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Tool for Machining of Blind Conical Holes by Surface Plastic Deformation

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***Abstract* — The report describes the construction of the tool for machining of blind conical holes by surface plastic deformation (SPD). Typical of the tool is that the machining is carried out by radial feeding of the deforming rollers, that the deforming force is applying elastically, that allows limitation of the longitudinal feed of the separator and that it allows adjustment of the size which has to be set and the deforming force.**

***Keywords*— tool, surface plastic deformation, machining blind hole**

I. Introduction

Reliability of machine-building products is ensured by the quality of the surfaces of their parts. In this connection, the role of the technological methods for finishing is decisive. Methods are implemented to ensure the quality of the machined surfaces corresponding to the requirements for the exploitation properties of the surfaces. Through the surface plastic deformation tools (SPD), all the elementary surfaces are machined from which the parts are built up (cylindrical, conical, planar, profiled) [1, 6]. Greatest applications have been obtained the tools for machining long cylindrical surfaces, which are characterized by the axial feeding of the deforming elements relative to the machined surfaces [3, 4, 5, 6].

The machining through SPD of short accurate holes (L/D≤5) using tools with axial feed has a limited application. One of the reasons is getting a defect at the end of the workpiece (increase in diameter at the front of the hole and leakage of the metal), which reduces the useful working area from the surface of the holes.

There is also a nomenclature of parts that have holes with broken and unclosed contours (slots, channels, etc.) for which the tools with axial feed are not applicable. These include and three-way distribution valves for high pressure. Their working surfaces are conical (through and blind) with high roughness requirements (Ra = 0,32 - 0,16 μm) and accuracy (6-7 grade).

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Finishing of blind conical holes through surface plastic deformation (SPD) has specific difficulties, most often carried out by tools with radial feeding of the deforming rollers [2, 8-11]. The known constructions of tools for machining blind conical holes have a hard action without the possibility of adjusting the size which has to be set and also the deforming force [1, 3, 5]. There is also an SPD-tool on external rotating surfaces [7].

II. Construction of a Tool for Machining of Blind Conical Holes by Surface Plastic Deformation

In the present work is described the construction of a tool for machining of blind conical holes by SPD with radial feeding of the deforming rollers, where is possible to limit the longitudinal feed of the separator with the rollers, the adjustment of the size which has to be set, as well as adjusting and elastic application of the deforming force.

Fig. 1 shows the construction of the proposed tool, which consists of several mechanisms. The first one consists of a mandrel composed of a front 4 and a rear part 16. A support cone 3 is formed on the front of the mandrel, on which are mounted cylindrical deformation rollers 2 wrapped by a separator 1 whose longitudinal feeding is limited by a supporting bearing 11 mounted to the separator and limited by a ring 15. The separator is spring-loaded by a return spring 14 axially located relative to it by a bush 13 and a bearing 12. Thus is formed a mechanism for limiting the longitudinal feeding of the separator with the rollers upon contact of the bearing 11 with the front of the workpiece and at the same time for restoring the original arrangement of the rollers relative to the separator after completion of the operating cycle.

With aim of additional static adjustment of the size, a mechanism is provided for locating the separator with the rollers in a certain position relative to the support cone. This mechanism consists of a nut 8 connected to the separator by a threaded bush 5 fixed to the separator by screw 6 and counter nut 7. The nut 8 is placed relative to the front of the mandrel 4 using a bush 10 and a bearing 9, which provides machining of the hole by surface plastic deformation with radial feeding of the rollers.

The rear part of the mandrel 16, on which is formed a tail for connecting the tool to the spindle of the machine, is mounted with the option of axial movement relative to its front and is connected with it through the pin 17. With aim of regulation and elastically apply a deforming force, the two

parts of the two piece mandrel are spring-loaded relative to each other by spring 20 housed in an adjustable cup-shaped nut 18 which is secured by a counter nut 19. Thus, a mechanism for regulating and elastic application of a deforming force is formed.

Therefore, thanks to the existence of the mechanisms mentioned above, with the proposed tool is achieved machining of a blind conical hole by surface plastic deformation with a radial feeding of the deforming rollers, with option for: limiting the longitudinal feed of the separator with the rollers; regulation of the size which has to be set; regulation and elastic applying of the deforming force; restoring of the size which has to be set.

III. Principle of Operation of the Tool

The principle of operation of the tool is as follows. By leading the pre-set tool into the machined hole at the moment of contacting the workpiece face to the supporting bearing 11, the longitudinal displacement of the separator 1 together with the rollers 2 is discontinued which ensures the size and the separator 1 is prevented from touching the left end of the separator 1 at the bottom of the machined hole.

At the same time, the rear part of the mandrel 16 continues its longitudinal displacement and the pin 17 is detached from the right part of the mandrel 4 slit as a result of which the spring 16 pre-adjusted by the nut 18, which through the front of the mandrel 4 transmits elastically its force on the support cone 3 which moves longitudinally relative to the rollers 2 which dissolve and provide simultaneous machining of the entire length of the hole. The longitudinal movement of the mandrel 16 is limited by pre-adjusted stopping element of the machine. When the tool is removed from the machined hole, the mandrel 16 pulls out the mandrel 4 by means of a pin 17 as a result of which the rollers 2 reduce the working size and together with the separator 1 easily exit the hole and the spring 14 restores the tilting position of the rollers 2 and always presses the bracelet of the support bearing 12.

The tool is inserted with clearance into the machined hole through which excludes machining by axially feeding. The size is adjusted by nut 8 and counter nut 7 and can be read by a scale applied on a threaded bush 5 and the conical surface of the counter nut 7. The pre-adjustment of the deformation force generated by the spring 20 is carried out by a nut 18 and a counter nut 19 and can be read on a scale.

Machining with this tool with radial feed of deforming rollers can be accomplished by two schemes:

- Rotary motion and forced axial shift of the support cone, as a result of which the deforming rollers performs a radial feed;
- Rotary motion of the workpiece and forced axial shift of the support cone, as a result of which the deforming rolls perform a radial feed.

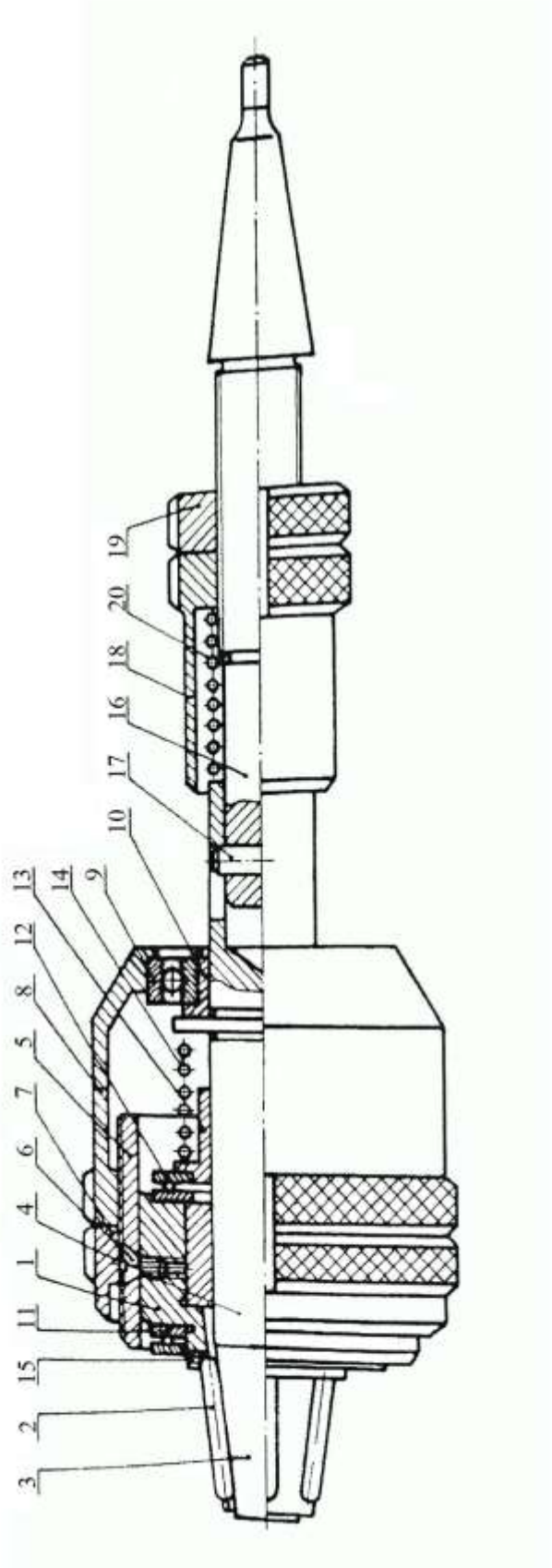

Figure 1. Tool for machining of blind conical holes by SPD

The choice of the machining scheme depends on the construction of the workpiece. The second scheme is applicable to rotational parts and to those which do not cause dynamic loads in its rotation.

The realization of the process of SPD is carried out by applying a radial deforming force that arises from the application of axial force on the support cone realized by a spring 20 (fig. 1), which in this case ranges from 100 to 200 daN.

For checking the technological capabilities of the tool are machined pre-experimental workpieces with conical surfaces – 6 pcs with a large diameter of 45 mm and a length of 50 mm.

The blanks are made of solid bronze material (CuSn10Pb10) pre-drilled and bored. The machining is done on a universal lathe C11M. The blank is fixed in the chuck of the lathe and the tool is placed in the tailstock assembly by using of transition sleeve. Thus, the machining is performed under the second scheme. The axial feeding is performed by the apron of the lathe. The machining on the first scheme can be performed on a drilling machine with fixing the tool in the spindle, and the axial feeding is performed by its feeder mechanism. The blank is fastened in a fixing device.

The roughness was measured by the TALYSURF 6 measuring device according to the Ra and Rz parameters. The fluctuation for Ra is in the range of 0.28 to 0.18 μm, for Rz from 1.4 to 0.9 μm. Accuracy is achieved by pre-treatment and after SDP is controlled by a grinded conical mandrel.

IV. Conclusion

Combining the capabilities of the tools with radial feeding with the advantages of the elastic application of the deforming force contributes to the obtaining of a layer with homogeneous physical-mechanical properties. Compared to the known solutions of the problem, the proposed design allows to improve the physical-mechanical properties of the treated surfaces and their respective performance characteristics, and the presence of a large number of parts with conical holes with small angles of cone in the machine-building is a prerequisite for its implementation.

From the description of the proposed tool it can be concluded that its advantages over the known designs consist in the possibility of limiting the longitudinal feeding of the separator with the rollers, in the possibility of elastic applying of the deforming force, in the possibility to adjust both the size and deforming force.

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