, then the solution of the system is the intersection point H0 (Fig. 2).

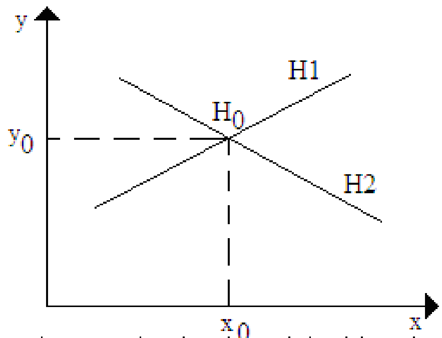

Fig 2 Behavioral model with unique solution

If there is a values string x_0 and y_0 as solutions of the system (1), then the behavioral model includes all these points (Fig. 3): (x_0', y_0'), (x_0'', y_0''), (x_0''', y_0''').

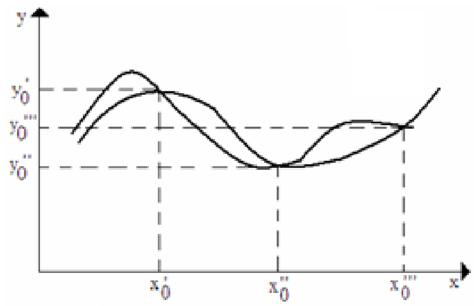

Fig 3 . Behavioral model with multiple solution

If the system (1) is incompatible, then there isn't any behavioral model that meets H1 and H2 assembly.

In the case of Fig.1.b, the case of the interaction of three elements H1, H2, H3, the behavioral model is given by (x_0, y_0, z_0, t_0), the system solution:

$$\begin{cases} H1(x,y,z,t)=0 \\ H2(x,y)=0 \\ H3(z,t)=0 \end{cases} . \quad (2)$$

As the number of variables is more then equations, we expect the system (2) is indeterminate. The model will include an infinite number of points.

The behavioral modeling method of the machining system-market assembly is developed on these assumptions:

- elements H1 (machining system) and H2 (market) operate and are monitored on-line;
- during operation, elements H1 and H2 pass through different states, that means they operate with various values of the state parameters.

For example, H1, the machining system, processes various products with various machining parameters and with various time, materials consumptions.

Element H2, market, operate similarly, selling various products with various prices in various supply conditions.

- elements H1 and H2 interact, but not throughout their operation (the machining system can interacts with another markets).

Models currently used in the management of the machining systems, whether analytical, numerical or neural (or, in general, algorithmic), refer to the components of the systems.

Building of models in all cases is based on off-line experimental investigation of an element, making up a set of experimental data and using it to select, out of a given family of data, the most appropriate model.

There are no cases reported in literature of behaviorally modeled systems where, by monitoring the current operation of the machining system concerned, to extract on-line knowledge which relates to the interactions taking place in said machining system, although, for a competitive management, it is in fact required to model the interaction between the system components.

The concept of competitive management of the machining systems will be developed based on behavioral modeling, which will describe the interaction between elements (technological system, machining products, market).

Behavioral modeling becomes increasingly complex as the number of interacting elements is growing too.

For example, in case of Fig. 1.b, three elements interact and behavioral model represents the relationship between the values of x, y, z and t for which the three elements can interact.

The algorithm used for modeling is based on states clustering

and consists of following steps [4]:

- Step 1: clustering of variables based on the causal relationships;
- Step 2: states clustering;
- Step 3: building of the mathematical model corresponding to the states cluster and variables cluster set.

Then the causality relationships between parameters are identified. Based on these relationships, clusters of independent variables are established.

Further, based on the dataset to be used for the model fitting, a cluster of neighbouring states is made up, at the centre of which is the state to which the respective input data are related.

Finally, a linear model whose variables are the variables of one of the clusters of identified variables is fitted on the manufacturing system states cluster. These input data are the ones which have been previously considered in the procedure of enclosing the manufacturing system states cluster.

It can be noted that, according to the proposed method, the model construction and its operation are accomplished within an integrated algorithm which is run through upon each interrogation of the manufacturing system model.

At the operational level, the variable clustering is based on the "*best NN model*" facility which is offered by the neural networks technique applied to a data set recently obtained from monitoring the manufacturing system. The states cluster construction implies the using of the 2^{nd} rank Minkowski distance for the classification of states. That is why only the variables representing these input data will be considered in the calculation of Minkowski distance.

The states cluster is to be obtained either by restricting the value of the distance or by restricting the number, *k*, of retained states or using these two conditions.

The construction of the mathematical model is made by linear regression. It can be noted that this is a local model, as it is valid only in the vicinity of the state for which the model is interrogated.

This model is meant to be used just once as, after the interrogation, it is given up.

In conclusion, the aim of the proposed method is to develop a cost estimation for the required product in terms of time required by the customer.

To be sure winning the product auction, the manager must to apply an attractive price.

In determining the price of the product is necessary to know the product cost. Thus, for a specific task required and in imposed time conditions, through modeling are obtained the relations as:

$$\text{Cost}=f(\text{task}) \quad (3)$$

$$\text{Time} = f(\text{task}) \quad (4)$$

At the same time, the manager must have a model of the product markets by monitoring the auctions.

Auctions provide data on market price quotation.

By modeling of market data it obtained a relationship of dependency as:

$$\text{Market}=f(\text{task}) \quad (5)$$

The method proposed for achievement of the three models consists of monitoring and recording the relevant state variables of the manufacturing system in a database (fig.4).

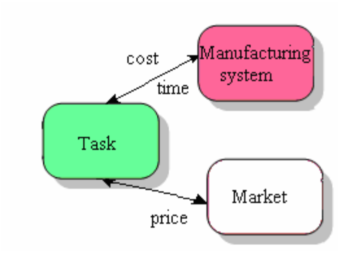

Fig. 4. The interaction between task-manufacturing system and between market-task

4 Study Case

In today's economic context, the corporations and the business environment in general are producing data in enormous quantity and on daily basis.

During the experiment data have been collected with regard to the manufacturing machines that had been used for manufacturing some important parts in the construction of dump truck bins, namely the attachment plate of the supplementary chassis of the dump truck bin (fig.5).

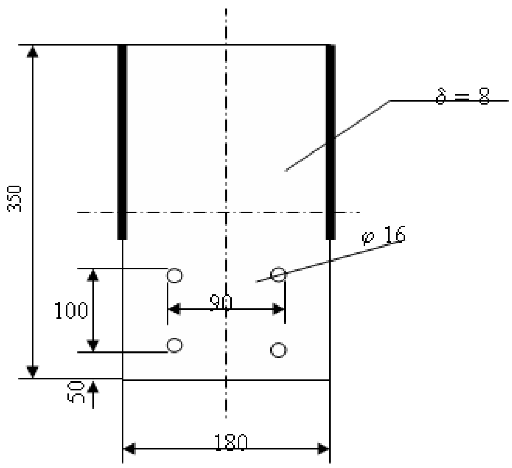

Fig. 5 Attachment plate of the supplementary chassis of the dump truck bin

Data regarding the actual work times, data referring to the modes of operation, data regarding the amounts of resulted wastes, data regarding all types of consumption, as well as data regarding the orders for delivered products were collected.

We use the database of a cutting process that has the following parameters: type of the material, length of cutting, cutting width, cutting speed, the advance of cutting, number of pieces, machining time, energy consumption, cost of operation and waste quantity, table 1.

Identification algorithm uses as input data a set of monitored variables, between which it exists an implicit relationship.

In order to succeed in demonstrating the viability of the solution to the problem of product time and cost estimation running of the modelled manufacturing systems, a practical database resulted from process measurements was obviously required.

For this, measuring and monitoring of the cutting process were made, whose results are summarized in the table 1.

Analysis of cluster is a descriptive technique used for grouping similar entities from a data set or equally for entities that present evidence substantial differentiation from the group.

Clustering techniques in clusters is based on algorithms from the neural networks.

Clustering variables consists in grouping variables which are variables in dependence.

Thus using "best NN model", the choice of many consecutive columns and determination of the best links with the 1, 2 or i variable we determine the cluster of variables which are in the best relationship of dependency.

For example, in table 1, considering the cutting process variables that denote the V_1, V_2, ..., V_{10} and using the "best NN model" facility, results the column V_7 - time of cutting, as the most influential variable in determining the time of operation.

There are the best relationships with dependent columns V_2 and V_4.

Clustering states:

Suppose that the manufacturing system is required to execute an operation that $V_2 = 150$, and $V_4 = 3$, where you don't find in our experiment.

Clustering states consists in identifying groups of related records that can be points of departure for further exploration of relationships. In the process of grouping elements is necessary to estimate the minimum distance between those elements with the function:

$$d=\sqrt{\left(V_2-150\right)^2+\left(V_4-3\right)^2} \quad (6)$$

Table 1 - Example of experimental data regarding the process variables collected for the cutting off process

Item nr.	Type of material	Length of cutting (mm)	Cutting off width (mm)	Cutting off speed (mm/s)	Feed rate (mm/s)	Number of pieces	Machining time (s)	Energy consumption (kwh)	Cost of operation (Euro)	Waste quantity (Kg)
-	**V_1**	**V_2**	**V_3**	**V_4**	**V_5**	**V_6**	**V_7**	**V_8**	**V_9**	**V_{10}**
1	OL 52	350,1	180,15	3,1	0,5	50	1200	14,74	1.781,35	26,512
2	OL 52	253,1	184,15	4,1	1,5	75	2254	18,24	2.186,25	32,787
3	OL 37	257,15	172,1	5,1	2,5	100	2011	24,84	2.861,66	42,912
4	OL 42	462,05	268,1	5,15	2	45	3201	18,45	2.190,45	32,862
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The mathematical model

Mathematically can write a linear relationship:

$$V_7=a\cdot V_2+b\cdot V_4 \quad (7)$$

Retaining the first 2 states, so for k = 2 according to k-NN algorithm can be written:

$$\begin{cases} a\cdot 158,25+b\cdot 1,2=8201 \\ a\cdot 158,25+b\cdot 9,25=8835 \end{cases} \quad (8)$$

which represents a system of two equations with two unknowns. Finding system solutions are obtained the values for *a* and respectively *b* which are replaced in the relationship (7) resulting relationship (9).

$$V_7=51,225\cdot V_2+78,75\cdot V_5 \quad (9)$$

Linear model so determined will be used in modeling task-time relationship. This is a local and ephemeral model.

Taking the reasoning again we modeled the relationship between task and cost. In this case we found that the influence variable is variable V_8, using "best NN model". Similarly on determine:

$$V_8=0,05\cdot V_2-1,08\cdot V_4 \quad (10)$$

Returning to the our example above, the V_2 = 150 and V_4 = 3, it follows the same steps as in modeling of relationships: task-time and task-cost and obtain a mathematical relationship for model task-market model, taking V_9 as the influence variable.

$$V_9=5,78\cdot V_2-116,52\cdot V_4 \quad (11)$$

In conclusion, if we introduce variations of the process parameters and a variable restriction we can get a table of solutions that will help to find common solutions through negotiation between the customer's requirements and possibilities of economic and technical producer.

5 Conclusion

The developed algorithm allows the identification of the variables of one model that represents the relation between the output and the input model.

This relation represents a technical-economic model that can control a manufacturing process without experiments and based on the extraction of the knowledge from the previous experience. The obtained mathematical model is used for the manufacturing system control, namely, to check its performances.

The adaptive character of the manufacturing system control is given by the change of the mathematical model depending on the customer requests.

The proposed method consists in determining of the causal relation between one controlled variable and the monitored variables and then predicting its value in order to realize adaptive control of the manufacturing system.

We propose to give managers a model so that they can interact with the economic environment (market). Practically, this happens before the actual work of manufacturing system, so we have to do with a function of anticipation.

The proposed method has the advantage of being applicable to any manufacturing system, regardless the physical nature of the process and the product features.

The method provides the extended modelling of the manufacturing system.

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