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ScienceDirect

Procedia Engineering 150 (2016) 241 – 246

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2016

# Controlling the Oscillatory Process Composition in Machining by Correcting the Exciting Force Structure in the Cutting Zone

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**Abstract**

The paper examines the power excitation of tool and workpiece subsystems during machining as a combination of elastic and dissipative components. The results of experimental studies show that it is possible to influence the structure of the excitation in the cutting zone as well as the oscillation process composition by changing the machining parameters.

Peer-review under responsibility of the organizing committee of ICIE 2016

*Keywords:* cutting process; elastic and dissipative excitation components; oscillatory process; random and regular vibration components.

## 1. Introduction

The aim of machining is to obtain high-quality products at its peak performance. High processing performance is achieved through intensification of the cutting process. However, here there is a traditional problem of two interrelated categories: high material removal rate often reduces the quality of machined surfaces.

Technological equipment can lose its dynamic stability in limit modes. The loss of stability is accompanied by intense vibration in the cutting system. In such circumstances, the likelihood of tool breakage increases, and there arise difficulties in achieving high processing quality.

The cutting dynamics in machining is influenced by numerous factors: from the cutting tool properties and the processed material characteristics to the dynamic characteristics of the process equipment. Therefore, at the same material removal rate but with different combinations of cutting speed, depth of cut and feed, it is possible to obtain different results in terms of processing quality.

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Peer-review under responsibility of the organizing committee of ICIE 2016
doi:10.1016/j.proeng.2016.06.755

The object of attention in this article are the factors that form motion conditions of the cutting elements in the treated material and can affect the processing dynamics differently on different machines.

Motion parameters of the cutting part of the tool in the treated material have a significant impact on deformation processes during machining. The main parameters here are the rate of the deformation processes in the cutting area and their three-dimension localization which are formed by treatment regimen.

Thus, the processing mode and the dynamic state of the processing equipment should be mentioned among the main factors that influence the dynamics of the cutting process and are related to the processing equipment characteristics. The article discusses aspects of machining quality and productivity on the basis of the analysis of related factors in 'processing mode - cutting process - oscillatory process' system.

## 2. Rationale

A lot of researchers show special attention to the problems of chip formation process in machining and emerging dynamic phenomena in machines. Examination of these issues involves a whole set of such processes and factors as:

- cutting process mechanics;
- the structure of tool and workpiece subsystems disturbance formed by the cutting process;
- the impact of the characteristics of visco-elastic environment of tool-workpiece contact area on dynamic properties of the cutting system;
- oscillation formation in the tool and workpiece subsystems;
- methods and means of extracting information from the oscillation process signal disturbed in the tool and workpiece subsystems.

The issues of chip formation mechanics and cutting instability manifestations during machining are reflected in [1,2]. The authors emphasize that the technological system of machining belongs to a class of vibration activity systems and has low dissipation. Cutting process has the biggest disturbing potential. Dynamic cutting system under intensive treatment modes is prone to buckling. Fluctuations formed in the cutting system can have a significant effect on tool life, processing performance and the quality of the treated surface. Self-oscillations can reach such high intensity that the cutting process may not be possible.

Chip formation occurs in a plastic shear of the treated material elements. There are two stages: the deformation to the shear plane and metal shift on the shear plane. Friction process is of high importance. It is viewed as two components. External friction component is generated by the sliding of the cutting tool elements on the treated material. Inner component is formed by the friction between the shifted elements of a deformable metal. In accordance with the proposed three-element chip formation model elastic and viscous disturbance components are formed in the cutting area. Their ratio can be influenced by the dynamic characteristics of workpiece and tool subsystems as well as the processing mode. Therefore, the issues of optimal settings of the processing equipment in the operating area must be matched and compatible with processing equipment capacities to provide machining without self-oscillatory process formation. Issues of self-oscillating process modeling for machining are discussed in [3-5].

An important place in the study of dynamic phenomena is given to oscillatory processes signal analysis issues. The oscillatory process is a dynamic system response to the disturbance of the cutting process in accordance with its dynamic properties. Therefore, the oscillation process signal carries important information about the state of the dynamic cutting system. Studies of self-oscillating modes and oscillating processes are discussed in works [3,6,7].

In general, it can be noted that the dynamic phenomena in machining belong to a very complex research field which has already been developing for several decades. There are many scientific schools that deal with machining dynamics and contribute significantly to the existing knowledge base. However, many issues remain unresolved. Therefore, research in the field of physical modeling and mathematical description of the dynamic phenomena in machining, stability of dynamic cutting systems, relations between the characteristics of the oscillation process and indicators of the cutting process quality, managing the processing quality as well as many other issues are still relevant.