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ScienceDirect

Procedia Engineering 206 (2017) 68–73

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Industrial Engineering, ICIE 2017

Assessing the Regenerative Effect Impact on the Dynamics of Deformation Movements of the Tool during Turning

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Abstract

The article is devoted to the modeling of the deformation movements of the tool during turning. Despite the fact that these studies have already been carried out, the issue of assessing the impact of regenerative fluctuations on the trajectory of the formative movements when turning has not been studied yet. The article gives a mathematical model and the results of numerical modeling of deformation shifts during the cutting process. It is shown that under certain conditions, depending on the parameters of the reformative system of a machine, the trail left by the tool during the previous turn, can not only be transferred to the next turn, but also increase. In this case, the phase difference of the regenerative oscillations and current deformation oscillations of the tools may not lead to the stabilization or damping of oscillatory processes.

Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering

*Keywords:*model; deformation; cutting force; system dynamics.

1. Introduction

Metal cutting processing is associated with the occurrence of complex deformation movements both in a workpiece and a tool used during this treatment [1-8]. These deformations result from the forces impeding the formative movements of the tool, but at the same time they participate in the formation of these forces. The system formed with the help of such deformations interacts with the environment, under which in this case we refer to a subsystem of drives, providing the forming movement of the tool. The result of this interaction is a constant flow of energy through the sub-system drives, and power dissipation, through the mechanism of irreversible changes of metal in the cutting area. To describe the dynamics of deformation movements of the tool, it is necessary to reveal these phe-

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1877-7058
Peer-review under responsibility of the scientific committee of the International Conference on Industrial Engineering.
10.1016/j.proeng.2017.10.439

nomena through the mechanisms of interaction of mechanical forces, which depend on the coordinates of the system status [9-13].

The properties of the process of irreversible transformations in metals at turning are characterized by non-linearity, temporal variability of the parameters of the equation and periodic disturbances, including violations of the kinematics [13-19]. As a result of kinematic violations, or some fluctuations of the parameters of the cutting subsystem, there are complex oscillatory movements in the area formed by the axes of deformation of the tool [5-8]. The nature of such movements is well studied and described [5-8], but some aspects are not fully studied. One of such cases is to study the impact of the previous periodic movements on the current space-expansion movements of the tool. Such periodic fluctuations that occur in each period of rotation of the detail are described in the works of Voronov S.A. This phenomenon is described by him as follows: - "The reason that there are fluctuations in the system, is a regenerative effect (or "cutting the trail"). The physical meaning of the regenerative effect is that the variable cutting force causes tool vibrations, whereby on the treated surface of the workpiece there are "waves", which are cut off at the next passage of the tool, causing irregularities ("waves") on the surface. Depending on the phase difference between the two surfaces, the maximum thickness of chips may increase, which in turn leads to an increase of the cutting force" [20]. However, this work did not investigate the effect of "cutting the trail" on the dynamics of spatial and deformation of the tool movement.

In this connection it is of interest to assess the impact of the regenerative effect on the dynamics of spatial and deformation movement of the tool, taking into account the complex interrelation of coordinates of deformation. Here, from the view point of study of dynamics, it is necessary to check the following two hypothesis. The first hypothesis - "cutting on the trail" is a mechanism of stability loss in the process of metal turning. The second hypothesis is connected with a possible compensatory effect of the phase difference between the current space - deformation fluctuations of the tool and the same fluctuations in the previous period. The result of such a compensatory influence may be damping of fluctuation processes in the deformation system of the tool.

2. Basic mathematical model

To enhance the visibility of input coordinates, as well as assessing the impact of the forces on the deformation of the tool, we shall consider the turning process in the following diagram (see Figure 1).

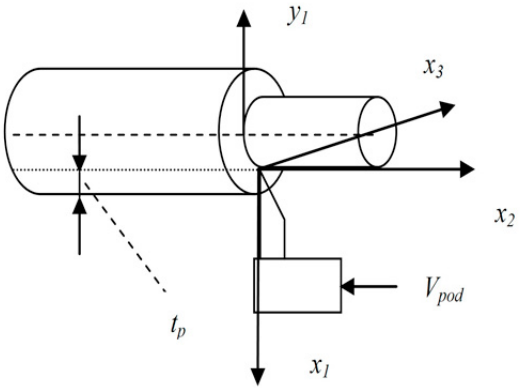

Fig. 1. To explain the deformation displacement.

In Figure 1 is a schematic description of the process of turning, the axis x_1, x_2, x_3, indicate the direction of the deformation displacement of the tool, the reference point in this coordinate system is the undeformed condition of the tool, V_{pod} - flow rate, t_p - the value characterizing the depth of the cutting.

The strength that prevents the introduction of the tool into the material of the workpiece has a complicated spatial arrangement in the coordinate system linked with the axes of the tool deformation. Let us take a general description of the projection of the cutting force on the axis of the deformation of the tool in the form [5-8]: