Control based on in-cycle learning of manufacturing system

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Abstract - *The paper approaches the problem of strategy and control of manufacturing systems which be according with present dynamic of market. The system environment gives on-line data regarding undertaken actions which analyzed and correlated will generate the solutions to manufacturing system to obtain and increase the competitiveness. In the specialty literature, the competitiveness is analyzed in specially from view point of economic and managerial, entering any the less or not at all in the analyze of technology role for the providing and increasing of the competitiveness. Appears here the necessity of competitive management of the manufacturing systems based on technical-economic modeling of the system environment and cycle learning. The aim work is the achievement of modern and general approach of technical-economical competitiveness of the manufacturing systems taking into consideration the dynamic of the interaction factors from the economical environment.*

Key-Words - competitiveness, reinforcement learning, on-line learning, manufacturing system, adaptive control, competitive management.

1 Introduction

On world wide plan, the enterprises are confronted with a dynamics more and more accelerated and unpredictable changes.

This is influenced by the technical and scientific progress, dynamic requirements of the customers (Edson Pacheco Paladini, 2008), (Gi-Tae Yeo, 2008). These changes determine an aggressive competition at the global scale, what require the establishment of new equilibrium among economy, technology and society.

The characteristic aspects of the present market, in particular case of the mechanical parts market, are the following:

i) the current dimension of the statement diminishes continuously what leads to the making up of small manufacturing series;

ii) the accentuated tendency of the products personalization leads to marked diversification of the forms, dimensions and another characteristics of the mechanical parts requested on market;

iii) flexibility, responsiveness and specially efficient management of the manufacturing systems tend to become the characteristics what determine firmly the competitiveness of the manufacturers of components and mechanical constructions on market. The present dynamism of the industrial and business environment is the great global challenge and we must carry out it.

In literature, a manufacturing system is competitive on a certain the market when it obtains certain economic indicator: encipher of business, profits, segments of the comparable its superior market with one have another competitors.

The approaches of the competitiveness problem (Gi-Tae Yeo, 2008), show that, in this time, the competitiveness is defined though economical factors and indicators obtained and it is a suggested notion than numerical evaluation.

In world exist the prestigious research centres of competitiveness, such us: Centre for International Development - Harvard University USA, European Institute of Technology with its centres from Cambridge, Geneva, Oxford and Organizational Competitiveness Research Unit of Sheffield Hallam University- Great Britain, which approach the competitiveness at global, regional level up to enterprise level. But, approaches, are economical and managerial nature, unless noticed the link with technical aspects of competitiveness (Jerard R.B., 2001).

To survive in present complex and unpredictable environment, the enterprise must have the capacity of the quickly reaction. In order to make this happen the enterprise must occupy favorable positions on market. But, this aim is very difficult for the companies, because involves many endogen and hexogen factors and the process is permanent, dynamic and unpredictable. In this context, three elements remark through their relevance: competitiveness, manufacturing system and knowledge system.

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, through competitiveness of the enterprises we understand the capacity (the potential) of enterprise operated comparative performant with other enterprises in the punctual mod context macro economical concrete to a given moment.

Thence, it follows at the current level the competitiveness is definited by the economical factors and indicators obtained.

We can say as through competitiveness of the enterprises we understand the capacity (the potential) of enterprise operated comparative performant with other enterprises in the punctual mod context macro economical concrete to a given moment. The performance is measure in which the enterprise meet aim for which is creased.

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 its 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.

Unless the competitiveness characterizes synthetically and completely the viability of 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 (Lan C.H, 2002).

Today the manufacturing systems are managed through the programs of the machines tools with numerical program (Koren Y, 1999), (Yun W.S, 2002).

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 (Jerard R.B, 2001). The dynamism from the market is transmitted into the management.

2 The development of the strategic and control concept of manufacturing systems based on cycle learning

The development of the concept will be based on the obtained results by the paper's authors, concerning the rigorous analytical and general describe of econometric of technological system, made up machine tool, apparatus, part and tool (Martin P, 2005).

In the figure 1 is presented a summary synthesis of the resultant conclusions: the ones obtained in the case of cutting process.

From analyze of figure 1, which, in the *ZOY* plane, presents cost curve, *c*, and productivity curve, *q*, depending on process intensity, *R*, it is observed that c is minimum in the point where value of the process intensity is *Rc* and productivity curve, *q*, is maximum in the point where value of process intensity is *Rp*.

It is not possibility to obtain simultaneously minimum cost and maximum productivity because *Rc* is different from *Rp*. For a better understanding, will preset the case of the cutting process. Thus, in the figure 2 is presented the productivity *q* and the cost of the cutting process *c* dependence of durability of the cutting tool. As important parameter in the technical and economic defining it is considered the specific price *p* as: $p = \frac{selling\ price}{surface\ area}$ (1)

The specific margin (ROL/min) it is defined with the expression:

$$P = (p - c)q \tag{2}$$

It is obtained the margin formula:

$$P = \frac{c \cdot p \cdot s^{1-x} \cdot T^{1-m} - c_\tau \cdot T - c_S}{T + \tau_S} \tag{3}$$

By nulling the derivative of the P from (3) with respect to T, it is calculated the optimum durability T_{op}.

The optimum durability T_{op} is given by expression:

$$T_{op}^{m} - \frac{(1-m) \cdot c \cdot p \cdot s^{1-x}}{c_r} \cdot \frac{T_{op} - T_{pr}}{T_{ec} - T_{pr}} = 0 \tag{4}$$

Using the cutting behavior in order to lead of a durability of the tool $T=T_{op}$ it can be computed the maximum margin.

In figure 3 it is shown the optimum dependence on selling price p_v. In order to achieve optimum it is necessary firstly to determine parameters characterizing the analyzed system. The question is: how do we manufacture, more and more expensive or less and cheaper to obtain a profit as much as.

To answer this question, let see the spatial evolution of the maximum profit (P_{max} curve), depending on the competitiveness, *C*, and process intensity, *R*. Let considered to levels of competitiveness $C^{(1)}$ and $C^{(2)}$.

From researches of authors resulted that during the competitiveness *C* is increasing, the productivity (q curve) becomes more important than the cost (c curve) and the optimum intensity of the process, *Rp*, tends asymptotically to the point *Rp* (see the path $C^{(1)}$-E-B-$P^{(1)}$max).

For the value of the competitiveness $C^{(2)}$ the cost becomes more important and optimum intensity of the process tends to point *Rc* which represents process intensity for minim cost c_{min} (see the path $C^{(2)}$-*D*-*V*-$P^{(2)}_{max}$).

In limit case, when the competitiveness is null, (all auctions are lost at limit), than the maximum profit what can be obtained is null and this situation can be only if the process intensity is *Rc*.

It is obviously that the working with minimum cost is a limit what we don't want to touch it. In conclusion, the process intensity modifies depending on the competitiveness between the limits *Rc* and *Rp* without to touch one of them. The competitiveness will determine, for each element of the manufacture system, the optimum level of the process intensity.

As it is shown before, by competitive management, the adaptation of the management system is made to maximization of the profit.

To achieve the adaptation, it is necessary the modeling of the interaction between the ensemble: manufacturing system-market. We consider two elements H_1 and H_2 which interact between them (figure.4). The model H_1 of the first element establishes a connection between input *x* and output *y*. If *x* and *y* are, in the same time input and out put of the other element H_2, then the two elements interact.

Their interaction modeling means establishment the values couple (x,y) which satisfy the transfer functions H_1 and H_2. The multitude of solutions which satisfy the both functions H_1 and H_2 represents the model, because it describes the elements behavior, during their interaction. *H1* could be represented the manufacturing system and H_2 – the market.

3 The application of the strategic and control algorithm of the manufacturing systems for the manufacturing systems of the mechanics buildings

Through application of the competitiveness management at manufacturing system of the mechanics buildings, we can release a management of these systems.

The authors of the paper propose a block scheme and on its base can elaborate a competitive management algorithm, figure 3, which is a strategic and control algorithm of the manufacturing systems for the manufacturing systems of the mechanical buildings based on in-cycle learning..

The manufacturing system receives contracts after auctions of the market.

The competitive management system means the competitiveness evaluation and, on its base of the auction the manufacturing system receives instructions about caring on mode of the manufacturing process to obtain maximum competitiveness.

On the other hand, as a result of the competitiveness evaluation, the management system must give the competitive offers which will enter in auctions.

To realise these two objects, the competitive management system uses reinforcement learning method to know the market and on-line unsupervised learning method to know the manufacture system.

Watching each line from block scheme (figure 5), we can see the following:

- the modelling algorithm of the market-manufacturing system relation includes using the data base from economical environment (auctions), extraction of the knowledge through data mining and realisation the model through reinforcement learning;
- for obtaining of the punctual competitiveness indicators will be constituted the data bases from competition environment and will extract knowledge to evaluate the competitiveness;
- the offers from market enter in competition environment to generate contracts for manufacturing system;
- the modelling algorithm of the manufacturing system is realised leaving from the contract specifications and identifying the system.

Using data mining, will be obtained data set about functional and economic parameters, the dates which will be used for development of the model through unsupervised learning methods.

On base of above learning processes will be realised the strategic and control modelling of the ensemble of the manufacturing system – market and a possible implementation of the management system. The manufacturing system will receive instructions about the way of development of manufacturing processes to achieve the maximum level of the efficiency (maximum profit).

The algorithm follows conceptual and it will be materialized through the system of relations between the value measures of exogenous and endogenous factors of the manufacturing system come from reality through relation modeling manufacturing system – economic environment and functional modeling of the manufacturing system.

The modeling is based on the reinforcement learning and on-line learning.

The stages of the algorithm are:

- the determination of the relations of the manufacturing system with economic environment through reinforcement learning;
- the determination of the relations results from functional modeling of the manufacturing system;
- the determination of the system of relations among the groups of endogenous and the exogenous factors of the manufacturing system.

For the verification of the accuracy and applicability of the concept of competitive management of the manufacturing systems it is necessity to obtain results on a concrete case. In this sense, it is simulated and modeled a real manufacturing system of a pilot enterprise which works in the real conditions on a real market with values of parameters tacked from the economic reality.

4 Conclusion

The paper develops the notion of competitive management of the manufacturing system through modeling and on-line learning.

Increase competitiveness is not a process of exploit of a short-time advantages but it appears as a complex process and constitutes the support of an economic structures based on capital investments, on scientific research, development and innovate.

It is necessary to put in obvious the correlations among economical average (the market, competition) and the manufacturing system and to study the role which they have it in the acquirement and the increase of enterprise competitiveness.

This becomes still more pressing due to the fact as the special literature consigns studies about competitiveness at least to the level of the enterprise and studies about process and technology of manufacturing system don't connection between the two entities in the context of the technical economic competitiveness.

In this context, the competitive management can offer solutions for development and competitive enterprises.

Through this type of management the technical phenomenon is associated with the economic phenomenon.

This paper proposes a modern approach about manufacturing system competitiveness because:

- manufacturing system competitiveness is approached in a new manner, original by using investigation modern methods, which takes into account all the factors which influence the realisation, keeping and increasing of industrial enterprise competitiveness;
- it is proposed a mathematical evaluation methodology of technical-economical competitiveness of manufacturing system;
- it is proposed a new management concept of manufacturing systems, based on modelling of ensemble of manufacturing systems-market and implement of this concept into the level of the manufacturing system.

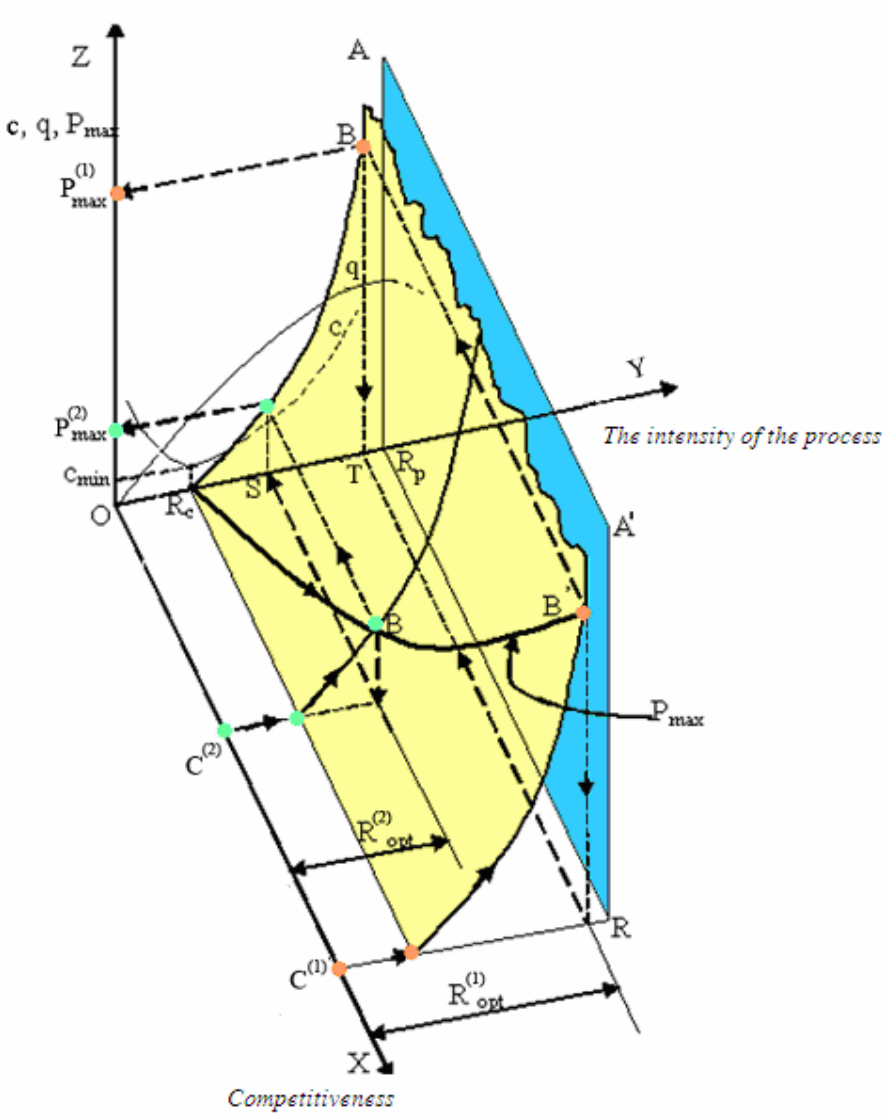

Fig. 1 Curve of maximum profit

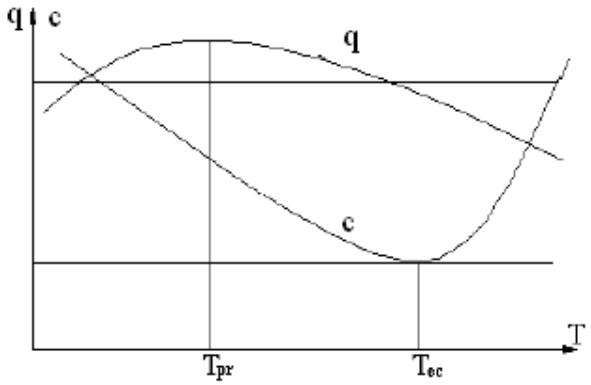

Fig. 2 Productivity q and cost c charts function of tool durability T

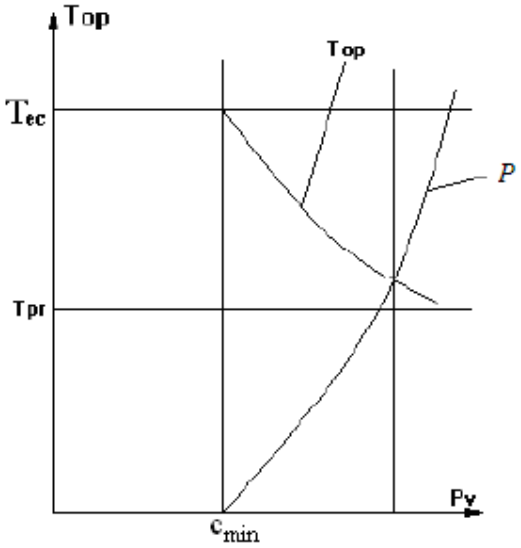

Fig. 3 The optimum durability chart and the ximum profit depending on selling price p_v

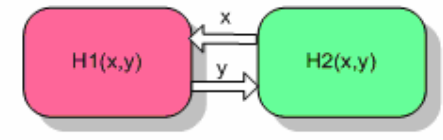

Fig 4 Interaction modeling of the elements of the strudied ensemble

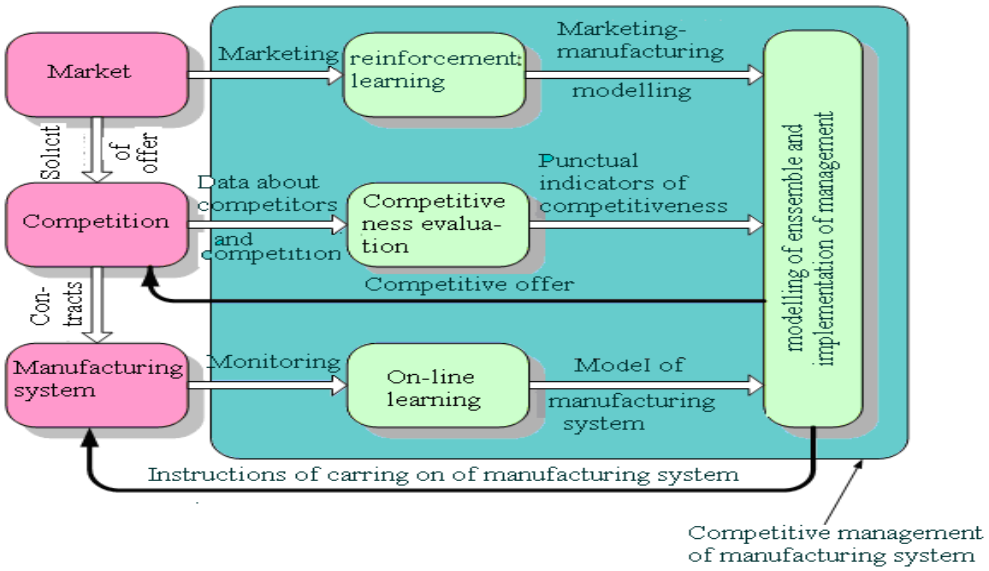

Fig.5 Algorithm of competitive management

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