About the Application of Knowledge Management in Engineering

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Abstract: In today's society, where access to data and information is more easily achieved thanks to the rate of development of information and telecommunication technologies, the problem is to know more and more, to know how to use the immensity of information that we can have at one time.In the paper we aim to offer a strategic vision of knowledge management (KM) that takes into account the synergy between technological and behavioural issues so necessary for progress in the current economic context.

In this view, all business processes involve creation, dissemination, renewal and application of knowledge for the maintenance and survival of the enterprise.

Key-Words: - knowledge, knowledge management (KM), knowledge-based economy (KBE)**,** machining process.

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1 Introduction

All over the world, companies are faced with increasingly accelerated and unpredictably dynamic changes. This is influenced by the scientific and technical progress, the dynamics of customers' demands, the scientific approach to management and the mathematical focus on economy "[1]". Changes lead to aggressive competition on a global scale, which calls for the establishment of new balances between economy, technology and society. The characteristic aspects of the present-day market, in particular case of mechanical components market, are the following:
i) continuously decreasing of the current orders, leading to the design of small series production;
ii) strong tendency to personalize the products leads to a pronounced diversity of shapes, sizes and other characteristics of the mechanical components required on the market;
iii) flexibility, responsiveness and especially efficient system management tend to become the characteristics that determine competitiveness on the market of components manufacturers and mechanical constructions. The current dynamics of the industrial and business environment is the great global challenge which must be faced.

To a new global challenge the scientific community responds by a new conceptual paradigm, which in this case is the knowledge- based economy (KBE)**,** "[2]".

Knowledge, innovation and creativity are keys to success with the globalization of the Knowledge Economy in the new millennium. The winners in today's knowledge – based economy will be companies that consistently leverage and increase their intellectual capital: knowledge of an organization's workforce, documented processes, methodologies, patents, guidelines and software "[3]".

In order to progress in the present-day complex and unpredictable environment, the company must feature abilities of quick response "[4]" and favorably 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. In this context, three elements are highlighted by their relevance: competitiveness, the manufacturing system and the knowledge system.
a) Competitiveness.
According to the literature, a company is competitive on a certain market when it succeeds to reach, up to an acceptable level, some economic indicators: turnover, profit, market share comparable or superior to that of other competing companies acting on the same market.

Many approaches to the problem of competitiveness "[5]", "[6]" show that, today, competitiveness is defined by the economic factors and indicators obtained and is more a suggested/induced notion than a numerically valued one. 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 valances, 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 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.

b) The manufacturing system.

Within this paper, by manufacturing systems we understand all the technological systems that are used to produce a specific product. Each of these technological systems is composed of machine-tool, tools, devices, parts, operators and carries out one of the operations of the technological process of making that product.

The manufacturing system is complete when the product is released for manufacture and remains there only until the end of the product completion. After this, when another product is released, the problem of structuring the manufacturing systems is taken from the beginning. This ad hoc structure of the manufacturing system is always present with manufacturing lots, but not in mass manufacturing, when all of the technological components of the manufacturing system remain unchanged for a long time.

The manufacturing system performance depends on how it is run. In more specialized papers, “[7]”, reference is made to the relationships between the parameters of the cutting processes and the technical performance of the manufacturing system (purely technical aspects), while in others, equally numerous references “[1]”, “[2]” are made to the relationship between the product made by the manufacturing system and the market (economic relations).

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 “[8]”, “[9]” and tools of economic management of the relationship between the enterprise as a whole and the market “[10]”, “[11]”.

Nowadays, the manufacturing systems are controlled by means of numerically programmed machine tools which are part of the system ”[12]”.

The control is exclusively technical because there is no economic variable, although this is actually the ultimate goal of any processing 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 said orders. As a result, long-term management is no longer possible. A sort of fluctuating (just like the market) on-line, fastly responsive, prompt and rapid, however, ephemeral management is called for ”[12]”.

c) The knowledge system

The market dynamics is further passed to the mode of operation and management. In a knowledge-based society and economy, operations such as determining the relevant information and aggregating them into pieces of knowledge must be automated, because in such a complex and unpredictable environment, they are indispensable tools for creating, searching and structuring knowledge.

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 ”[4]”. Consequently, it is necessary to exist a knowledge management system to avoid increased costs, waste of time and increased errors.

The recognition of the Knowledge Management (KM) imperative will provide an impetus for enterprises to understand and nurture their knowledge resources and activities.

KM has assumed a broad range of meanings from its inception; however, most of the published material remains ambiguous and provides little empirical evidence to support a specific definition for the knowledge management concept. KM has been acknowledged as being important to competitive advantage and organizational progress.

Thus, a clear understanding and agreement about KM should prove to be of great value for enterprises. As enterprises strive to create a competitive advantage with their products and services, they continue to contemplate the KM concept and the impact on organizational success.

In an effort to define KM, enterprises must determine which corporate knowledge should be harvested, organized, managed and shared. A general definition has been 'getting the right information to the right people at the right time' in order for them to make better decisions.

Knowledge management implementation is an advantage for the enterprise from the viewpoint of competitiveness.The new knowledge will be used both in the enterprise management and to develop new products and new services or make important changes in the business decisions.

By means of learning, the enterprise uses the knowledge able to adapt and respond continuously to the changes of the business environment. An important goal of KM is seen to be the sharing of best practice. So, by the improving the flow of knowledge through the enterprise can be obtained the following benefits:

- the sharing of the best practice around business processes;
- the ability to respond more effectively to customer demands.

Due to technology facilitating the rapid exchange of information, the pace of acquisition is growing exponentially in both large and small enterprises. The vast amounts of knowledge possessed by the enterprises are spread across countless structured and unstructured sources.

To improve processes and bring new products to the market faster and more cheaply, the enterprises have to identify, make available and apply this knowledge. Thus, information must be understood, organized and transformed for problem solving. Consequently, information transformed in product is knowledge and coordination of this kind of knowledge is made by means of knowledge management.

As shown above, the manufacturing industry faces the challenge of responding quickly to the ever-changing requirements of customers. It is necessary that in these high competitive environments, enterprises to control production system dynamics of such as:

- change in the product types and variants;
- change in the production quantities.

Enterprises have to develop and implement more responsive and flexible manufacturing systems based on knowledge. By this way, they can respond to outgoing and difficult to predict changes in production requirements and make products with high quality, low cost and fast delivery.

The paper has the following structure: section 2 discusses the related literature, section 3 presents problem formulation, section 4 describes KM in engineering, section 5 illustrates KM on machining systems, and section 6 summarizes the main conclusions achieved.

2 Related literature

The paper is related to several strands of literature.

To be competitive organizations should react adequately, interpret non-standardized information for problem solving and decision making, as well as change their infrastructure and management strategies "[13]". Usually there is a lot of information and knowledge within organizations, but at the same time many of them (service organizations, in particular) are "information rich and knowledge poor." The information and knowledge assets, often called an "intellectual capital," i.e., knowledge that can be converted into value, make a great potential for organizations if utilized well "[14]", "[22]".

Knowledge management (KM) has become an effective way of managing an organization's intellectual capital or, in other words, an organization's full experience, skills and knowledge that is relevant for more effective performance in future.

Studies in KM mainly focus on organizational knowledge captured in corporate and/or organizational memories "[15]", "[16]", "[17]" and on the development of knowledge management systems (KMS). However these initiatives in organizations have often run into difficulties mainly because the expansion of individual's personal tacit knowledge to knowledge of organization as a whole causes implementation problems.

In the paper "[13]" there are defined tacit knowledge and explicit knowledge. Tacit knowledge is personal knowledge gained through experience. It may be shared and exchanged through direct communication with others. Explicit knowledge is represented in documents, emails, knowledge repositories (data and knowledge bases), etc. Explicit knowledge can be formalized in words and numbers and it is easily distributed and shared. Acquisition of explicit knowledge is indirect because it must be encoded and decoded in one's mental models where

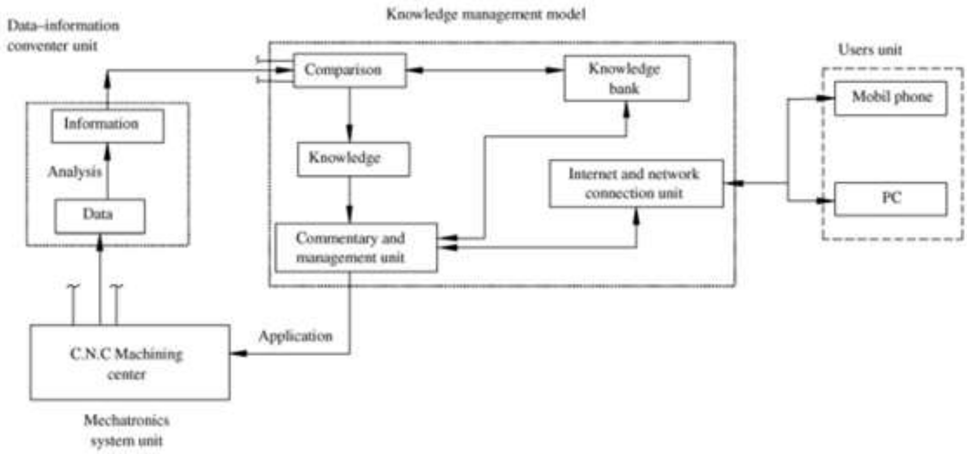


Figure 1 System diagram of KM of internet-based mechatronic system

it is kept as tacit knowledge.

In "[18]" it is shown that the concept of managing knowledge has become increasingly popular both in the practical and in the academic discussion in the fields of engineering and management. Successful management of knowledge-related resources of companies has been recognized as a key basis for acquiring competitive advantage and other organizational success and the acquisition and application of knowledge has even been argued to constitute the focal role of organizations in the society "[19]".

The paper "[20]" is concerned with an application of knowledge management on the mechatronic system. The Internet –based CNC machining center has been considered and its knowledge management model has been prepared. The model prepared has been analyzed for machining performance of the manufacturing system. The architecture of the KM model of internet – based mechatronic system is presented in figure 1.

The system presented in this paper consists of the KM model (PC), mechatronic system (CNC machining center), user unit (PC, SMS) and data, information converter unit. KM model consists of knowledge bank compare, internet and network connection, commentary and management units. Operations of CNC Machining Center which is the main production unit of the system can be controlled both by the machine tool control panel and by email, network from distant places. Also, the machine tool is equipped with a lot of sensors so that the machine tool performance can be monitored and unexpected conditions can be controlled.

Motivated by the literature discussed above, this paper presents a knowledge management structure of the machining system to provide competitiveness of the enterprise.

3 Problem formulation

Knowledge, like information, is worthless if not applied in decisions on necessary actions in the context of economic activity of the company. Many companies have worked hard to store information on available knowledge, but did not give enough attention to the chase how to apply, are used not only actual work but also to generate new ideas for future activity.

The application and use of knowledge requires that they be communicated from person to person, although this transfer is accomplished smoothly, without effort. In fact, in the company there is a "market" knowledge, with an evaluation system of exchanges, with sellers, buyers and intermediaries. In many companies the transfer of knowledge is made difficult because there is no time to transfer and therefore the exchange "price" of knowledge grows.

In today's society one can access an immense volume of information from almost anywhere. But only information is not sufficient. The feature of knowledge society is not that it has large amounts of information, but inside it always has to know more. For this information to become useful, it must be transformed into knowledge and then used efficiently in company management.

What we propose in this paper is to provide the manager, based knowledge he has, (economic and technical knowledge) a model of KM for his enterprise to be competitive. When there is a model that interconnects data and information, the model has the potential to be a knowledge. A such model, which is knowledge, provides when the model is well understood, a high level of certainty or prediction regarding how less static models will evolve over time. We intend to offer an enterprise manager a such model.

KM provides the necessary information for solving the problems of adaptation, progress and competence of enterprise to cope with changes occurring in the environment.

4. Knowledge management in engineering

Knowledge-based engineering is an engineering methodology in which knowledge about the product, the techniques used in design, analysis, and manufacturing, is stored in a special product model "[23]", "[22]".

Knowledge discovery in databases (KDD) is the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data. It can acquire implicit and useful knowledge in large scale datasets, and involves an integration of multiple disciplines such as statistics, artificial intelligence, machine learning, pattern recognition, etc. KDD has had great success in commercial areas, and has begun to be used in knowledge acquisition of engineering disciplines. The overall KDD process includes data selection, data preprocessing, data transformation, data mining, interpretation, and evaluation, as shown in Figure. 2 "[21]", "[22]".

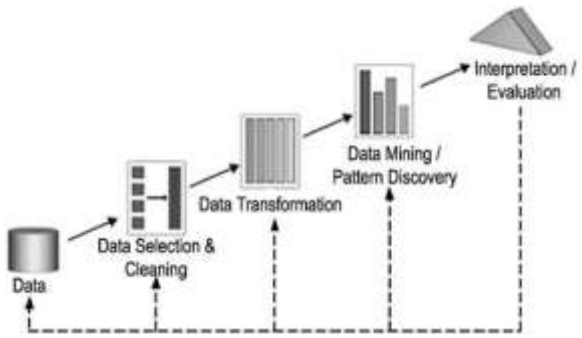


Figure 2. The process of knowledge discovery

Defining data, information and knowledge is difficult. It is possible to distinguish between data, information and knowledge on the basis of external means or from the perspectives of the user.

In "[20]" it is shown that, data are considered as raw facts, information is regarded as an organized set of data, and knowledge is perceived as meaningful information.

Data consists of symbols that represent objects, events, and their properties. Information is data that has been made useful. Information answers who, what, where, when, and how many questions. Information is helpful in deciding what to do, not how to do it.

Knowledge consists of instructions and know-how. Knowledge answers questions. Knowledge is more than information. Information is data organized into meaningful patterns. Information is transformed into knowledge when a person or an intelligence system reads, understands, interprets and applies the information to a specific work function.

One person's or one intelligence system's knowledge can be another person's or intelligence system's information. If the information cannot be applied to anything, it remains just information.

However, a person can take that same information, understand it and interpret it in the context of previous experience, and apply it to anything, it is transformed to knowledge "[12]".

Information is becoming ever more important in engineering. It is not suitable to use data, information and knowledge conventionally. That is there is conceptual confusion. Also, today's technological products need interaction between different disciplines. So the confusion increases more. In the multidisciplinary engineering system, any discipline contains some information peculiar to the system. However, most of the information mean essentially the same even if they are expressed in different terms in different disciplines. Therefore, the available information must be evaluated, simplified and transformed into a usable form that is knowledge.

Next, the knowledge is coordinated and connected with the system. So, a kind of know-how is acquired for the technological product. This case is generally based on a model, while it has special characteristics. An example of a machining system has been analyzed in the following section. The model is produced by technical knowledge which is acquired by the interaction of data, information and knowledge, by the coordination and the application of them to the engineering system. The KM model is presented in Figure 3. KM is a comprehensive process of knowledge creation, knowledge validation, knowledge presentation, knowledge distribution and knowledge application [12]. When the KM model is applied by the enterprise into its production process it is obtained increasing the competitiveness of the product in the market. That is the KM model can be used for every stage of the engineering works such as design, manufacture, maintenance and repair.

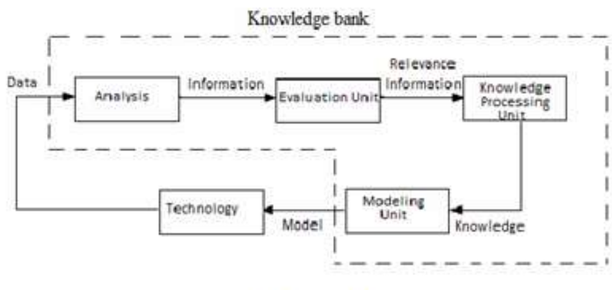


Figure 3 KM model

5. Application of the knowledge management on machining system

5.1 Knowledge Management architecture of the Machining System

The architecture of the KM model of machining system is presented in Figure 4. The system shown in Figure 4 consists of the KM model, CNC Machining System, Marketing Knowledge.

The KM model contains very important features of the system.

KM model consists of knowledge bank, compare, modeling and control units. The knowledge bank is formed according to the characteristics of the system.

It is very important that information which concerns the subject, correct, update, and concordant must be converted to knowledge and they must be stored in this unit. It is necessary that this unit becomes a flexible structure because it can be updated depending on the market dynamics and technical characteristics of the new manufacturing products.

The information coming from the Marketing Knowledge-unit is diagnosed by the comparison unit. Also the comparison unit has information-receiving ability from knowledge bank. The essential function of the comparison unit is to compare the information and knowledge with each other. The output information from the comparison unit is new knowledge. This new knowledge has been sent to the modeling unit.

Not only does the modeling unit receive information from the comparison unit, it also interacts with the knowledge bank. The output of the modeling unit is the model which is analyzed in the control unit. This unit sends the manufacturing instruction to the CNC Machining System.

Through on-line learning, the output information from the CNC Machining System unit becomes the new knowledge and has been sent to the knowledge bank.

The machining system receives contracts after the tenders (competitions) generated by the market offer quotations. The competitive control means competitiveness assessment, and based on it, an intervention on the machining system through instructions regarding the progress of the machining process in order to obtain maximum competitiveness. On the other hand, after assessing competitiveness, the management system should enable them to develop competitive offers for the tenders. To achieve these two objectives, competitive control uses reinforcement learning to get to know the market and the non-supervised on-line learning technique to get to know the machining system.

5.2 Behavioral modeling

As shown above, based on behavioral modeling, the unit control elaborates the necessary instructions to adjust the machining process and the manager can elaborate the management policies. 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 (Figure 5. 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.

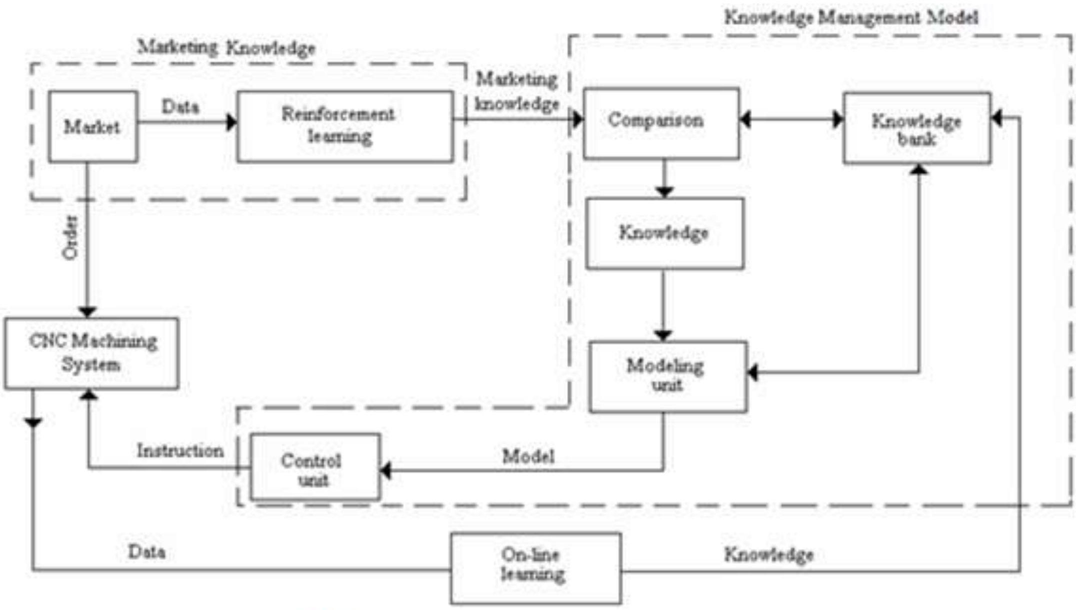
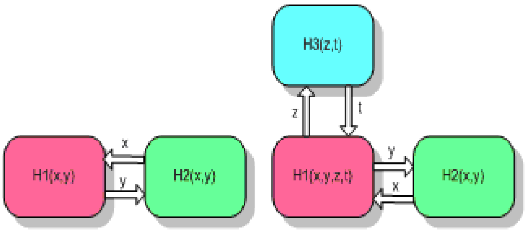


Figure 4 Knowledge Management architecture of the Machining System



a. b.

Figure 5. 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 machining system while H2, for the market .

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

For example, in the case of Figure 5.b, three elements interact and the behavioral model represents the relationship between the values of x, y, z and t 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 (Figure 6).

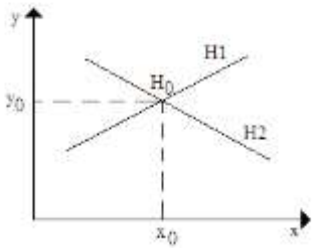


Figure 6. Behavioral model with unique solution

If there is a values string x_0 and y_0 as solutions

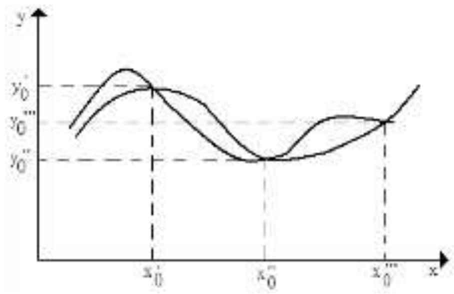


Figure 7. Behavioral model with multiple solution

of the system (1), then the behavioral model includes all these points (Figure 7): (x_0', y_0'), (x_0'', y_0''), (x_0''',y_0''').

If the system (1) is incompatible, then there isn't any behavioral model that meets H1 and H2 assembly. In the case of Fig.5.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 than equations, we expect the system (2) is indeterminate. The model will include an infinite points number. 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, operates 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 interact with other 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 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).

6. Conclusions

In this paper the architecture of the knowledge management of the machining system was achieved.

Using and comparing marketing knowledge with stored and updated ones the machining model is carried out, analyzed and on its basis are generated instructions regarding the progress of the machining process in order to obtain maximum competitiveness.

By modeling and simulations, the manager can decide if the order is accepted and control the machining system to satisfy the customer demands.

To achieve these objectives, competitive control uses reinforcement learning to get to know the market and the unsupervised on-line learning technique to get to know the machining system.

Note that we propose to give managers a knowledge management model, so that they can interact with the economic environment (market).

This knowledge management model represents a technical-economic model that can be used for competitive control of the manufacturing process without requesting experiments and based on the extraction of the knowledge from the previous experience.

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