THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224-5615
2014

MONITORING AND CONTROL OF MANUFACTURING PROCESS

Assoc. Prof. Dr. Eng. GHELASE Daniela
Assoc. Prof. Dr. Eng. DASCHIEVICI Luiza
„Dunarea de Jos” University of Galati

ABSTRACT

According to this new approach, a machining system interacts with the “market” carrying out a certain “service” (machining “service”) for a specified “client” (the work piece) it establishes a full economic relationship with. We consider that the machining system has itself a business model and a business plan.
In this paper, competitiveness will be understood as the capacity (potential) to provide performance (compared to other similar elements), in a very exact way, within a macroeconomic concrete context and at a certain time. The concept of competitive management can offer solutions even to make competitive and develop enterprises as a whole.

KEYWORDS: competitive management, manufacturing process, efficiency, econometric model.

1. Introduction

Nowadays, the manufacturing systems are controlled by means of numerically programmed machine tools which are part of the system [1], [2]. The control is exclusively technical because there is no economic variable, although this is actually the ultimate goal of any manufacturing process. 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 those orders [3], [4]. As a result, a long-term management is not appropriate. A sort of fluctuating (just like the market) on-line, fastly responsive, prompt and rapid, however, ephemeral management is called for [5], [6].

In the literature, no attempt to approach the whole manufacturing system – market *assembly* is reported, despite 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 manufacturing system [4], and tools of economic management of the relationship between the enterprise as a whole and the market.

It is obvious that, when applied to manufacturing systems, the business integrated manufacturing can offer solutions to make it more competitive and develop even the enterprise as a whole.

Models currently used in the management of the manufacturing systems, whether analytical, numerical or neural (or, in general, algorithmic), refer to the components of the systems [7], [8]. Building 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 models, the most appropriate one [9],[10].

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

Business integrated model is based on the modelling of the manufacturing operation taking into account its corresponding business operation.

On a practical level, the aim is to create the business integrated manufacturing model of the machining system, available for any part operation and its use for either on-line or off-line control.

The machining system interacts with the “market” carrying out a certain “service” (machining “service”) for a specified “client” (the work piece), with which it establishes a full economic relationship.

This relationship is characterized by the following variables: the service quality, the service necessary investment, the service profit rate, as well as the environment impact which occur during the service being carried out. The business model has as input the process characteristics, and as output the “service” characteristics, while as parameters the machining system-market relationship characteristics.

In this paper, it is proposed a numerical study of the competitive management efficiency by comparison to the conventional management.

2. Control Efficiency

The conventional management is based on the minimum cost, while the competitive management is based on the success of manufacturing product on the market.

The competitive management is more efficient as the profit increases. This management exploits the efficiency resources of the manufacturing system. In this context, the model of the competitive management efficiency was carried out.

The econometric model has as input the process characteristics, as output the “service” characteristics, while as parameters the machining system-market relationship characteristics.

Service characteristics of the econometric model developed in this paper are:

- cost *c*;
- time *τ;*
- profit rate *r*;

The *cost, c,* is defined as

$$c = \frac{C}{S} \text{ [Euro/cm}^2\text{]} \qquad (1)$$

where:

C –refers to the expenses of manufacturing process: salaries, tool cost, tooling allowance cost, energy cost and machine-tool cost;

S - the machined surface area.

Consequently, the cost is given by the following relation:

$$c = \frac{c_\tau}{10vs} + \frac{\tau_{sr}c_\tau + c_s}{10Tvs} + \frac{t \cdot c_{mat}}{10} + \frac{K_e c_e}{10000vs} + \frac{C_M}{10K_M} v^{\alpha-1} s^{\beta-1} t^{\gamma} \text{ [Euro/cm}^2\text{]} \qquad (2)$$

where:

c_τ – means the sum of all expenses directly proportional to the time;

τ_{sr}- time needed for the tool change and adjustment of the tool [min];

c_s- tool cost between two successive reshaping processes;

c_{mat} – tooling allowance cost;

c_e – cost of 1Kwh electric energy;

K_e- energy coefficient [wh/min];

K_M - machine-tool coefficient;

C_M - machine-tool cost [Euro];

v – cutting speed [m/min];

s – feed rate [mm/rot];

t – depth of cut [mm];

α, β, γ – coefficients;

T – tool durability, given by the Taylor relation.

The necessary *time, τ,* for 1 cm^2 surface area machining is calculated with the formula:

$$\tau = \frac{T + \tau_{sr}}{10Tvs} \text{ [min/cm}^2\text{]} \qquad (3)$$

Another service characteristic is the *profit rate, r,* and it is defined by the following relation:

$$r = \frac{p - c}{\tau} \text{ [Euro/min]}, \qquad (4)$$

where *p* is specific price, [Euro/cm^2].

3. Profit rate

By means of the relations presented above, figure 1 presents the curves of the profit rate *r* calculated the relation (4) for three levels of the price, where:

$p_1 = 0.0104$ Euro/cm^2,

$p_2 = 0.0142$ Euro/cm^2,

$p_3 = 0.0242$ Euro/cm^2,

$c_\tau = 0.45$ Euro/min,

$\tau_{sr} = 10$ min, $c_s = 20$, $c_{mat} = 0.008$ Euro/cm^3, $c_e = 0.23$ Euro/Kwh,

$K_e = 150$ wh/min, $K_M = 5400000$ min$^{1/3}$cm, $C_M = 100000$ Euro, s = 0.15 mm/rot, t = 3 mm, α = β = γ =0.5.

As shown in figure 1 there is a maximum $R_0 = 1.8679$ Euro/min for the specific price $p_3 = 0.0242$ Euro/cm^2 and corresponds to a cutting speed $v_0 = 136$ m/min (optimal operation point). Also, on the diagram, there are negative values of the profit rate *r*.

The cutting speeds associated with maximum profit rates are situated between $v'_{op} = 84$ m/min and $v''_{op} = 176$ m/min.

According to the price increases, the maximum of the profit rate goes to the right, as shown in figure 1. The comparative numerical study of the competitive management efficiency reported to the conventional management was carried out.

Table 1

v [m/min]	r_1 [Euro/min]	r_2 [Euro/min]	r_3 [Euro/min]
35	-0.17255	0.02397	0.541124
38	-0.14798	0.064659	0.624231
41	-0.12445	0.104101	0.705548
44	-0.10203	0.142205	0.784925
52	-0.04813	0.236645	0.986052
60	-0.00355	0.319586	1.169942
72	0.04438	0.420172	1.409101
84	0.068646	0.490351	1.600102
96	**0.069486**	0.529687	1.740743
116	0.023281	**0.530565**	1.865522
136	-0.07147	0.462569	**1.867933**
176	-0.34678	0.192472	1.611568

We have considered a reference case having a cutting speed v = 84 m/min. The cost *c* is minimum for that cutting speed. We may say that, from the viewpoint of the conventional management, that cutting speed is even the optimum cutting one.

Analyzing figure 1 and table 1, it can be noticed that for a cutting speed of v = 84 m/min, for a specific price p_1 = 0.0104 Euro/min, the profit rate r_1 = 0.068646 Euro/min is very close to the maximum profit rate (0.069486 Euro/min), the difference E_1 is approximated by null, but the profit rate is different from the maximum one for the specific prices p_2 = 0.0142 Euro/min and p_3 = 0.0242 Euro/min. In those cases, the cutting speed can not be considered as being an optimum one. The competitive management efficiency is given by the differences E_1, E_2, E_3 (Fig. 1).

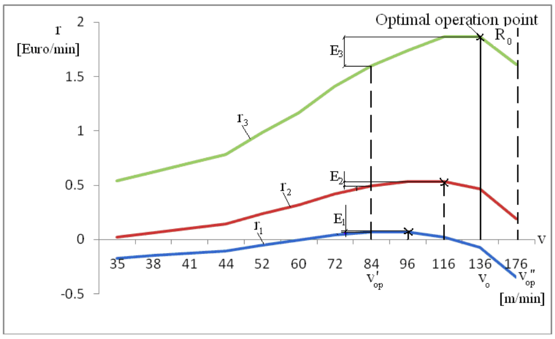

Fig. 1 Profit rate

Table 2

P [Euro/ cm^2]	r [Euro/ min]	r_{max}[Euro/ min]	E=r_{max}-r Euro/min	E/r [%]
0.010	0.068646	0.069486	0.000840	1.22
0.014	0.490351	0.530565	0.040214	8.20
0.024	1.600102	1.867933	0.267831	16.73
0.034	2.709853	3.273298	0.563445	20.79
0.044	3.819604	4.678662	0.859058	22.49
0.054	4.929355	6.084027	1.154672	23.42

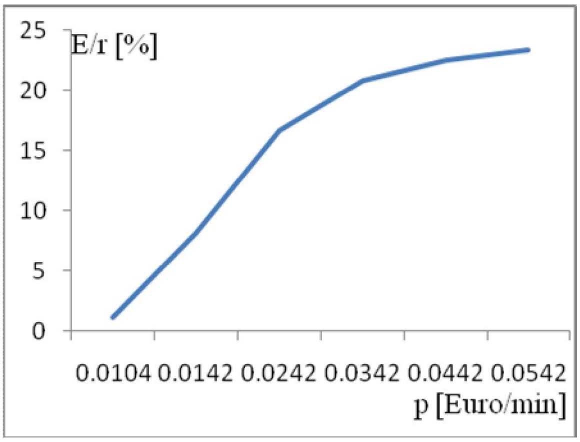

Fig. 2. Competitive management efficiency

On the basis of the data from table 2, figure 2 it is represented the curve of the competitive management efficiency depending on the specific price p.

Six product prices were considered in simulations and the corresponding profit rates.

As it may be seen, in figure 2, as the price increases, the competitive management efficiency becomes higher. Note that, it can begin from zero.

The management is considered efficient, as the competitiveness is higher. As seen in figure 2, the competitive management efficiency can reach 23.4 %.

4. Conclusions

In this paper, a numerical study of the competitive management efficiency has been achieved.

In the case of the products which do not have market success, the decrease of the cost is the most efficient method, applying the conventional control.

If the market success of the products is important, then the cost minimization does not provide maximum efficiency. In this case, the increase of the productivity is more important than the decrease of the cost.

As the market success of the products increases, the competitive management efficiency will also increase continuously. So, in the simulation case presented in this paper, the management efficiency reaches 25%.

References

[1] **H'nida, F., Martin, P. Vernadat, F.** - *Cost estimation in mechanical production: The Cost Entity approach applied to integrated product engineering*, International Journal of Production Economics, pp. 103, 17-35, 2006.

[2] **Wooldridge, J.** - *Introductory Econometries: A Modern Approach*, Mason: Thomson South-Western, 2003.

[3] **Tharumarajah, A.** - *Self-Organising View of Manufacturing Enterprises*, Computers in Industry, Elsevier Science B.V., 2003, pp. 185-196, 2003.

[4] **Morel, G., Panetto, H., Zaremba, M., Mayer, F.** - *Manufacturing Enterprise Control and Management System Engineering: Paradigms and Open Issues*, Annual Reviews in Control, Elsevier Ltd., pp. 199-209, 2003.

[5] **Rooney, A.** - *Handbook on the Knowledge Economy*, Cheltenham: Edward Elgar, 2005.

[6] **Epureanu, A., Virgil**, **T.** - *On-Line Geometrical Identification of Reconfigurable Machine Tool Using Virtual Machining*, Enformatica, vol. 15, Spain, 2006.

[7] **Paladini, E. P.**- *A Pattern Recognition and Adaptive Approach to Quality Contro*l, WSEAS Transaction on System and Control, Vol. 3, pp. 627-643, 2008.

[8] **Epureanu, A., Marin, F.B., Marinescu, V., Banu, M., Constantin, I.**- *Reconfigurable Machine Tool Programing- A New Approach*, WSEAS Transaction on System and Control, Vol. 5, pp. 463-472, 2008.

[9] **Marinescu, V., Constantin, I., Epureanu, A., Banu, M., Marin**, **F.B.** - *Online Adaptive Learning System for Reconfigurable Machine Tool*, WSEAS Transaction on System and Control, Vol. 3, 2008, pp.473-482, 2008.

[10] **Ozbayrak**, **M.** - *Activity – Based Cost Estimation in Push/Pull Advanced Manufacturing System*, International Journal of Production Economics 87 (1), pp. 49-65, 2006.

[11] **Steven, L.Y., Rogelio, H. L., Landers, G. R.** – *Machining Processes Monitoring and Control: The State- of- the- Art*, Journal of Manufacturing Science and Engineering, DOI 10.1115, 2004

[12] J. M. Simao, P. C. Stadzisz, G. Morel,. Manufacturing Execution Systems for Customized Production, *Journals of Materials Processing Technology*, Elsevier B.V., 2006, 268-275.

[13] **Huang, B., Gou, H., Liu, W., Li, Y., Xie**, **M.** - *A Framework for Virtual Enterprise Control with the Holonic Manufacturing Paradigm*, Computers in Industry, Elsevier Science B.V., pp. 299-310, 2002.

[14] **Wang, D., Nagalingam, Sev. V., Lin, G.C.I.** - *Development of an Agent-based Virtual CIM Architecture for Small to Medium Manufacturers*, Robotics and Computer-Integrated Manufacturing, Elsevier Ltd., 2005

[15] **Valckenaers, P., Van Brussel**, **H.** - *Holonic Manufacturing Execution Systems*, Annals of the CIRP 2005, Elsevier Ltd., 2005.

[16] **Zhang, J., Gao, L., Chan, F.T.S., Li**, **P.** - *A Holonic Architecture of the Concurrent Integrated Process Planning System*, Journal of Materials Processing Technology, Elsevier Science B.V., pp. 267-272, 2003.

[17] **Jarvis, J., Ronnquist, McFarlane, R. D., Jain**, **L.** - *A Team-Based Holonic Approach to Robotic Assembly Cell Control*, Journal of Network and Computer Apllications, Elsevier Ltd., pp. 160-176, 2004.

[18] **Shao, X., Ma, L., Guan**, **Z.** - *A Market Approach to Decentralized Control of a Manufacturing Cell*, Chaos Solitons & Fractals, Elsevier Ltd. 2007

[19] **Leitao, P., Restivo**, **F.** - *ADACOR: A Holonic Architecture for Agile and Adaptive Manufacturing Control*, Computers in Industry, Elsevier B.V., pp. 121-130, 2005.