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ADAPTIVE DIMENSIONAL CONTROL SYSTEM FOR RECONFIGURABLE MACHINE TOOLS

CIPRIAN CUZMIN, GABRIEL FRUMUŞANU, FLORIN BOGDAN MARIN, VIOREL PAUNOIU, GHEORGHE CUZMIN, ALEXANDRU EPUREANU

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Abstract: The paper is presenting a method for online identification of the dimensional dynamics to be used for dimensional control of reconfigurable machining systems. The dimensional control is a key action in order to achieve quality desired for finite product. As diminishing deviation is accompanied with high costs, deviation compensation seems to be a better control of the process.

Introduction

Dimensional control is key action to obtain needed quality for finite product. For the control of dimensional deviations there are used two methods:

a) diminishing of the deviation by reducing process parameters values or by performing several consecutive processes [3];
b) deviation compensation by modifying programmed trajectory of the tool [2].

As reducing deviation presents the main drawback that is leading to increase of the cost, deviation compensation is a more suitable solution.

When a reconfigurable machine tool (RMT) is manufacturing a parts batch we can identify the machining system for its dimensional control using sensors system for aquisition of the measurement process values.
In order to implement dimensional control system, the sensors are placed on the machine for monitoring the process and also measurement equipment is used to evaluate dimensional deviation. The signals transmited by sensors will be recorded, and by processing the data, a control model will be developed to describe dimensional dynamics.

Deviation compensation emerged during the machining process is reached using a model which describes dimensional dynamics of machine tool, meaning the relation between dimensional changing of processed part and the values of process parameters. On the other hand, the behavior of machining system is changing significantly in time during the process, even for a small number of parts processed. This is the reason for that dimensional dynamics must reveal the changing in time of relation between parts dimensional variation and process parameters.

In literature there are presented several ways for achieving error compensation:

a) after the current part is processed its dimensional deviation is evaluated and the obtained value is used for deviation compensation of the next part of the batch;

b) the processing parameters are maintained at a constant level in order to obtain constant deviation and its value is compensated for all parts;

Many papers present methods to identify and compensate the error components and not the error at hole [1].

The method for identification of the dimensional behaviour of the RMT presented in this paper is willing to avoid some disavantages namely:

- the data used to identify the dimensional behaviour of RMT is obtained by RMT monitoring during current process;
- behaviour description of the RMT is achieved, not by using a general model, but by using a simple model, locally applied;
- RMT model obtained by sugested method is following closelly the evolution in time of the machine behaviour;
- deviation is modeled entirelly, not only some of its components.

2. Description of adaptive dimensional control system

We may consider that, in the common case of processing by cutting, any analysis concerning the processing accuracy can be developed using the following surface system: initial surface, reference surface, target surface, programmed surface and final surface. The process is described as follows: knowing reference surface it is programmed the machine tool in order to obtain the target surface. After processing it is found that the obtained surface is not the target surface, but the intermediary surface. In order to operate necessary compensation, the programmed surface is the intermediary surface mirrored with the respect to target surface. This way, the final surface will be as close as posibile to target surface. When processing next parts, in order to identify programmed surface, are taking into account the errors emerged to previous parts. As a conclusion, the current processing is taking into account the events evolution recently emerged in the process.

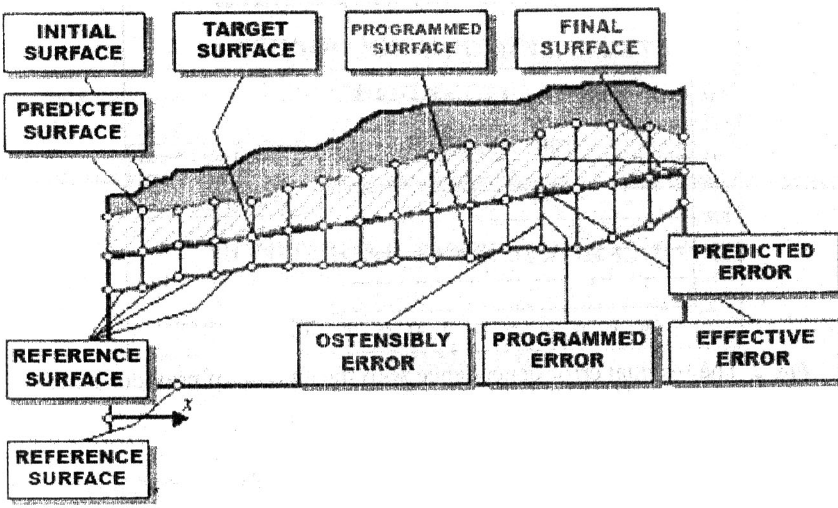

Fig.1. Dimensional control system

The difference between target surface and final surface it is the rezidual error.

Dependence between processing error ε and dimensional variation of the part can be approximated by linear function : $\varepsilon = K_1 \cdot \Delta D$, when K is a constant value. When processing next part, will be considered the value of the K as its mean value corresponding to the previous several parts. The some, it can be operated the approximation $\varepsilon = K_2 \cdot F$, when F is average force on an area of tool trajectory, and K_2 is a constant value.

3. Experimental research

The experimental research aims to study the importance of the amount of previous parts used for evaluate K value. As a result of the research we have used 87 parts, processed in the laboratory and we succeeded simulating dimensional control of the RMT for different scenarios. Figure 2 is depicting the result of data processing for two scenarios. We remark that, as the previous amount of parts is increasing, the residual error is increasing too and the performance of the adaptive dimensional control is diminishing.

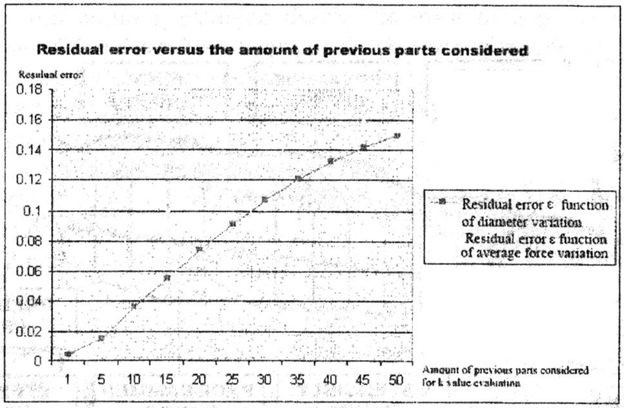

Fig. 2. The residual error dependence with the amount of previous parts considered

4. Conclusions

The proposed adaptive dimensional control system is leading to a good corellation between predicted error values and those mesured. As effect of this result the workpiece accuracy is increasing several times.

Data analysis shows that the mathematical model proposed for dimensional control is more precise as the amount of previous parts considered is smaller.

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"Dunarea de Jos" Galati University
Department of Manufacturing Science and Engineering
alexandru.epureanu@ugal.ro

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