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Research of Force Dependences at Diamond Ironing

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Abstract: The article covers the force dependences at diamond ironing at the beginning of movement with various mandrels, in contrast to the mandrel with a rigid structure: a pneumatic mandrel and a pneumatic mandrel on springs.

Keywords: diamond ironing, pneumatic mandrel on springs, rigid mandrel, gauging, pneumatic mandrel, friction

Introduction

During the process of diamond ironing of parts with a round profile, the ironing force can change and change direction when using different mandrel designs. When the direction of the force changes, the friction against the surface changes, and this affects the wear of the tool. Diamond ironing can be performed both from the movement beginning of the part and during its movement [1, 2].

In the process of machining axial parts, it is impossible to avoid movements of the indenter. Radial flapping can influence this. 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, and it is difficult to fix it and can greatly affect the parameters of the surface of the part with instruments. The same thing happens when moving is started. 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 [3]. 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.

Main part.

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 flapping, 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 three-component dynamometer 5233A1 from "Kistler" firm [4] is installed, and various mandrels with a diamond tip are fixed directly onto it. The axis of the ironing device must exactly coincide with the axis of the centers of the machine. Industrial oil I-20 is used for ironing with lubricating fluid. In the process of diamond ironing on a lathe, there are two movements, which are the movement of rotation of the part and the movement of feed. All changes in forces will be recorded on the computer. For a noticeable display, there is always a temporary pause between actions. When comparing different mandrel designs, the following external ironing mandrels were used: a) rigid mandrel; b) dynamometric mandrel (power element is a flat spring with a damper) c) pneumatic mandrel (power element is bellows with compressed air) with a receiver; d) pneumatic mandrel (power element is bellows with compressed air) on flat springs with receiver; and for internal ironing: e) a torque mandrel; f) pneumatic mandrel (power element is

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bellows with compressed air) on flat springs with receiver [5]. Two mandrels for comparison are presented in this article.

Pneumatic mandrel for external ironing

The pneumatic mandrel with a power element in the form of pneumatic spring or bellows refers to the elastic fastening of the tool and allows processing the outer cylindrical surfaces of a detail with radial flapping or shape deviations. The bellows is an elastic corrugated chamber that experiences compression stresses during ironing. To stabilize the force, a receiver has been added to the "indenter – bellows" system, which allows significantly reducing the pressure fluctuation in the bellows by increasing the volume of compressed air. The volume of the receiver is more than 10 times the volume of the working chamber of the bellows. Ironing is performed at a certain value of the pressing force [5, 6], which is set using the air pressure in the system and controlled by a pressure gauge.

The design features of a pneumatic mandrel should ensure a constant ironing force *Py* even with a large surface flapping, since the change in the volume of the bellows is small in relation to the volume of the receiver, therefore, the change in pressure in the bellows and the ironing force is also small.

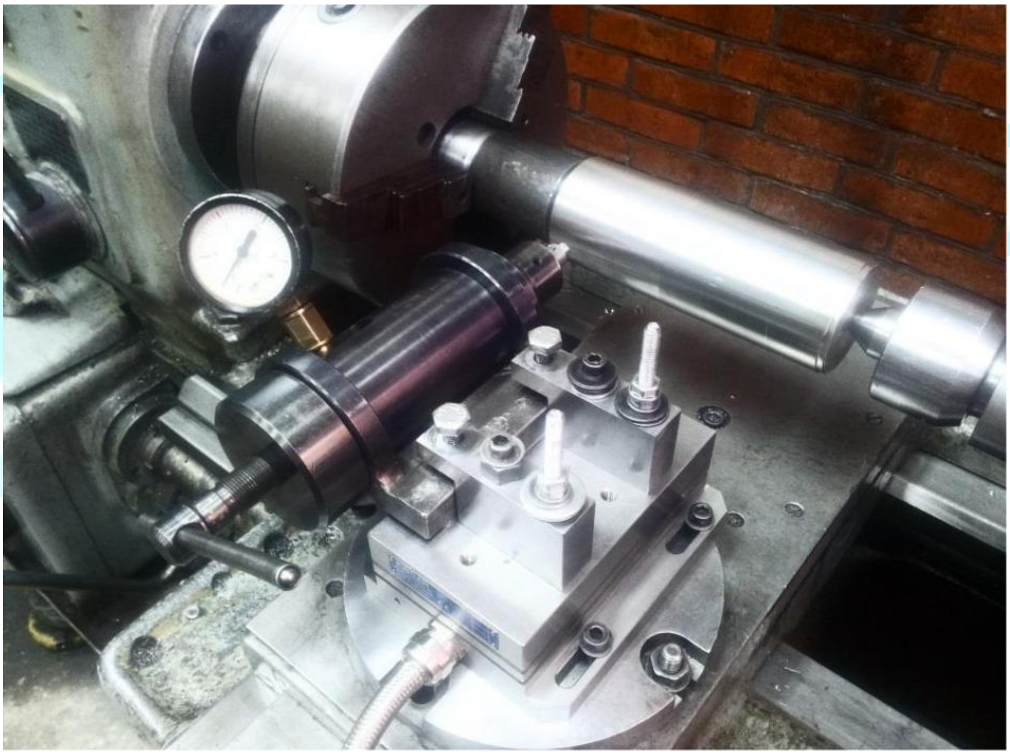

Fig. 1. Installed pneumatic mandrel

Gauging with a three-component dynamometer

In order to determine the required pressing force, it is necessary to select the required pressure in the receiver [6, 7]. The screw pressed through the ball limits the bellows stroke. The air system is determined for air leaks.

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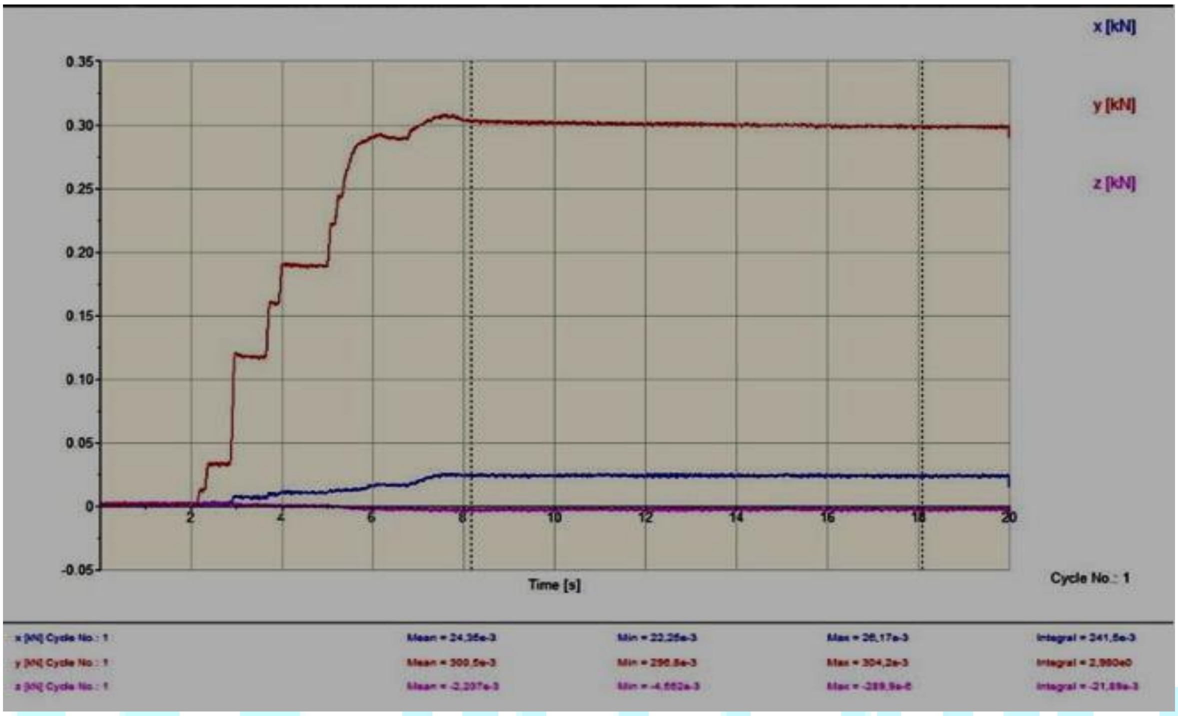

Fig. 2. Force verification graph

The radial force *Py* decreases slightly over time due to the deflation of the pneumatic system. There was a change in the axial force *Px*, possibly due to the tool overhang relative to the dynamometer on Fig. 2.

The force dependences of the ironing force at the beginning of the unidirectional movement are carried out in the same way as with a rigid mandrel.

Measurements were made according to the following criteria: in the direction of cutting motion; on the degree of loading forces 100N, 200N and 300N; and on the use of lubricants.

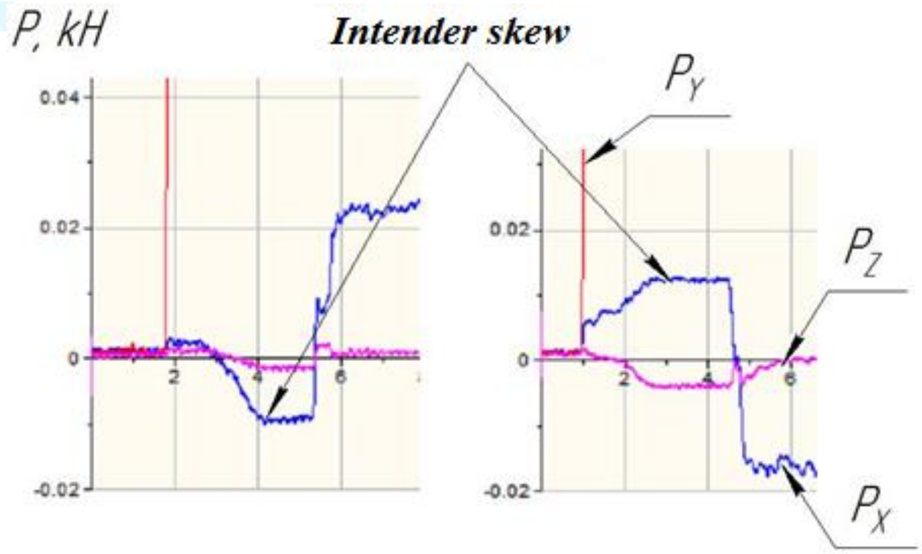

Fig. 3. The change of axial force

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Fig. 3 shows two strongly pronounced graphs under equal conditions with a force of 100N and the use of lubricant, only movement in different directions. Axial force *Px* under load takes on different values. This observation is present on all charts. This phenomenon can be explained by the design of the mandrel. The diamond is fixed in a sleeve that moves along the hole with a gap and becomes with a different skew. Oscillation of the radial force *Py* can also occur due to seizure in connection with the sleeve, but there can also be seizure on the surface of the part associated with bending of the tool.

Because of the study of crack starting on a pneumatic mandrel, it was established that when the force is loaded, the indenter often becomes skewed.

The fault is because of the design of mandrel. No visual bending was observed, as this may have occurred inside the body.

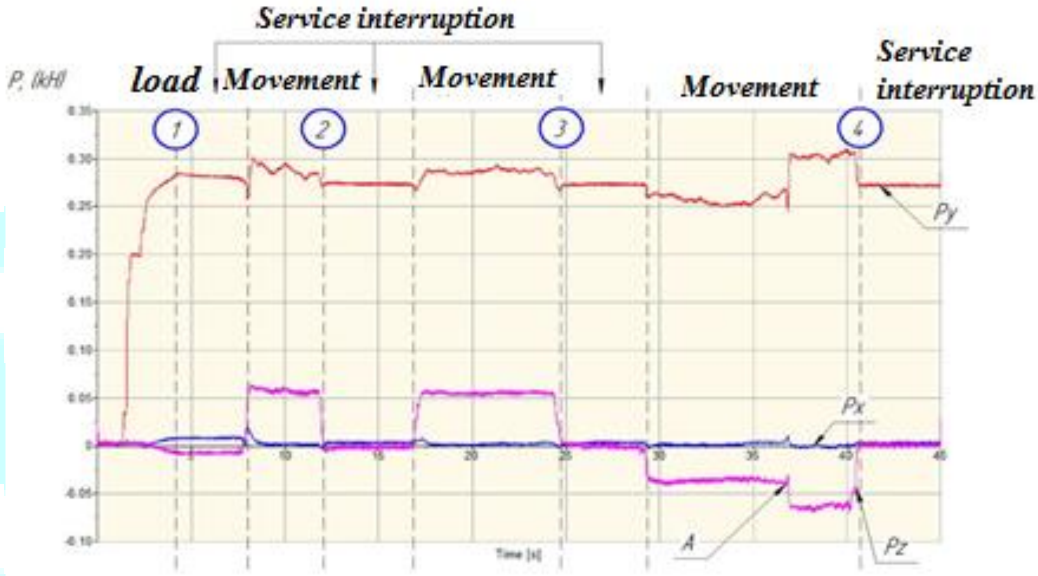

Fig. 4. Scheme of the reversible movement of the pneumatic mandrel during rotation

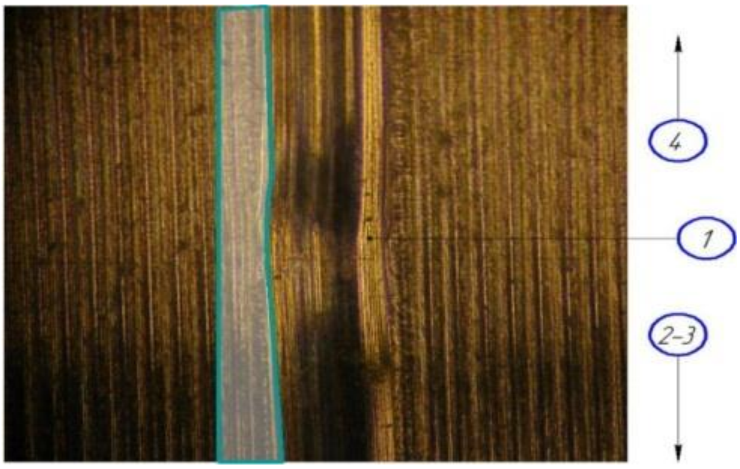

Fig. 5. Passing the point of injection

Fig. 4 clearly shows the passage of section A of injection. There is a change in the direction of the ironing force. We can also visually observe the passage of the injection point 1 in Figure 5. In theory, there should be a constant pressing force on this mandrel, but structurally, due to the friction force, a change in the radial force occurs.

Pneumatic spring mandrel for external ironing.

A mandrel for diamond ironing with a power element in the form of a pneumatic spring and a flexible spring support is intended for processing the outer cylindrical and shaped surfaces of parts, as well as surfaces of parts installed with eccentricity.

The design of the mandrel includes a diamond indenter fixed in a sleeve, which in turn is rigidly fixed to a spring support. The spring support consists of four flat springs reinforced with plates to avoid spring deflection and contact between the movable part of the mandrel and its body. This support allows moving with a small amplitude around the starting point: ± 3mm. The ironing force is provided by a hollow metal corrugation, i.e. a pneumatic bellows. Constant air pressure in the bellows gives a constant pressing force of the working element of mandrel on the detail surface. Constant pressure is achieved by a multiple excess of the air volume in the receiver compared to the air volume in the bellows, thereby avoiding significant changes in air pressure in the bellows due to compression of the bellows and a decrease in air volume. This should reduce the magnitude of fluctuations in the force of the force element, compared with the magnitude of the force generated by it. To control the pressure in the system, a pressure gauge is installed on the receiver.

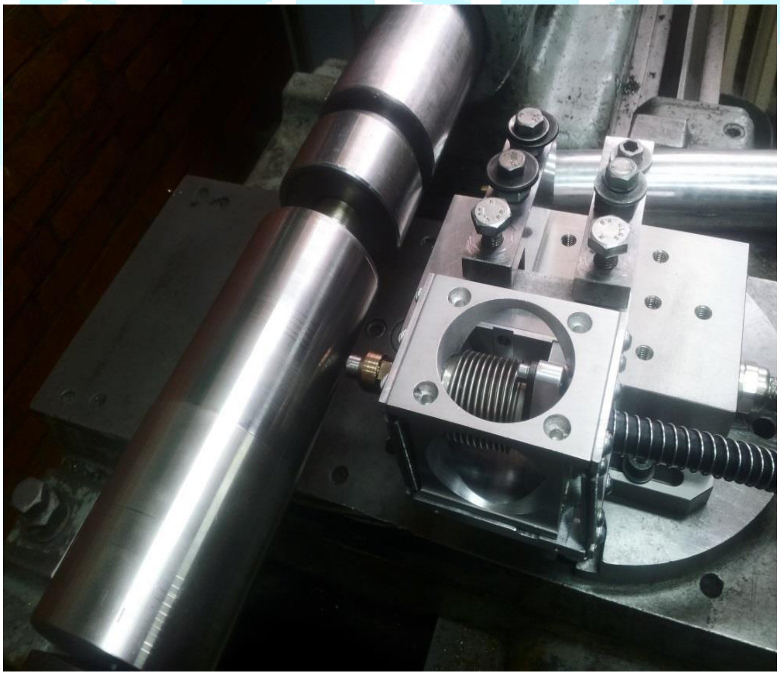

Fig. 6. A pneumatic spring mandrel mounted on a machine with a receiver.

In order to determine the required pressing force, it is necessary to select the required pressure in the receiver. The gauging schedule for this mandrel is already available, therefore only verification is carried out. The air system is determined for air leaks.

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Fig. 7. Force verification graph

On the graph (Fig. 7), a verification gauging was performed using a dynamometer. The pressure was selected in relation to the required effort. First, air was pumped into the system. Then the measurement process was started and air was gradually released from the receiver at intervals.

The deviation of the axial component of the force *Px* is a large overhang of the tool. By the tangent component *Pz,* we can say that the axis of the indenter is lower than the axis of the centers of the machine.

Measurement of the force dependences of the ironing force at the beginning of unidirectional movement is carried out in the same way as with a rigid mandrel. Measurements are made according to the following criteria: in the direction of movement; at the degree of loading forces 100N, 200N and 300N; and on the use of lubricants. All data and graphs are presented in Appendix A and Tables 19-22. The graphs are shown at five-fold ironing. The friction coefficients are indicated in table 2.5, where the loading force is approximately for the gradation, the exact force is shown on the graphs in the appendix.

Conclusions

Pneumatic spring-supported mandrel allows ironing with a constant direction of force vector. From the graphs it can be seen that the radial component of the force *Py* remains unchanged during movement. The same happens with the friction force during the movement of rotation of the tangential *Pz* and for the longitudinal movement of the support of the axial force *Px*. The graph shows the crack starting at the start of the movement. The change in the friction coefficient from the ironing effort is more uniform, but differs from the direction of movement.

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