ANALYSIS OF DYNAMIC CHARACTERISTICS OF TECHNOLOGICAL SYSTEMS METAL CUTTING

Asatillaev Yuldashali Malikovich, Associate Professor, Ph.D., Namangan Engineering Construction Institute Republic of Uzbekistan, Namanagan city, 12 Islam Karimov street.
e-mail: yaldash@umail.uz

Annotation. The article discusses two main components of vibration: the workpiece system and the cutting tool. The research was carried out by comparing the reciprocating motion of the cutting tool with the workpiece in two coordinates, the inertia of the one-sided system and the inertia of the spindle. A technological model of the machine for analyzing the output characteristics of the quality of the processed surface has been developed.

Keywords: dynamic, flutter, vibration, stability, stagnation, accuracy, model, spindle.

Introduction. Analysis of machine dynamics is the determination of optimal machine parameters. The issues of analyzing the dynamics of machine tools are considered in the work of V.A.Kudinov, the following main indicators of the dynamic quality of the machine: the stability margin, the reaction of the system to external influences, the speed during cutting determining the duration of the transition process in the system [1].

In the machine – tool – tool – workpiece system, vibrations occur during the cutting process – periodic oscillatory movements. Vibrations have a harmful effect on the cutting process, noise occurs, the quality of the treated surface deteriorates, tool durability decreases.

The oscillatory system of the machine is the unbalance of the rotating parts of the machine, fixtures, workpieces and tools, cutting conditions, fluctuations of closely located equipment.

Methods and objects of research. The paper considers two main oscillatory links: the workpiece system (spindle, workpiece, pinole tailstock) and the tool system (tool, tool holder, caliper).

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 theoretically calculated trajectory. In management, the goal of the process is to achieve the required output characteristics to ensure the quality of the treated surface in a minimum time with a minimum cost. Therefore, the process is like a controlled object, which is affected by external influences (shown in Fig. 1).

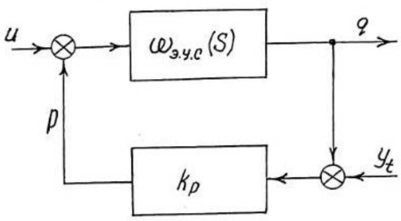

Figure 1. Block diagram of the dynamic system of the machine

The vibrations of the technological elastic system arising during cutting significantly reduce the processing performance, tool durability, negatively affect the quality of the treated surface, accuracy decreases and roughness increases [2].

In this case, it is possible to mathematically substantiate this phenomenon by considering a technological elastic system as a closed dynamic system with feedback. The research of the

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mathematical model of the turning process will be built taking into account the closure of the technological elastic system with feedback [3].

When studying vibrations during turning, it is possible to make assumptions about the rigidity of the spindle in comparison with the rigidity of the subsystem of the relative movement of the cutter and the workpiece along two coordinates, in certain directions of which deformations most affect the accuracy of shaping and the linearity of the system (Fig. 2).

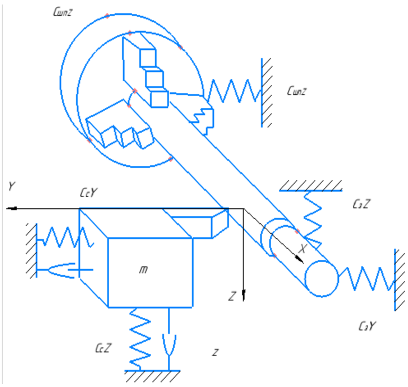

Figure 2. Dynamic model of the technological elastic system of the machine.

The input effects are the force effect u(t) from the unbalance of the workpiece system and the tool system and the change yt(t) of the cutting depth of the tool [4, 5]. We take the state variable change q(t) of the relative position of the cutting tool and the workpiece normal to the processing surface to use the Dalembert principle, we obtain a mathematical model of the system in the form of a differential equation

$$\{mq(t) + hq(t) + cq(t) = P(t) + u(t); \qquad (1)$$
$$\{P(t) = k_p[y_t(t) - q(t)],$$

where m, h, c are the reduced mass, the equivalent damping and stiffness coefficients of the workpiece system and the tool system;

P(t) – change in cutting force;

kp is the proportionality coefficient (characteristic of the cutting process).

In the initial conditions, we take the Laplace transform to the differential equation (1), dividing all its parts by c, then

$$\left\{(\frac{m}{c}s^2 + \frac{h}{c}s + 1)q(s) = [P(s) + u(s)]\frac{1}{c}; \qquad (2)\right.$$
$$\{P(s) = k_p[y_t(s) - q(s)],$$

where q(s), P(s), u(s), yt(t) are Laplace transformations of the variables q(t), P(t), u(t), yt(t); s is a common variable.

We introduce the notation m/c =T2, h/c = 2ξT (ξ is the damping coefficient) and k = 1/c, we write (2) formula b as follows:

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$$q(s) = \frac{k}{T^2 s^2 + 2\xi Ts + 1}[P(s) + u(s)] = \omega_{э.у.с}(s)[P(s) + u(s)]; \quad (3)$$

where ωe.u.s. (s) is the transfer function of an equivalent elastic system.

From equations (3), it makes it possible to represent the structure of the considered dynamic system of the machine in the form of a combination of an elastic system and a cutting process interacting with each other is shown in Figure 1.

Then

$$\omega_{э.у.с.}(j\omega) = \frac{k}{(1 - T^2\omega^2) + j2\xi T\omega},$$

ωe.u.s.(jω) is the amplitude–phase frequency response in the work corresponds to the prevailing horizontal vibrations of the headstock (frequency 125 s-1), bending vibrations of the spindle. Resonant characteristics corresponding to the prevailing vibrations of the caliper (frequency 70c-1).

Results. The analysis of the experimental results obtained shows that the amplitude – phase frequency response of the machines depends on the design of the machine and the values of its parameters, the operating mode of the machine, the method of fixing and the size of the workpiece, the coordinates of the point of the working space of the machine [5].

Conclusions. The following conclusion can be made that the dynamic properties of the machine can be estimated by the magnitude of the negative maximum of the real component of the frequency response of the dynamic system

$$\omega(f) = k_p\, \omega_{э.у.с.}(f).$$

On the amplitude – phase frequency response of the elastic system of the machine, this value corresponds to the segment Re.u.s. in Figure 3.

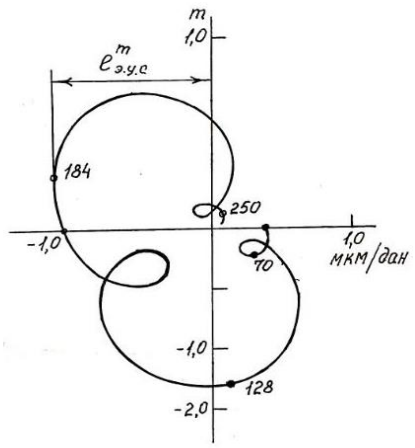

Figure 3. Amplitude – phase frequency response of the machine.

Coming out of this, the stability of the machine is the higher, the smaller the Re.u.s. segment, so that the value of the chips goes out at the maximum cutting depth, processing goes without vibrations, and vibration increases with increasing cutting speed.

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