THE INFLUENCE OF DISTURBING FACTORS IN THE OCCURRENCE OF VIBRATIONS IN THE SPINDLE ASSEMBLIES OF MACHINES

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Abstract. The article deals with analyzes of the influence of disturbing factors arising in the process of cutting the vibration of the executive bodies of machine tools.The patterns of the change in the trajectory of the instantaneous center of the rotating section of the billet are studied. The figure shows the direction of the cutting force of the relative movement of the cutting edge of the tool and the workpiece, as well as the appearance of spatial displacements caused by disturbing influences and violations specified by the law of spindle movement.

Keywords. Vibration, disturbing, tools, workpiece, spindle, trajectory, molding.

Introduction. The metal-cutting machine must ensure the required accuracy of processing and the quality of the treated surface at high productivity. To obtain a high-quality surface of the part during the cutting process, it is necessary to ensure constant movement of the workpiece and the tool along a certain trajectory. It is known that various dynamic effects occur during cutting, they significantly affect the cutting process, where the geometric shaping of the workpiece and the physical course of the processing process are consistent. Vibrations arising in the cutting process of machine tool actuators negatively affect the quality of the treated surface, dimensional accuracy decreases and the roughness of the surface of the treated part increases [1].

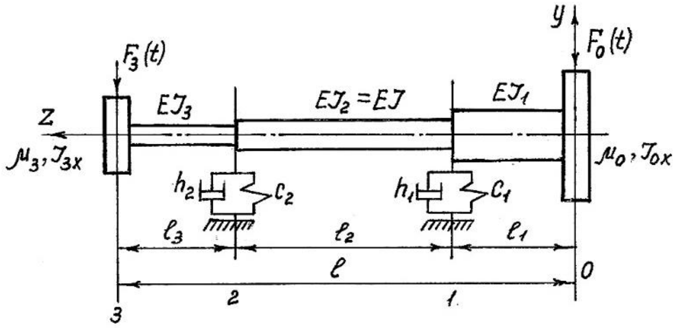


Figure 1. Parametric diagram of the machine

The machine spindle is presented as a stepped beam of length l on elastic supports with viscous damping proportional to the oscillation rate (Fig.1). The beam is divided into N sections delimited by a change in diameter, support, concentrated mass, external concentrated load or a jump of distributed load. Each i –th section has a constant distributed mass mi and bending stiffness EJi .

The spindle is divided into three sections. At its ends there are concentrated loads: a cartridge and a belt drive pulley. In the zero section of the spindle there are disturbances from the cutting process – force F0 (t), in the third section – disturbances from the drive F3 (t).

The methodology of the work. When studying the designs of spindle assemblies of machine tools, it was taken into account where disturbances from the cutting process act – the cutting force, in the third section – disturbances from the drive. In spindle nodes, under the influence of external

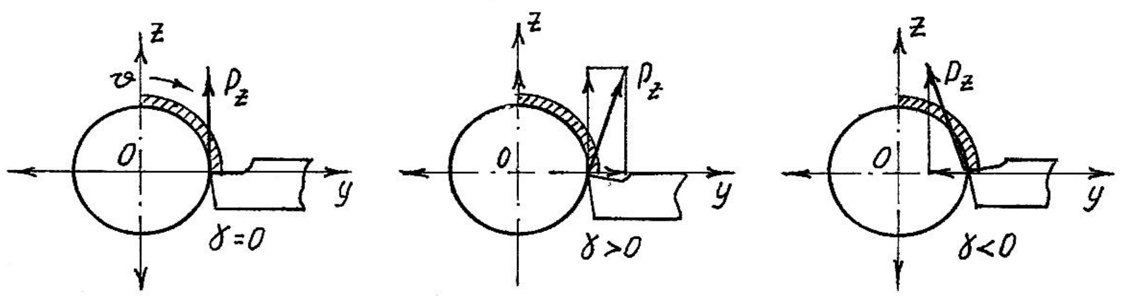
ISSN 2349-7793 (online), Published by INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, IT, ENGINEERING AND SOCIAL SCIENCES., under Volume: 16 Issue: 12 in December-2022
https://www.gejournal.net/index.php/IJRCIESS

force influences, the axis of its own rotation rotates around a fixed point. Such turns are the appearance of moments of resistance, which tend to prevent forced turns of the axis of its own rotation in space. There is an interaction of these moments, which leads to the appearance of spatial movements in the processing zone and violates the set laws of motion, this is an uneven rotation or movement of executive bodies. In turn, it causes the appearance of deviations in various indicators of the accuracy of the processed workpieces [1,2].

In the workpiece processing zone, various trajectories of movement of the instantaneous center of the rotating section of the workpiece are formed, this movement is carried out with variable speed. This leads to the appearance of variable amplitudes and frequencies that depend on the conditions of workpiece processing are directly dependent on the dynamic characteristics of spindle assemblies [3].

During the processing, the coordinates of the relative movement of the cutting edge of the tool and the workpiece being processed continuously change, caused by disturbing influences. There are disturbing influences on the process, such as cutting modes and the geometry of the cutting tool. The cutting depth and feed, depending on the properties of the processed material, the cutting force vector is formed [3,4,5].

The direction of the cutting force vector is determined by the geometry of the cutting tool, where the angle in the plan is φ and the front angle is γ. With increasing S, the cross–section of the slice increases, then the vector of the disturbing force P in the plane of OHU increases, O is the stationary pole of rotation, at the same time the external disturbing moment Mp1 increases, with a change in the trajectory and frequency of the forced spatial movement of the axis of its own rotation of the spindle assembly in the processing zone (Fig.2).



When the forward angle γ changes, the direction of the vector of the disturbing force P in the zOy plane changes, as a result, the ratio between the components of this force in the xOy and yOz planes changes, which also affects the moments from these components relative to the stationary pole of rotation.

Results. Based on this, the hardness of the workpiece material to be processed, the dependence of the deformation parameters of the equipment elements and the cutting force of the Rc on the feed value S, which are presented in the table below, are taken into account. Due to the fact that the width of the wear zone on the back surface of the cutting tool increases by 0.7-0.8 mm, the Ru force is doubled. With increasing DRu, the processing error increases [6,7].

Dependence of the cutting force on the feed value

Table 1.

ISSN 2349-7793 (online), Published by INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, IT, ENGINEERING AND SOCIAL SCIENCES.,
under Volume: 16 Issue: 12 in December-2022
https://www.gejournal.net/index.php/IJRCIESS

Material of the workpiece	Number	Longitudinal feed S, mm/rev	Cutting force DRu , kgf
Steel 45	1	0,06	17,3
Steel 45	2	0,12	62,9
Steel 45	3	0,18	76,8

Conclusions. In the study of the designs of spindle assemblies, it was possible to establish that the center of gravity of the rotating masses of spindle assemblies does not coincide with the pole of rotation located within the first bearing of the spindle. It turns out to be shifted either up or down. Horizontally to the right or left. When the spindle nodes are idling, their axis of self-rotation describes a conical surface in space, since the moment vector from the weight of the rotating masses in the rotation pole rotates with the spindle and the axis of self-rotation of the spindle, striving to align with the vertex of the moment vector, rising, rotates in space together with this vector [8].

During cutting, the resulting cutting forces create moments relative to the rotation pole, the vectors of which, like the vector from the weight of the rotating masses, continuously change position in space, rotating together with the spindle. Where the complexity of spatial displacements of the axis of self-rotation of the spindle group leads to lower processing accuracy on machines with horizontal axis of rotation of spindle units compared with vertical axis of rotation, which have a simple character of spatial displacements and simpler forms of control of the ratio of the speeds of own and forced rotations, as a result, high processing accuracy can be achieved when cutting [8].

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