The Simulation Model of the Trajectory of the Point of Contact of Tool-Workpiece during Friction Hardening

Petro Dmyterko, Yurii Novitskyi

Department of Mechanical Engineering Technologies, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: dmyterko.petro@gmail.com

***Abstract* – The simulation model to simulate the trajectory of the precession motion of the point of contact with the tool-workpiece when there is direct and reverse the course of table machine during high-speed friction hardening is developed.**

Keywords – consolidation of friction, surface roughness, gyroscopic phenomenon, precession motion, high-speed friction.

I. Introduction

Friction processing is a method of hardening using highly energy sources. Research of temperature and power parameters of mechanical processing shown that the required pressure and temperature for formation hardened (white) layers can be obtained by increasing the friction between the tool and processed detail [1].

A characteristic feature of this method - the opportunity to hardenen not only the bodies of rotation and flat models, but different profile details. White layer can be obtained in all steels that gather and also of gray and ductile iron.

Research of friction hardening conducted in terms of materials, namely the the formation of hardened layer, its properties, the impact of hardened layer on wear resistance. Currently, research gyroscopic effects and their impact on quality parameters and roughness of the surface layer that arise during friction hardening of machine parts, is missing.

II. Page Setup

Friction processing belong to methods for surface hardening using highly concentrated energy sources. During the consolidation of friction in the contact zone of the tool-part is a high-heat metal to temperatures higher point of phase transitions through high-friction tool to the workpiece. In the surface layer of metal additionally there is intense shear deformation of the metal.

Conditions of the contact between the hardening tool and machined piece has a great impact on the quality of processing. During hardening micro and macro inequality depend on the material and shape of the working surface of the tool, the number and size of grooves. To date, not enough investigated the kinematic and dynamic phenomena associated with the movement of precession and gyroscopic instrument phenomenon [1].

When considering the process of friction hardening, the speed of the instrument should be considered in relation to the speed of the workpiece. Speed of the process of hardening is defined how the vector sum of speed of rotation of the tool and the speed of the workpiece. Assuming that on the top disk take fixed point, during the the process of hardening, it describes a curve, cycloid, which is its trajectory. The curve describes the tool contact with the workpiece, depending on the direction of the workpiece (Fig. 1), which in turn has a significant impact on the surface roughness (Fig. 2).

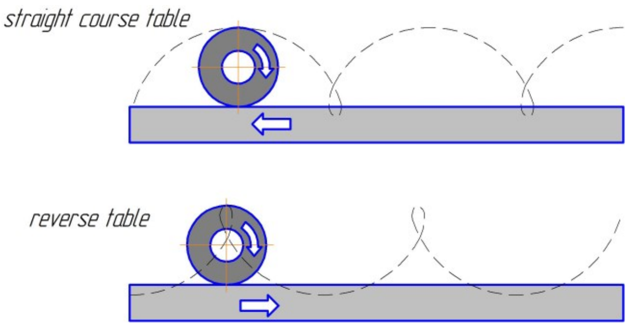

Fig. 1. Trajectory of movement of the tool with the workpiece

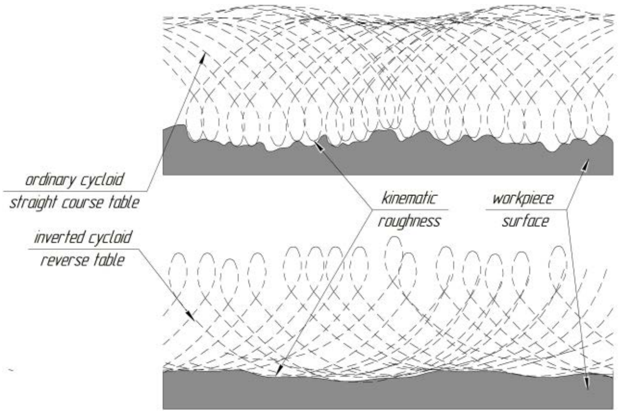

Fig. 2. Trajectory of movement of the tool during the friction hardening when there is direct and reverse the course of table machine

When rotating the spindle clockwise direction and longitudinal movement of the table left curve looks like an ordinary cycloid, and when the spindle rotating clockwise direction and longitudinal movement of the table to the right curve takes the form of inverse cycloid. [2-3].

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. With high frequency spindle rotation is its precession motion, and through the force of gravity and shock pulse, inertia forces and their moments gyroscopic phenomenon arise, it is impossible to balance by the end of the spindle with the tool. The movement of machine spindle can be decomposed into translational motion with the pole and rotating (relative) motion relative to this pole. Consider spindle rotation under static and dynamic (Fig. 3), which determines the position of the spindle and through the corners. γ i β .

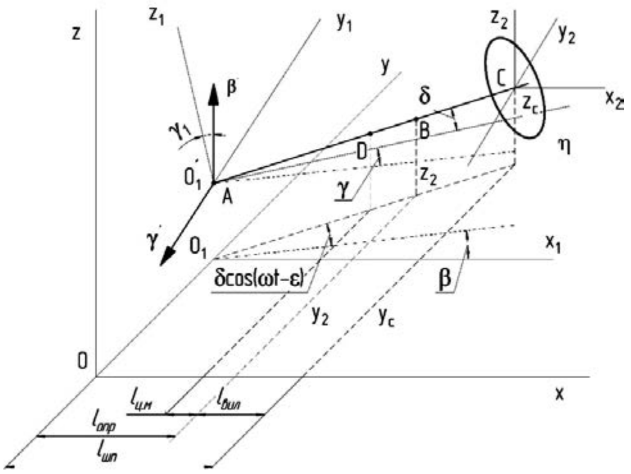

Fig. 3. Location of the spindle in a fixed coordinate system x y z

Write the system of equations that determine the position of the spindle through corners. γ i β [3]: spindle machine tool has unequal stiffness supports. During process of hardening the spindle forces act that arise in the contact zone of the tool-a detail under action which it flexes. There deflection axis spindle rotation plane and end the tool is tilted at an angle to the axis. To describe the processes that occur during high-speed rotation of the tool, assume that the center of mass and the spindle behind the geometrical axis of rotation at a distance with the main axis of inertia makes with this axis angle δ, voctor $O_1'A$ and axis η form an angle ε, plane, which is the angle δ and plane xy, form an angle $(\omega t-\varepsilon)$ [4-5]

The equations describing the precession motion of spindle will look like as:

$$\beta=\frac{l_{opr}\cdot\left[\left(\begin{array}{l}\frac{1}{2}\cdot Q\cdot\cos\omega_{sp}\cdot t+\\ +m_{sum}\cdot e\cdot\omega_{sp}^{2}\cdot\cos\omega_{sp}\cdot t+\\ +\frac{1}{2}Q\cdot f_{tert}\cdot\sin\omega_{sp}\cdot t\end{array}\right)\times\\ \times\left[-c_a\cdot l_{sp}-c_b\cdot l_{vyl}\right]\right]}{f_2(\omega_{sp})}$$

$$\gamma=\frac{l_{opr}\cdot\left[\left(\begin{array}{l}\frac{1}{2}\cdot Q\cdot\sin\omega_{sp}\cdot t+\\ +m_{sum}\cdot e\cdot\omega_{sp}^{2}\cdot\sin\omega_{sp}\cdot t+\\ +\frac{1}{2}Q\cdot f_{tert}\cdot\cos\omega_{sp}\cdot t\end{array}\right)\times\\ \times\left[-c_a\cdot l_{sp}-c_b\cdot l_{vyl}\right]\right]}{f_2(\omega_{sp})} \quad (1)$$

On the basis of equations (1) it can be concluded that the forced vibrations of the spindle caused static and dynamic, is a direct precession of the angular velocity ω, which is equal to the speed of rotation of the spindle $\omega_{шп}$. Spindle axis describes an ellipse, turning in the same direction how the spindle. The curve that describes the point of contact with the tool in the workpiece precession motion under action unbalance spindle is a cycloid. [5].

Conclusion

In this work was developed a simulation model that describes the trajectory precession motion point of contact for instrument-disk workpiece during high-speed spindle rotation machines. Determined that the cycloid's form depends on scheme of friction hardening, such as direct or reverse movement machine tool table. The given researches have shown that scheme of friction hardening affects not only the shape of the trajectory of the point of contact tool-workpiece, and the magnitude of surface microirregularities hardened parts. In reverse course table during high-speed friction hardening surface roughness is less than the course of hardening direct desktop machine.

References

[1] Hurey I. V. Vplyv udarnykh navantazhen' na heometriyu poverkhni pry fryktsiynomu zmitsnenni detaley mashyn / V. I. Hurey // Avtomatyzatsiya vyrob. protsesiv u mashynobud. ta pryladobuduvanni : ukr. mizhvid. nauk.-tekhn. zb. – L. : Vydavnytstvo L'viv. politekhniky, 2011. – Vyp. 45. – S. 283–288.

[2] Springer-Verlag Berlin Heidelberg. Manufatsturing Protsesses 2. Grinding, Honing, Lapping. Klotske, F. 2009, XXIV, 433 p. 35 illus., Hardtsover. ISBN: 978-3-540-92258-2.

[3] Hurey I. V. Modelyuvannya hiroskopichnykh protsesiv pid chas fryktsiynoho zmitsnennya detaley mashyn / I. V. Hurey, V. I. Hurey, P. R. Dmyterko // Optymizatsiya vyrobnychykh protsesiv i tekhnichnyy kontrol' u mashynobuduvanni ta pryladobuduvanni : [zb. nauk. pr.] / vidp. red. Z. A. Stots'ko. – L. : Vyd-vo Nats. un-tu «L'viv. politekhnika», 2013. – S. 14–18. – (Visnyk / Nats. un-t «L'viv. politekhnika» ; №360)

[4] Bat' M. Y. Teoretycheskaya mekhanyka v prymerakh y zadachakh : ucheb. posobye. T. II. Dynamyka / M. Y. Bat', H. Yu. Dzhanelydze, A. S. Kel'zon. – 8-e yzd., pererab. – M. : Nauka, 1991. – 638 s.

[5] Kolev K. S., Vas'kov V. Y. Vlyyanye pretsessyonnoho dvyzhenyya osy shpyndelya shlyfoval'noho stanka na sherkhovatost' poverkhnosty pry obrabotke tuhoplavkykh metallov almaznym instrumentom. Trudy SK·HMY, vыр. 32. Voprosы tochnosty y konstruyrovanyya v mashynostroenyy. Ordzhonykydze, 1972, s. 70-81