A Conceptual Model for Evaluating the Competitiveness of the Enterprise

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Abstract: - The paper aims to develop a new concept regarding the analytical-mathematical evaluation of the state of the enterprise based on technical-econometric indicators and on this basis, the design of a preventive, adaptive-optimal management and management system that ensures competitiveness. This approach opens new and more advanced horizons in imagining management systems that can operate holistically with technical, economic, commercial and managerial aspects.

Key-Words: - evaluation**,** state of the enterprise, holon, manufacturing system, competitiveness

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1 Introduction

The current period is marked by budgetary constraints and significant barriers of the domestic and international markets. In order to be competitive, the bidders must constantly concern themselves with satisfying the requirements of the customer/client. This shows us that there is a strong relationship between product quality and competitiveness, which becomes the engine that contributes to the company's development in the present and in the future. The evaluation of the company's competitiveness can be done by analysing the economic efficiency compared to the other competitors on the market.

The enterprises aim to satisfy the customers' requirements in order to obtain an important market share and the profit necessary for the development of the activity. Studying the needs of consumers is an essential condition for the realization of quality products and services, so the strategy based on quality determines the progress in obtaining the company's competitiveness [1].

An enterprise is competitive when it manages to obtain results comparable to those of its competitors or better than theirs. This is achieved when the conditions at its disposal (production factors, managerial and marketing capabilities, financial, technical and creative resources) become a sustainable advantage over the competitor (in terms of cost, diversity, quality and renewal of the offer), ensuring normal dividends for shareholders, resources for self-financing and for the wages of the labor force, correlated with productivity. Therefore, competitiveness largely depends on the company's internal conditions, which express all the components and functions that define it.

2 Development of a New Concept for Assessment of the State of the Enterprise

We define the state of the enterprise as the situation from a technical, economic, managerial, commercial point of view in which a production unit is found at a given moment. For its concrete and correct establishment, it is necessary to establish some attributes of the system. These attributes characterize both the technical-managerial functionality of the enterprise and the extent to which it satisfies the market requirements, so they can be called command attributes to be used both in the techno-econometric analysis and for the management of the enterprise.

These attributes change their level depending on an important number of parameters, which condition them and which are actually the state parameters of the enterprise system, endogenous as well as of the macrosystem, of the external environment of the enterprise, exogenous.

Some of the state parameters, belonging to one or the other group, can be modified as desired, and, consequently, they can be used as control variables. Through the controlled action on the control

variables, it is possible to monitor the state or parameters of variables. All state parameters will be part of some mathematical modeling relations and, by analyzing these relations, it will be possible to evaluate the enterprise's attributes, and its state will be evaluated.

For the purpose of a relevant, realistic, comprehensive and mathematically accurate analysis, within the limits of an allowed margin of error, the analysis will be approached starting from the attributes of the enterprise system, their definition, followed by the elaboration of a regulatory system that describes the dependence of their level on the level of the optimal performance of the enterprise and the state parameters of the enterprise.

This new approach of the design, production and use of the machine-tools, based on a new concept, hereby named holonic enterprise concept.

Enterprise holon interacts with the "market" carrying out a certain "service" (machining "service") to a specified "client" (the workpiece), with which establish a completely economic relationship.

This relationship is characterised by the following variables: the service quality, cost, time and price, the service necessary investment, the service revenue rate, as well as the environmental impact which occur during the service is carried out.

Until now the literature has made very brief reports on applications of holonic modelling of manufacturing enterprises, of shop floor control systems, of material handling and of logistics systems [2].

3 Development of the New Process Management Concept Based on Holarchic-Attributive modelling

A Holonic Manufacturing System (HMS) is a manufacturing system that is distributively controlled according to the holonic system paradigm [3].

Competitiveness of firms is studied mostly from a strategic management perspective. It is only rarely a subject of analysis from the viewpoint of operations [4].

The level of the command attributes of the enterprise system will be able to be evaluated by monitoring the state variables and will be controlled by corrections applied, at appropriate times, to the control variables. This is actually, in essence, the new concept of management of the production process, proposed by the paper, namely management based on holarchic-attributive modeling. The concept will be theoretically developed and experimentally verified through its pilot implementation in an enterprise that at that time will correspond to the conditions for conducting the experiment. During the process, in its various technological phases, the state variables are measured and analyzed, the values of which will finally give the level of the command attributes. Holarchy analyzes the level of these attributes and, based on the regulations of which it is composed, provides the decision tree. The holarchy regulations reflect the managerial policies regarding the enterprise-market relationship in the sense of ensuring competitiveness.

The decision tree is transmitted to the "command system", that is, to the specialized departments that generate the necessary corrections for each command attribute, thus ensuring the optimal character of the control system.

This system can be extrapolated to the level of compartment or group of technological machines, operating on the same principle of holarchic-attributive modeling.

The database of long-term results from the process monitoring process, according to this concept, is stored and then can be used automatically by an online learning system. In this way, the optimal adaptability of the enterprise system is ensured, automatically, it can re-enter the in function. The holarhic analysis of the level's attributes of command provides the decision tree in the moment when the concrete conditions coincide with the stored data. Of course, for this, suitable software is needed to manage this process.

Through holarchic-attributive modeling of processes we give a new approach to develop in terms of the competitiveness of the enterprise.

The model starts from the extrapolation of the driving concept of a technological machine to the process level and further to the technological compartment level.

Based on the definition of those command attributes, at the process level, a system of regulations will be developed to describe the dependence of these attributes on the performance level of the technological process and its state variables.

The representation of a holarchy can be presented in different ways, depending on the field of study. Intuitively, we can associate a holon with a circle or sphere shape, to suggest autonomy, independence, but also the ease of association to form a higher level holon.

It should not be forgotten that each holon can act alone and is at the same time a part of the holonic manufacturing system. As such, each must be characterized by input parameters and output parameters, but at the same time there must be one or

more parameters that allow the ordering of the holons in terms of the sequence of operations and the type of product that results at the end.
The intuitive holonic model based on the description of the components that compose it, presented above, figure 1, is made up of a series of schematic representations which, by joining, lead to the representation of a holonic manufacturing system.
Each technological system holon-type has at its level a certain environment. The environment in which they act/work is governed by a series of laws, rules or situations.

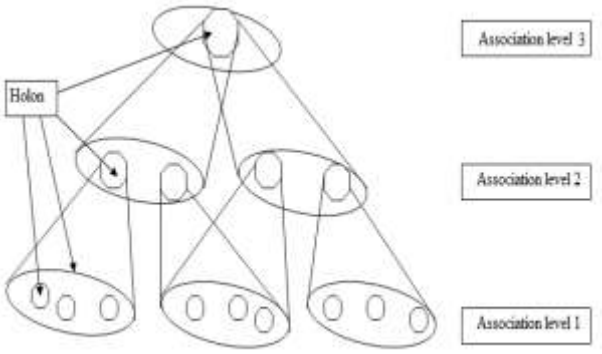

Fig.1: The intuitive representation of a holarchy

The modeling refers to a structure that interacts with the environment. If we were to represent this, figure 2, we notice that information, materials, documents are received from the environment and are returned to it with certain data, records. In practice,

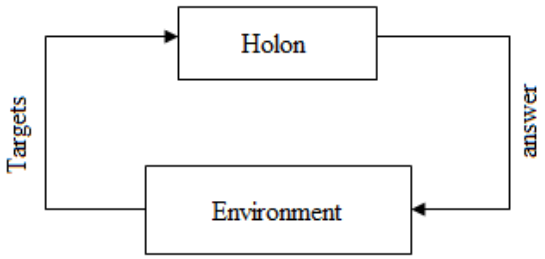

Fig. 2: The interaction between holon-environment

targets/objectives to be achieved and the conditions and consumptions for accomplishing the tasks are returned to the environment.
If we were to refer to a specific target, the answer given by the holon is undetermined, as it may vary in a certain area.
For example, for a target of "n" pieces with certain dimensions, the holon's answer will be given by the consumption of material for these pieces, specific work parameters, and amount of waste.

However, we must note that we can have different answers for the same targets. We can state that we do not have a single solution, but we have a range of solutions values.
Following the interaction with the environment, a learning process takes place, which is a process following which the holon who learns improves its capacity for action so that, during subsequent requests, the holon undertakes actions with increased efficiency.
The actions of the holon take place within an environment, and depending on the interaction between the holon and the environment, several types of learning are distinguished. In this case, reinforcement learning technique can be used because the economic environment provides data about the correctness of the holon actions but does not say what are the correct actions.
Practically, through the reinforcement learning model, in the sense that the relationship between the holon is modeled and the environment, the behavior of this relationship is described and the holon is taught to interact with the environment so that the rewards are maximized and the penalties minimized over a certain period of time. In this case, the holon must discover by himself which actions lead to obtaining a greater reward.
The unsupervised learning mode is applied in causal modelling, in which the environment does not provide information about the correctness of the actions undertaken by the holon.
Causal modeling is a modeling of an objective reality, which includes the enterprise's internal environment under its economic, technical and organizational aspect. This type of modeling includes functional modeling through reinforcement learning, because it includes both the targets and the independent variables given by the work parameters and the dependent variables given by the state variables.
Since, frequently, the manufactured products are identical/similar, for this reason the holon works in a narrow vicinity of a point of operation; thus the models used will have to be simple, to describe the behavior in the vicinity of the operating point; instead of complex/general models, many local and temporal models will be built.
So, it will be possible to evaluate the level of performance indicators using little initial data, stable and influential data, which will be discovered during the use of the model.
The functional modeling characterizes the relationship of the holon with the economic environment. At the same time, the relationship with the market is a conjunctural relationship, because if it

is described at this moment, it is not certain that it will be the same over a short time.

4 Programming and Virtual Processing System

In order to verify the accuracy and applicability of the concept of competitive management of manufacturing systems, results obtained practically, on a concrete case, are needed. In this sense, a real manufacturing system, of a pilot company, which works in real conditions, on a real market, with parameter values taken from economic reality, will be simulated and modeled and, based on this modeling, an experimental system. In this framework, by using the methodology, the values of the attributes generated by online learning will be introduced, the state of the system will be determined, and the solutions for achieving optimal competitiveness will be determined. These will be applied to the model and the solutions for the generation of management policies will be determined.

In figure 3, the experimental system is illustrated, consisting of the virtual enterprise model and the manufacturing system, materialized by a proof-of-concept type stand, incorporated in it. Through modeling, the physical parameters obtained on the stand will be introduced into the production process chain of the virtual enterprise, which functions as a complex (physical-virtual) system.

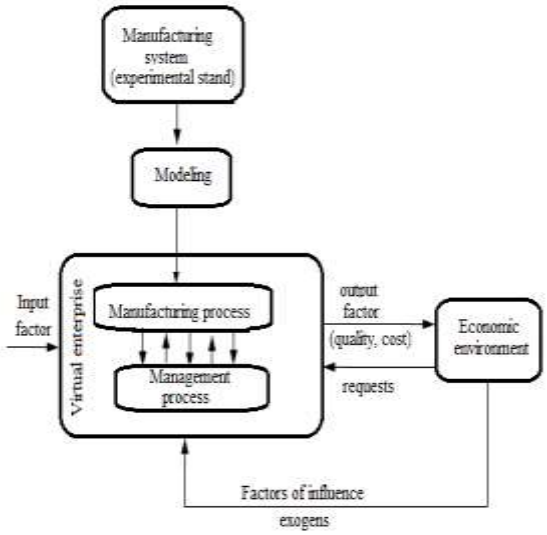

Fig. 3: Scheme of the experimental system

The experimental stand intended for laboratory validation of the concept will be realized considering the case of the simplest manufacturing system, which contains only one technological system that executes the entire product. The technological system used will be based on a numerically controlled machine-tool, existing in the laboratory, which will be equipped with a monitoring system corresponding to the competitive driving algorithm. The manufacturing processes carried out experimentally with the help of the stand will be monitored, obtaining an experimental database. This will be used to implement unsupervised online learning techniques. By evaluating the obtained results, conclusions will be drawn regarding the feasibility and robustness of the competitive driving algorithm.

Machine-process holon interacts with the "market" carrying out a certain "service" (machining "service") to a specified "client" (the workpiece), with which establish a completely economic relationship. This relationship is characterized by the following variables: the service quality, cost, time and price, the service necessary investment, the service revenue rate, as well as the environmental impact which occur during the service.

The business model has as input the process characteristics, as output the "service" characteristics, while as parameters the holon-market relationship characteristics. In figure 4 it is presented the generic business model for turning holons, where the cutting speed V is the process characteristic, the cost C, the time T, the revenue rate r (for three levels of the price - P1, P2, P3) and the environmental impact I are the service characteristics while the machining operation price P is the model parameter. In this figure, the R curve is the maximum revenue rate versus the price P. Flexible manufacturing systems easily adapt to market changes in which they include a great number of specialized modules (non-convertible) that can meet all needs. As one single module is used among all those available in a given moment, the capital invested in the other modules is capital waste.

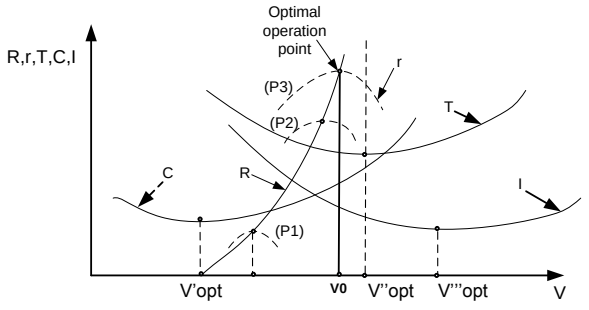

Fig. 4: Business model of the machine – process holon

As a consequence, the part-program should comprise information regarding the characteristics imposed on the manufactured object in order to be considered acceptable, and not information on the way in which the functioning cycle of the machine should develop so that the object may have these characteristics. This means that the part-program should contain a list of targets and not a list of instructions. Starting from the targets included in the part-program, the holonic structure of the machine should allow for proper machine cycle scheduling and control.

5 Conclusion

In this paper, the conceptual development of new ideas regarding the integral and interdisciplinary treatment of the notion of the competitiveness of the enterprise was followed, using modern methods and innovative approaches.

Also, we developed at a conceptual level a new way of evaluating the state of the enterprise based on the analysis of econometrics and technometrics using all the state parameters that characterize the enterprise and the manufacturing process.

Thus, the foundations are laid for the development of a generation of SMEs in the field of industrial production capable of fully and sustainably capitalizing on scientific advances in fields such as artificial intelligence, information and communication technology, combined with econometrics, engineering and management.

This new generation of companies will reach the ability to produce, in economic conditions, customized products at the level of quality required by the market.

References:

[1] L. Daschievici, D. Ghelase – Holonic Approach to manufacturing systems – *The Annals of Dunarea de Jos University of Galati, XIV*, vol. II, 2016, pg. 17 – 20

[2] Babiceanu R.F and Frank C.F, Development and applications of holonic manufacturing system: a survey, *Jounal of Intelligent Manufacturing* 17, 2006, 111-131

[3] Hendrik Van Brussel - Holonic Manufacturing Systems, *CIRP Encyclopedia of Production Engineering*, 2019, pp 654–659

[4] A. Chikán, E. Czakó, B. Kiss-Dobronyi, D. Losonc, Firm competitiveness: A general model and a manufacturing application, *International Journal of Production Economics, Elsevier*, Volume 243, 2022