Features of Using the Structural Damping in Construction of Cutting Tools

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***Abstract* – The influence of internal friction parameters in the joints of structural elements on the machine for vibration amplitude of cutting tool and detail was analyzed. The possibility of effectively suppress the amplitude of oscillation of the cutting tool by selecting optimal parameters of frictional connection of the cutting blade was shown.**

Key words – structural damping, cutting tools, oscillations, amplitude, resonance, friction.

I. Introduction

As you know, oscillations that occur in the process of cutting metal, a negative impact on the quality of surface details, and the stability of the machine tool and resource. Because these oscillations occur in one of the resonant frequencies VPID system (usually at a very high frequency), then the decrease in amplitude oscillation damping uses [1], the impact of which is particularly effective for resonance and near the resonant frequencies. Effective damping is achieved through the use of internal friction in the joints still VPID elements of the system, known as structural damping [3] machine elements. The influence of structural damping of the amplitude fluctuations can be estimated by the following data. Logarithmic decrement damping of the lathe is 0.23 - 0.25 [4], while for ordinary steel its value is 0.02 - 0.04. It should be noted that the development of modern machine tools made toward reducing structural damping through the use of guide bearings. However, high value decrement is not a sufficient condition for oscillation absence, or smallness of their amplitudes. In [2] showed that it is link tool - detail is responsible for self-oscillation and the introduction of high damping in massive structural elements such as machine tool spindle and the caliper does not reduce the amplitude of oscillation of tools and parts. The most effective damping is the introduction of the least massive element, usually it's cutting tool and very rarely - detail. Therefore, designing instruments with high value of the logarithmic decrement zatuhan is an urgent task, especially for cutting hard materials.

II. Discussion

The scattering of energy in the oscillations fade, can be characterized Absorption [3], which is equal to

$$\psi = \frac{\Psi_n}{\Pi_n} = \frac{A_n^2 - A_{n+1}^2}{A_n^2} \approx \frac{k}{m} T \approx 2\delta \,, \qquad (1)$$

where Ψ_n – the energy dissipated during the n-th cycle fluctuations and Π_n - potential energy at the beginning of that cycle. In the case of cyclic loading strength thin plate αP_y, uniform pressure to squeeze to hard p basis for the length l (Fig. 1), the displacement of the plate relative fundamentals will not occur until the condition is performed:

$$P_y < fpbl \,, \qquad (2)$$

where f - coefficient. friction, b - width of the plate, α - dimensionless parameter load. At maximum load $\alpha = 1$, and at a minimum - $\alpha = r$, where $r = P_{y\,\min} / P_{y\,\max}$ - characteristic asymmetry of the cycle.

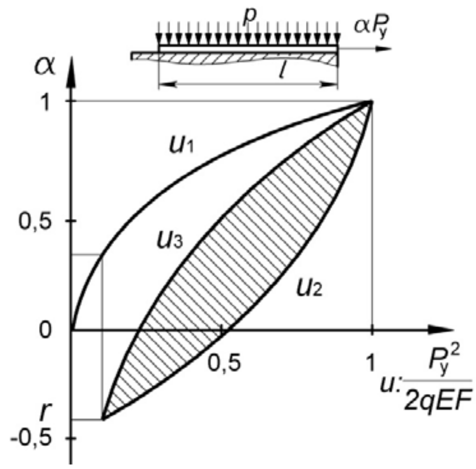

Fig. 1. Hysteresis loop Ψ

Fig. 1 shows the formation hysteresis loop between the thin plate and rigid base area which characterizes the energy dissipated during a cycle fluctuations. On the vertical axis delayed relative movement end plate from 0 to 1. This full shift plate relative to fundamentals impossible because of the condition (2), that shift will only occur in a certain length of the plate, and the greater the length of this shift, the greater the area hysteresis loop (Fig. 1), and hence the energy dissipation. The value of this energy can be calculated by the formula [3]

$$\Psi = \frac{P_y^3 (1-r)^3}{12qEF} \,, \qquad (3)$$

where $q = fpb$ – the threshold friction force (per unit length of the plate or cutter clamped in the tool carriers); E – modulus material plates (cutter body); F – cross-section area of the plate (the body of the tool).

From the analysis of Fig. 1 and (3) we can conclude that the pressure pressing plates (a cutter tool carriers) affects the energy dissipation in the connection. The less pressure, the greater the energy dissipation, but with decreasing pressure should come true condition (2). This is the tracker and shown in Fig. 2. solid curve 1. In order to prevent displacement of the tool in the tool carriers in achieving maximum energy dissipation, cutter should be fixed in stubborn resistance. This situation is reflected bar dotted curve in Fig. 2. Thus, as can be seen from Fig. 2, there is an optimal pressure value on the cutter, which corresponds to the maximum value of energy dissipation.

The scheme of fixing tool in the tool carriers shown in Fig. 3 Since the passing cutter fluctuate in a horizontal plane x - y, then it need additional support along the axis x, and it should be regulated. All this would require structural changes to the machine tool carriers. Ideally it would not make changes to the design of tools, and to design appropriate instruments that would have sufficient energy dissipation to self-oscillation does not occur.

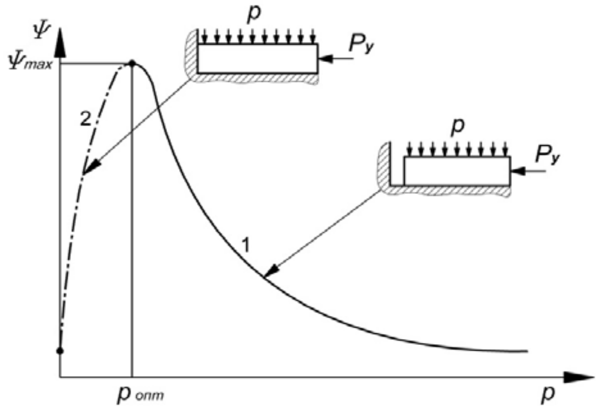

Fig. 2. Schedule dependencies $\Psi = f(p)$

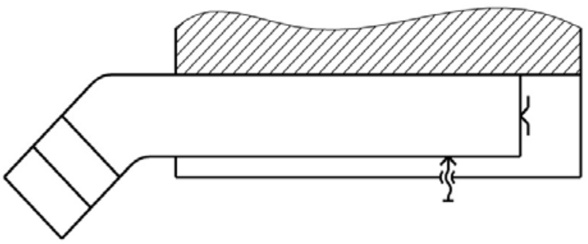

Fig. 3. The scheme of fixing tool in the tool carriers

Conclusion

So dissipation of vibrational energy at fixing tool, or in the instrument, can prevent the occurrence of oscillation in the process of cutting metal or significantly reduce their amplitude only optimal pressing the cutting blade.

In further research the system of differential equations which describe the motion of the four-mass vibrating system will be built. The vibrating system (Fig. 4) consists of caliper, cutter, detail and spindle, which are connected with machine carcass with elastic ties and dampers. This scheme corresponds to the scheme of classical lathe, the mass of the carcass of which is much greater than the mass of its individual units.

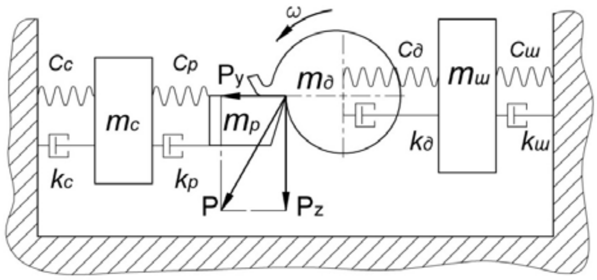

Fig. 4. The vibration scheme of the machine

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