Project: PN-II-ID-PCE-2007-1
DEVELOPMENT OF A NEW CONCEPT FOR MANUFACTURING MACHINE CONTROL-HOLARHIC ATTRIBUTIVE CONTROL

State-of-the-art

In the following paragraph we present in a synthetic and very succinct manner a view of the actual stage of the technological machine (defined as the machines used for material processing into mechanical constructions parts) control concept. On the other hand, this presentation has the same structure as the approach of this project concept. Finally, this presentation contains the critical opinions of the project team members and the way they understand to direct the research.
The driving(1) of a technological system implies: geometrical control(2), dimensional control, stability control, economical control, adaptability and predictably control, optimal-adaptive or predictive character of control and the typology of models and their construction methodology. This aspects are approached as it follows:

1. <u>The geometrical control.</u> The existing control systems of the technological machines cover entirely only the piece nominal geometry using CAD/CAM/CIM software and numerical control systems.
2. <u>The dimensional control.</u> Concerning the deviation from the nominal geometry, the technological machines are controlled using online or offline control loops. These loops act upon several control variables such as the intensity of the process (finishing, roughing) or the tool trajectory (using a variable called the tool correction). On the other hand the deviations are evaluated and controlled only for the common geometrical elements (plane, cylinder) and not for the entire group of surfaces with which two components of the mechanical structure are joining. Thus the fits are only pairs of common surfaces and not pairs of topological structures as in reality. A control system which is to cover the dimensional deviations needs to consider all the surfaces from a group and each surface alone, and must act based upon the adaptive and predicative control of the tool correction for keeping the intensity of the process at a economical level.
3. <u>The stability control</u>. For technological machines the stability control (defined using the level of the perturbations regeneration) varies within wide limits with the cutting conditions (see figure 1) and is changes along the tool trajectory and when the tool geometry is changing. For a machine-tool-piece system the stability control is made offline using a decrease of the cutting intensity (and of the productivity) for a avoiding of the instability for the machining surface. Thus there is a permanent stability reserve unused and for this reason the machine is never used at its maximum capacity. Therefore a technological machine control system which will cover the stability control using the maximum machine capacity will bring an important contribution to the machine performance.

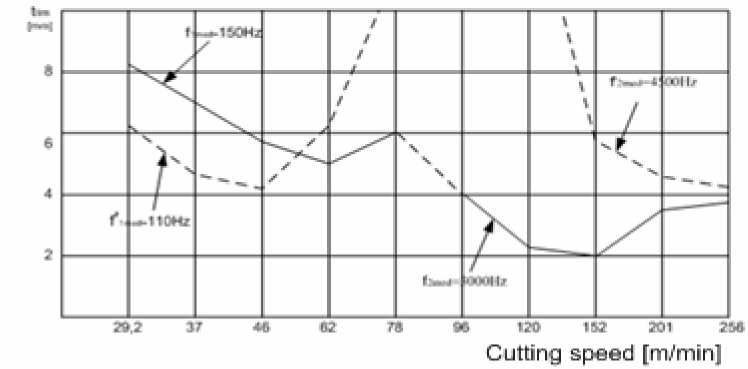

Fig.1 Stability variation and freqvency limit by cutting speed

4. <u>The economical control.</u> For technological machines the economical control consists only in offline adjusting of the cutting conditions according to the characteristics of the tool and of the

piece in such a manner that the productivity and the costs will have favorable values. The uncertainties which appear are given by the fact that productivity and the cost cannot be simultaneous in their extreme points(fig 2). The following question appears: how should we produce more and expensively or less and cheaply. The answer is given by a commercial aspect: the success of the product on the market. If the control system of the machine will also cover and the economical part then a correct relation will be made between the technical, economic and commercial aspects of the machining.

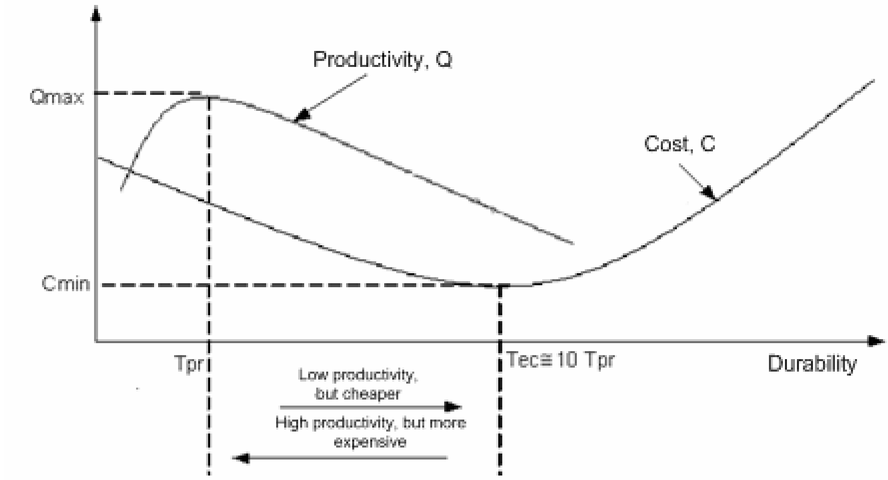

Fig2. Productivity and cost variation by cutting tool durability

5. The machine adaptability to the market and operator demands. This is only conceptual adjusted by the computer numerical control and by flexible/ reconfigurable hardware constructions (the interface with the mechanical product market). In this manner there are two critical aspects: a) the fact that the machine is controlled by the operator using a part program in which the machining task is described in detail, leading to an important time consumption; b) the fact that the reconfigurable machine tools consume time for the control system modification. A control system which will cover these aspects must include in the part program a set of task and not a set of instructions and must be adjustable to be in accord with the machine's mechanical structure.
6. The machine predictability. In the commercial activity of biding-negotiation-contracting, the necessity of the pre-evaluation of the relation between the product and the technological machine always emerges. This aspect is not taken into consideration in the actual control systems for the technological machine tools. The commercial control of the technological machines implies the modeling of the relations between the machining task and the min-max level of the consumption of any kind (materials, energy, tools, time) for this machining task
7. The adaptive, optimal or predictive character of the technological machine control. At the present moment this aspect implies two conceptual models: a) the adaptive control with restrictions; b) the adaptive-optimal control. These models are shown in figures 3 and 4. Until now nobody proposed control systems based on the predictive control.

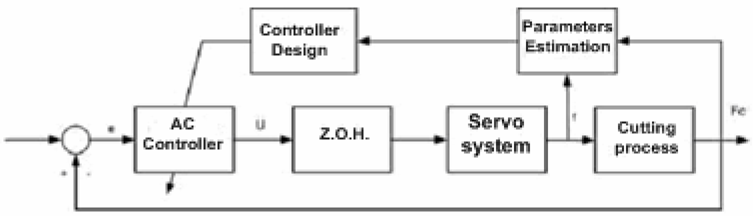

Fig.3 Constraints adaptive control system concept

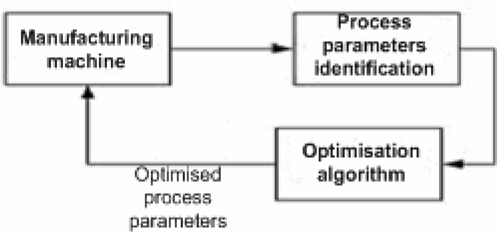

Fig.4 Adaptive optimal control system concept

The typology of models and their construction methodology. Up to the present, the models used for the command of technological machines are analytical, numerical and neuronal. The model construction is based on offline investigation of a prototype, building an experimental database and using this database to select from a model family the most suitable model. In the specialty literature there are no reports about cognitive systems which by monitoring the machine during the machining to extract online knowledge which will be immediately used for real time control of the machine. In the artificial intelligence domain exists some techniques which permit the online extraction of knowledge. A control system for a technological machine should build online models necessary for control using a cognitive system. The main drawbacks of the actual technological control systems, and the modality in which the proposed project deals with the drawbacks is shown in table 1.

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