Impact of Processing Modes and Parameters of the Working Part of the Instrument on the Surface Quality of Flat Parts During High-Speed Friction Hardening

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***Abstract* – Impact of processing modes and parameters of the working part of the tool-workpiece on the quality and surface precision of details during high-speed friction hardening of flat details is developed.**

Keywords – surface precision, surface roughness, oscillation, precessional motion, high-speed friction.

I. Introduction

Increasing the requirements for the precision and quality of the surface layers of details during processing and the high speed of the tool disk creating periodic forces makes the problem of oscillations very important during the consolidation process. In addition the high quality of the surface layer of the workpiece is strongly influenced by the intense heat fluxes was formed during processing [1].

During friction hardening when the technological system “machine tool–tool–detail” is fluctuating there are such processing errors as wavelengths and deviations from geometric shapes. These fluctuations have moderate intensity in the energy plan and a random nature. Fluctuations of the dynamic system developing in the process of hardening affect on the change of force in the contact area and temperature difference. [2-3].

To reduce the oscillations and vibrations of the elastic system of the machine to its nodes is put high requirements of dynamic quality. This is especially true for spindle machine nodes.

To ensure high process parameters, it is necessary to choose the ratio of the width of the groove to the length of the working disk of the disk and the number of grooves. As the maximum amplitude of oscillations of an elastic system arises when coinciding the eigen frequencies of a system with perturbation frequencies then it operates in resonance mode. The large amplitudes of oscillations are undesirable not only because of the possibility of an elastic system in the resonant mode but also because of the deterioration of the surface layer quality. During the work of the machine tool in a non-resonant mode the oscillation amplitude decreases and the process of hardening normally takes place. So the change in the excitation frequencies is caused by a periodic change in the amplitude of oscillations which leads to unstable operation of the machine. Besides when working at frequencies close to the resonance frequencies of an elastic system, the process of consolidation proceeds in adverse conditions [3-4].

II. Main Material Presentation

On the formation of the quality parameters of the treated surface is significantly influenced by the dynamic processes that arise in the contact area of the tool-detail with their friction hardening.

As the process of friction hardening occurs at high speed friction tool on the treated surface (60-80 m / s) in the area of contact of the tool with the workpiece arise shock loads, so consider mandrel system-spindle machine tool as a gyroscope that spins at high speeds.

The spindle of the machine tool is located on two elastic supports A and B. We denote the forces acting on the spindle with the tool and determine the coefficient of stiffness of the supports in the directions for the left support. Denoted the forces acting on the spindle with the tool and determine the coefficient of stiffness of the supports in the directions for the left axis support $y-c_{1y}$ and axis $z-c_{1z}$ and for the right axis support $y-c_{2y}$ and axis $z-c_{2z}$.

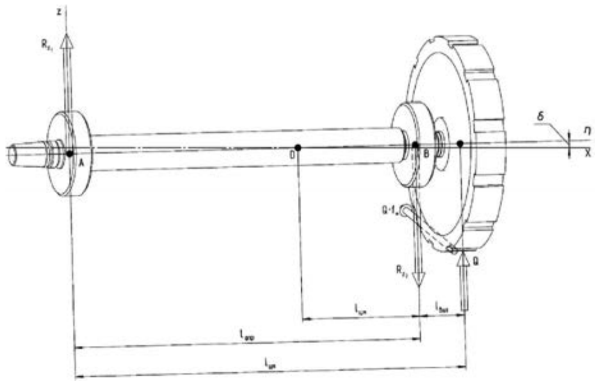


Fig.1. Scheme of strength in a plane with precessional motion of a spindle.

Where Q – the active strength in the plane XZ; R_{z_1} – strength of the reaction of the support A in the plane XZ; R_{z_2} – strength of reaction in the plane XZ.

For the simulation of a gyroscopic phenomenon in the precessional motion of a spindle during frictional processing of rigidly fixed parts, a program in the Matlab/Simulink environment was developed.

The precessional movement of the spindle of the machine with the frictional hardening of flat surfaces is modelled when angular velocity changes from ω = 200 rad/s to ω = 600 rad/s with the application of a constant force Q = 1000 N (Fig. 2). The obtained results show that the external and internal radii of the cone, which are described by the end of the spindle of the machine in the process of strengthening, increases with increasing processing regimes (increasing the angular velocity at different pressures) (Fig. 2).

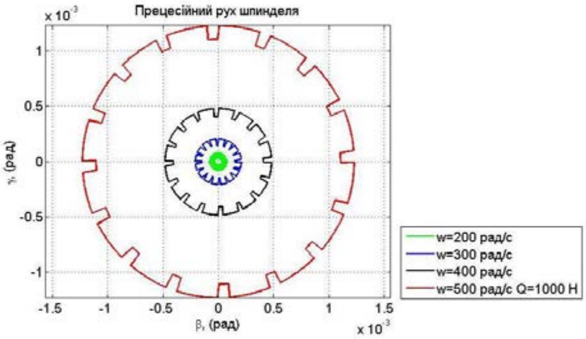
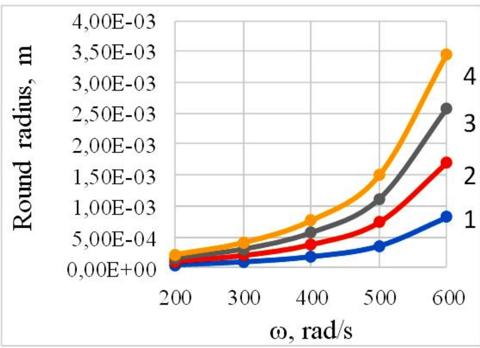
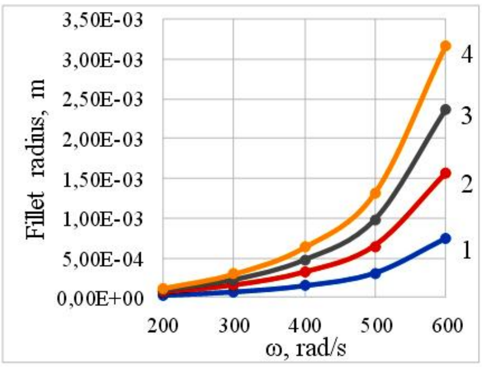


Fig.2 – Precessional motion of the spindle of the machine with friction hardening (Q = 1000 N).



a



b

Fig.3 –The dependence of the precessional machine on the change of angular speed and clamping force (external radius (a) and internal radius (b)): 1 – Q = 500 H; 2 – Q = 1000 H; 3 – Q = 1500 H; 4 – Q = 2000 H.

To determine the influence of the diameter change of the strengthening tool was modelled the process of hardening on two different diameters, namely, 200mm and 360 mm (Fig. 3). The obtained results of the dependences of internal and external radii of discs of different diameters in the precessional motion of the spindle of the machine with a change in the force of the clamping show that the change in the diameter of the disk at different forces does not significantly affect their relationship in the processing, and they don't essentially increase during the precessional motion of the deflection of the end of the spindle of the machine tool. The results of simulation of the strengthening process with the change in angular speed from ω = 200 rad/s to ω = 600 rad/s also show that the change in the diameter of the tool doesn't significantly affect the ratio of their radius in the precessional motion of the spindle, deviations are insignificant.

Conclusion

The obtained results in the process of modelling precessional motion of a spindle during superficial friction strengthening have shown that in the process of cutting a tool into a workpiece, the spindle begins to oscillate under the action of gyroscopic moments and reaction forces. The spindle oscillation amplitude decreases by the exponential curve, and the oscillation amplitude coefficient increases with increasing spindle hardness and stabilizing action of gyroscopic moments.

From the results of the research can be concluded to increase the stabilization action of gyroscopic moments, it is necessary to increase the angular speed of the spindle, moments of spindle inertia and tool hardening. In order to improve the quality of the surface to be treated, it is necessary to reduce the static and dynamic imbalance of the spindle with the frame and the strengthening circle, to reduce the outflow of the frame, to increase the gyroscopic moment from the precessional movement of the spindle-frame by increasing the angular speed and rotation of the spindle-frame with the tool hardening, increasing the mass and the middle radius of spindle and tool hardening, increase the stiffness of the spindle-frame.

References

[1] Ya. O. Shakhbazov, "Tekhnolohichni mozhlyvosti znyzhennia amplitudy kolyvan tekhnolohichnoi systemy shlifuvannia," *Optymizatsiia vyrobnychykh protsesiv i tekhnichnyi kontrol u mashynobuduvanni ta pryladobuduvanni*, vol. 515, pp. 51–54, 2004.

[2] S. P. Nikitin, "Vliyanie kolebaniy dinamicheskoy sistemyi stanka na tochnost i temperaturu pri shlifovanii," *Vestnik Permskogo natsionalnogo issledovatelskogo politehnicheskogo universiteta*, no. 3, pp. 31–47, 2010.

[3] A. G. Suslov, V. F. Bezyyazyichnyiy, Yu. V. Panfilov, *Injeneriya poverhnosti detaley*, Moscow: Mashinostroenie, 2008.

[4] I. V. Hurei, V. I. Hurei, P. R. Dmyterko, "Modeliuvannia hiroskopichnykh protsesiv pid chas fryktsiinoho zmitsnennia detalei mashyn," *Optymizatsiia vyrobnychykh protsesiv i tekhnichnyi kontrol u mashynobuduvanni ta pryladobuduvanni*, no. 760, pp. 14–18, 2013.