Academicia Globe: Inderscience Research

ISSN: 2776-1010 Volume 3, Issue 2, Feb, 2022

CONTROL OF FORCE PARAMETERS DURING PROCESSING DIAMOND GRINDING

Urinov Nasillo Fayzilloevich
Candidate of Technical Sciences, Associate Professor
Bukhara Engineering-Technological Institute

Dubrovets Lyudmila Vladimirovna
Senior Teacher Bukhara Engineering-Technological Institute
Urinov1960@Mail.Ru

Annotation

The article covers analysis of various methods of cutting forces measurement at diamond smoothing and their description, advantages and disadvantages.

Keywords: smoothing, force, microroughness, dynamometer, piezoelectric effect, piezoelectric sensors, hydraulic dynamometer.

Introduction

Diamond smoothing is widely used due to considerable advantages associated with physical-mechanical properties of diamond. Diamond has a low coefficient of friction on metal due to its high hardness and thermal conductivity. To achieve a low roughness of the smoothed surface, the working surface of the diamond can be polished to Rz = 0.025-0.063 microns. As opposed to rolling, the main distinguishing feature of diamond smoothing is the ability to machine parts with a very high hardness. Due to the small contact areas between the tool and blank, the smoothing force is in the range of 50-300 N, which allows machining non-rigid parts (thin-walled bushings and shafts).

Main part

During smoothing, the force P is decomposed into its components: normal P_y, tangential P_z and feed P_x forces. The magnitude of smoothing forces depends on the radius of shape of the working part of smoother, the plasticity and roughness of machined surface, on the penetration depth of the smoother, feed, etc. Research has established that the main force that creates the required pressure in the contact area of the tool with the part is the normal component P_y. The components P_z and P_x are 10-20 times less than P_y [1]. Therefore, P_y is taken as the smoothing force.

When smoothing formed surfaces of parts (parts with variable radius), the following types of mandrel design are distinguished: dynamometric (flat spring is used as a load-bearing element); spring (a load-bearing element is helical spring); hydraulic (a load-bearing element is the energy of the compressed fluid in the hydraulic cylinder); pneumatic (a load-bearing element is compressed air energy) and others, which have a number of disadvantages, leading to significant fluctuations in the smoothing force R_u during processing.

When smoothing microroughnesses of a relatively small height, their deformation is carried out by upsetting with a predominance of compressive stresses. For this reason, even with a significant increase in the smoothing force, the plasticity resource is quite large. If the height of the profile irregularities is relatively large, their deformation is carried out largely by bending, and to a lesser extent by upsetting. Because of bending deformation, tensile stresses prevail, which reduce the ductility resource of the alloy and reduce its resistance to deformation. Therefore, an increase in the smoothing force beyond the optimal value leads to the exhaustion of the plasticity resource of the part material and manifests itself in the form of “peeling” of its surface, i.e. an increase in roughness compared to smoothing with the optimal force [2].

To obtain parts with the required surface layer quality, a constant smoothing force is required. Dynamometers are used to record strength changes. The dynamometer consists of a power link (elastic element) and a reading device. In the power link, the force causes deformation, which is transmitted directly or through a transmission to the reading device. According to the principle of operation, there are mechanical dynamometers (spring or lever), hydraulic and electronic. Sometimes two principles are used in one dynamometer.

There are two types of mechanical dynamometers: spring and lever. In a spring dynamometer, a force or moment of force is transferred to a spring, which, depending on the direction of the force, is compressed or stretched. The amount of elastic deformation of the spring is proportional to the force of impact and is recorded. In a lever dynamometer, the action of the force deforms the lever, the amount of deformation of which is then recorded.

Fig. 1. Mechanical dynamometer

The action of the hydraulic dynamometer is based on the displacement of the fluid from the cylinder by the measured force. Under pressure, the liquid flows through a pipe to the recording device and is recorded. The disadvantage of hydraulic dynamometers is their lack of sensitivity at low forces (less than 100 kg), as well as a tendency to vibrations. Due to their bulkiness and high inertia, hydraulic dynamometers are rarely used; they are unsuitable for investigating the instantaneous values of forces.

Electric dynamometer consists of a sensor that converts the deformation from the force into an electrical signal, and an additional sensor that amplifies and records the electrical signal of the first sensor. To convert a force or moment of force into deformation, inductive, piezoelectric, strain gage and vibration-frequency resistance sensors are used. The force deforms the sensor and the currents of the resistance bridge change. The strength of the electrical signal is directly proportional to the deformation of the element and, as a result, the strength of the impact.

The most common way to measure cutting efforts and forces is strain measurement. Physically, the method is based on the deformation of the measuring element under load and the change in its electrical resistance. As a rule, the measuring element enters the measuring bridge, and by measuring the voltage in the measuring bridge, due to the change in the electrical resistance of the measuring element, the applied force can be judged. Existing dynamometers have very large overall dimensions and require replacement of the tool holder with an appropriate device, and have inertness. Another variant of such devices are modified units of machine tool equipment, which monitor the deformation of the machine bed or the load on the spindle unit or on the feed unit [3, 4]. However, such devices require a significant modification of the machine tools and do not provide sufficient accuracy when measuring small forces.

Also known are devices that use the properties of the direct piezoelectric effect when measuring. The piezoelectric force measurement system differs significantly from other methods. The forces acting on a quartz crystal are proportional to the electrical charge that occurs. The compression of the sensing element is a few thousandths of a millimeter. Quartz dynamometers are very rigid systems. Thanks to their high natural frequencies, they are able to accurately measuring even very fast processes. Quartz piezoelectric force sensors do not need to be zeroed, because they are immediately ready for measurement at the push of a button.

Such devices are devoid of such a big drawback as inertness, high rigidity, a huge measurement range, linearity and absence of hysteresis.

To measure cutting forces, inductive devices are also used [13]. The disadvantage of such devices is the ability to measure only static loads. There are also induction devices for cutting forces that allow measuring forces in dynamics, but this type of device does not allow measuring large forces and has a small measurement range.

When diamond smoothing of parts with a round profile, the blasting force can be changed and change direction when using different designs of mandrels. When the direction of the force changes, the friction against the surface changes, and this affects the wear of the tool. Diamond smoothing can be performed both from the beginning of the movement of the part and during its movement.

In the process of machining axial parts, one cannot help but avoid movements of the indenter. This can be influenced by radial motion variation.

Fig. 2. External view of three-component dynamometer using the piezoelectric principle of force measurement

The diamond tip can vibrate back and forth in one revolution. In the process, the seizure of the tool occurs. This happens so quickly that it is not visually noticeable, it is difficult to fix it with instruments, and this can greatly affect the parameters of the surface of the part. The same thing happens when start moving. There is a jump in the component of the smoothing force directed against the direction of movement of the indenter, that is, the friction force. This case can be experimentally fixed. In theory, the force should increase, but the theory is written for cases with a rigid mandrel. It is necessary to reproduce the process with mandrels other than rigid construction.

As equipment for the experiment, we use a 1K62 screw-cutting lathe. For all experiments, we use an indenter with a synthetic diamond with a radius of R1.5 mm. For comparative experiments, a part of a rod made of 12X18H10T material for external processing was used. The part is installed in the centers on the machine. To avoid radial motion variation, the outer surface of the part is machined. For internal processing, a part with a hole made of D16T material is used. Instead of the tool holder, a “Kistler” 5233A1 three-component dynamometer is installed, and various mandrels with a diamond tip are attached directly to it. The axis of the smoother must exactly coincide with the axis of the centers of the machine. Industrial oil I-20 is used for smoothing with lubricating fluid. In the process of diamond smoothing on a lathe, there are two movements, this is the movement of rotation of the part and the movement of feed. To study the process, it is necessary to divide them into: direct rotation movement - direct rotation of the machine spindle; reverse rotation - reverse rotation of the machine spindle; longitudinal straight feed movement - longitudinal feed direction is straight or to the left; longitudinal reverse feed movement - the direction of longitudinal feed is reversed or to the right. The movement pattern is shown in Fig. 3.

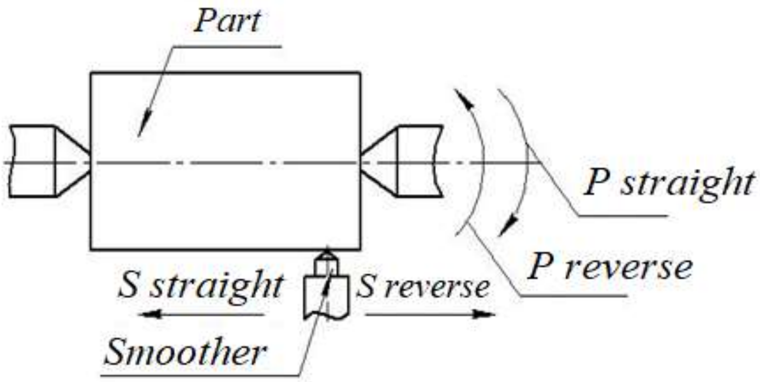

Fig. 3. Scheme of the movements

Conclusions

To study the beginning of the movement, the movement is carried out manually by rotating the spindle and manually moving the caliper. All changes in forces will be recorded on the computer. For a noticeable indication, a temporary pause between actions is always carried out.

When comparing different mandrel designs, the following external smoothing mandrels were used: a) rigid mandrel; b) dynamometric mandrel (load-bearing element is a flat spring with a damper) c) pneumatic mandrel (load-bearing element is bellows with compressed air) with a receiver; d) pneumatic mandrel (load-bearing element is bellows with compressed air) on flat springs with receiver and for internal smoothing: e) torque mandrel; f) pneumatic mandrel (load-bearing element is bellows with compressed air) on flat springs with receiver.

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