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DRILLING HOLES WITH A CUTTING TOOL WITHOUT A TRANSVERSE EDGE AND THEIR EFFECT ON THE ACCURACY OF THE MACHINED HOLE

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Abstract

To drill high-strength and heat-resistant steels and alloys, it is necessary to create such a geometry for the cutting part of a double-flute drill that, while maintaining axial stability and a sufficiently strong cutting wedge, would ensure a uniform, vibration-free cutting process even if chip formation occurs in some areas of the cutting edges in the presence of growths. For chip formation conditions during drilling, the appearance of build-up and build-up is possible near the transverse cutting edge, where cutting speeds are low. Most researchers believe that the main reason for the decrease in the performance of drills, including those equipped with inserts made of hard alloys, is the large negative values of the rake angles near the transverse cutting blade. Therefore, the improvement of the design of spiral drills is carried out mainly through different types of sharpening of the transverse blade and special sharpening of the cutting part. In general, the size of the breakdown of the hole after applying the developed drill is less than that of the spiral. This difference increases with increasing feed and reaches 2 times when reaching a feed of 0.17 mm / rev. The article considers the issues of ensuring the accuracy of holes machined with a special drill and presents the results of studies with a standard drill.

INTRODUCTION

In general, the accuracy of machining is understood as the degree of correspondence of the machined part to its geometrically correct prototype or sample. Considering the accuracy of processing a particular part, distinguish:

1) the accuracy of the dimensions of the surfaces of the part in relation to the processing of holes, this corresponds to the size of the diameter of the hole and its depth;

2) the accuracy of the shape of the surfaces, for holes, by this we mean the degree of their correspondence to the geometrically regular surface of a circular cylinder, and in the cross section to a geometrically regular circle;

3) the accuracy of the relative positioning of the surfaces of the part when processing holes, it includes coordinate errors characterizing the location of the hole, the removal of the axis of the hole, deviation from the alignment of the location of sections of stepped or intermittent holes, etc. [1].

An axial tool in a real process makes a complex movement relative to the work piece. Additional relative tool movements associated with deviations from the kinematic cutting pattern are the main factor determining the error of the machined hole. The deviation of the real axis of rotation of the tool from the axis of rotation defined by the machine spindle represents a precession, and the deviation of the diameter of the real hole from the size of the tool is a breakdown. The hole breakdown can be represented as the result of the complex effect of the precession of the tool axis and the natural vibration of the tool relative to its axis. The study showed that with an increase in cutting speed, the size of the breakdown of the hole first increases and then falls, both in the case of a spiral drill and in the case of a new one. In all cases, the size of the hole breakdown after drilling with the developed drill is less than after spiral processing in the entire studied range of speeds. This is due to the absence of a transverse edge and, as a consequence, a sharp decrease in axial forces of the projected drill. Axial forces, especially their difference, have a rather large impact on the accuracy of the resulting holes. The study of the effect of feed on the accuracy of the obtained holes showed that when processing all materials with increasing feed, the size of the hole breakdown also increases [2].

Drilling of sheet material is carried out in the vast majority of cases through the hole. Therefore, a number of additional requirements are imposed on drills. The main ones are: reduction or complete absence of burrs on the exit and entry sides of the hole, absence of indentation and warping of the material during drilling (especially sheets of non-ferrous material), absence of burns to the sides of the hole when drilling, for example, plastics, obtaining the correct shape of the hole in the drilling process without securing the work piece, the absence of torn edges of the hole when drilling, for example, plywood and plastics. These requirements can be met when working with drills with special sharpening of the cutting part and subject to the recommended cutting conditions and processing conditions.

EXPERIMENTAL RESEARCH

Drilling relatively small holes in sheet materials is associated with certain difficulties that arise when inserting and exiting the drill from the material [3]. When drilling, the sheet material experiences significant deformations along the axis of the drill and for processing a quality hole, it is necessary to choose the type of drill used and the shape of the sharpening of the cutting part.

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Spiral drills are considered the most used tool for drilling. However, the most common among them are twist drills of small diameters, which are most widely used when drilling holes in sheet materials. The company National Twist Drill Co (USA) found that on average 90% of drills are in the diameters of 1.25 ... 12.0 mm and only 5% in dimensionally higher or lower than this interval. Characteristically, drills with a diameter above 19 mm made up only 1% of the total number of drills.

Although spiral drills are manufactured within fairly tight tolerances, they are not an accurate tool and are intended, in essence, for pre-machining holes. If we consider the working conditions of a spiral drill, then its cutting part consists of two elements that differ in the nature of the work - two main cutting edges and one transverse cutting edge. If the work of the main cutting edges is, in general, similar to the work of the cutting edges of other metal cutting tools, then the mechanism for removing material with a transverse edge is extremely complex [1]. As you approach the center of the drill, the work of the transverse edge becomes more like the work of a blunt wedge shaped indenter, pressed into the material being processed. In this small area, severe deformation of the material displaced into the chip grooves takes place. As a result of this, almost half of the axial force of the drill with diameters up to 12 mm falls on the transverse cutting edge, the length of which is determined by the thickness of the core of the drill. [11].

One of the biggest problems in using small tools is the fact that the stiffness of a cylindrical rod is inversely proportional to the fourth power of its diameter.

According to the methods of changing the cutting part, drills can be divided into three main groups:

a) drills with a cut transverse edge;

c) drills for drilling sheet materials;

e) drills with different sharpening to separate chips.

The selection of drills for processing holes in sheet materials and a separate group is mainly associated with the desire to reduce axial force, which is the main parameter determining the execution of a technological operation. The slump is measured by a needle-tipped indicator whose direction of movement is parallel to the axis of the drill. (FIGURE 1).

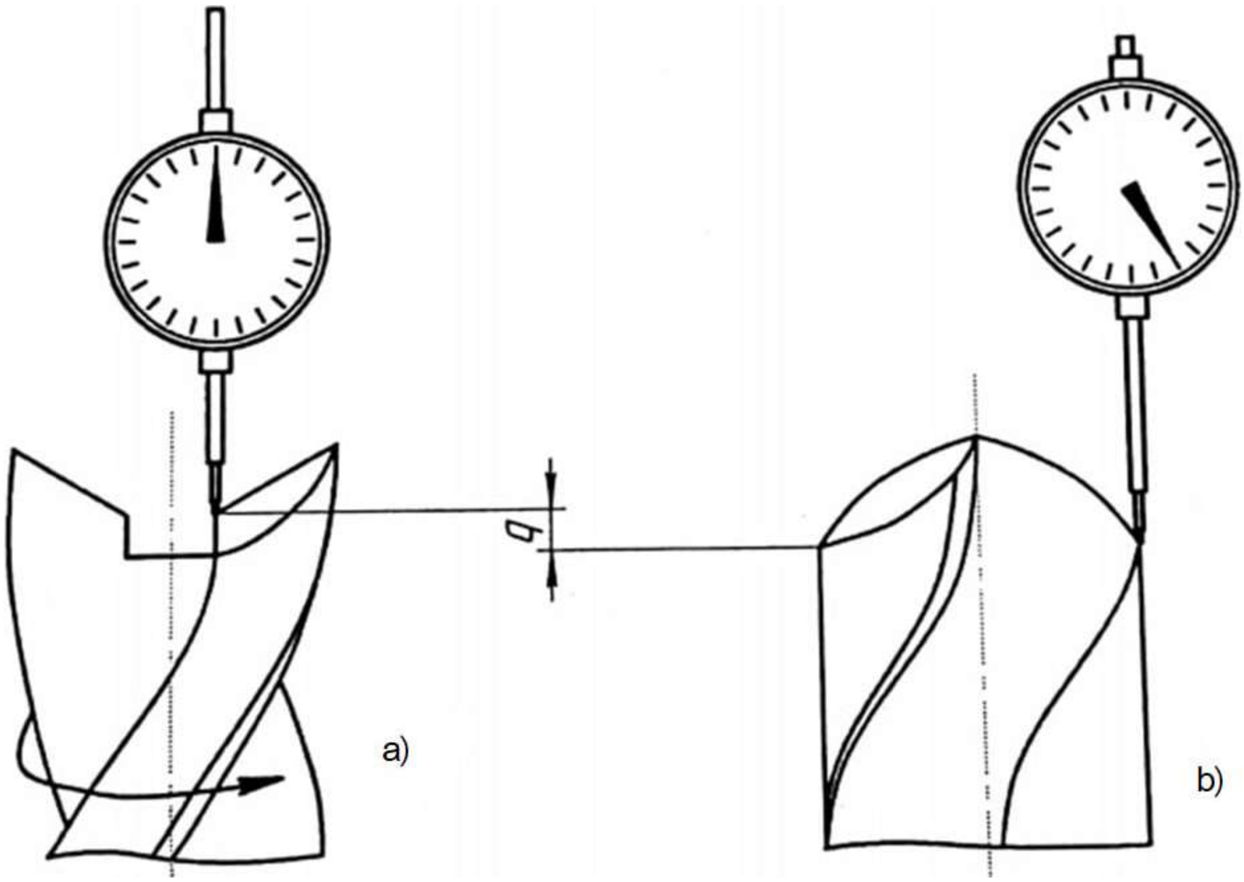

FIGURE 1. Scheme for controlling the amount of decline of the rear surface: a - initial and b - final positions.

The drill tip angle 2φ (FIGURE 1) is located between the projections of the main edges onto the axial plane of the drill, parallel to them.

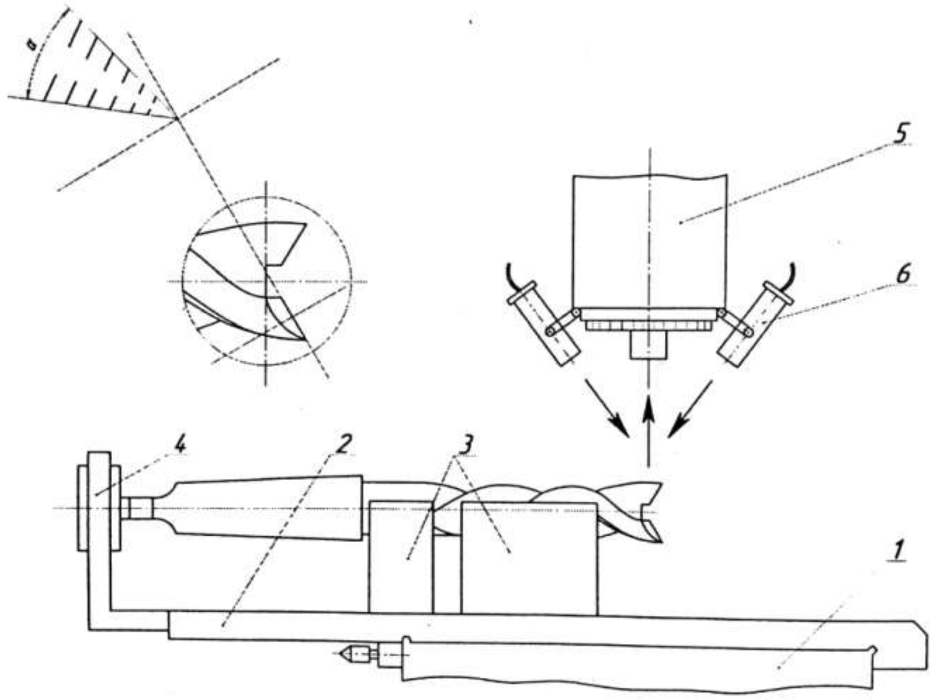

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FIGURE 2. Scheme for monitoring the value of the back angle of the drill on an instrumental microscope: 1 - microscope table; 2- base of the device; 3-mount prisms; 4-stop; 5 microscope tube; 6-illuminator

When sharpening, the angle between the drill axis and the plane of the grinding wheel φ_0 is always less than the angle φ.

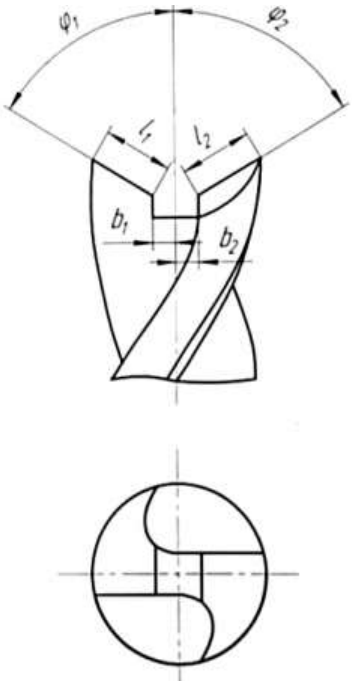

FIGURE 3. Parameters characterizing the symmetry of sharpening drills $\boldsymbol{l_1}$ ***and*** $\boldsymbol{l_2}$- lengths of the main edges; b - groove width; φ_1 and φ_2 are the angle values;

The angles 2φ and α are selected according to the drilling conditions and mainly depending on the material being processed. Most sharpening methods allow these angles to vary widely. The symmetry of sharpening the back surfaces means that the back surface of one feather, after rotating around the drill axis by 180°, completely coincides with the back surface of the other feather.

Provided that the drill flutes are accurately manufactured and the clearance angles are approximately equal, the symmetry of the clearance surfaces can be assessed by the location of the main cutting edges. Typically, control of the following combinations of parameters is used (FIGURE 3);

a) the lengths of the main edges $\boldsymbol{l_1}$ ***and*** $\boldsymbol{l_2}$**;**

b) values of angles φ_1 and φ_2**;**

The shape of the back surface of the drill depends on the nature of the relative movement and the shape of the grinding wheel. The shaping process is carried out using the folding method or the complete copying method.

The method of bending. The back surface of the drill is created during shaping movements and is essentially envelope of the working surface of the grinding wheel.

These surfaces are not identical in shape and have linear contact. Among the relative movements of the wheel and drill, a distinction is made between shaping movements, which affect the shape of the flank surface, and free oscillation movement, which is necessary to level out the wear of the wheel. So, with conical sharpening the forming movement is one swing of the drill around the axis of the head. The displacement of the drill or grinding wheel along the line of their contact does not change the shape of the rear surface and is free oscillation.

The parameters of the sharpening method are considered to be angular, linear and relative values that, during shaping, affect the geometric parameters of the drill. Among the method parameters, sometimes called machine setting parameters, are the installation parameters that determine the relative position of the drill and the grinding wheel in the initial position before sharpening.

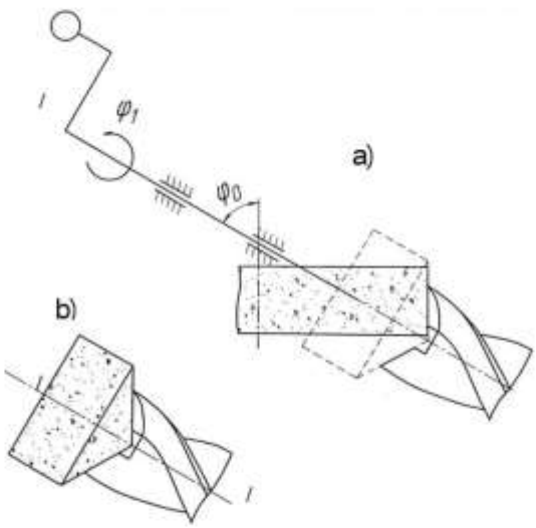

FIGURE 4. Conical sharpening of the drill: a) by bending method and b) - completely copied; I-I axis of sharpening cone and drill.

The shaping parameter is the distance from the initial position to the current one for each shaping movement. For example, for conical sharpening, the concepts of method and installation parameters coincide (this is the distance between the axes of the drill and the head, the angle of the sharpening cone, the distance from the top of the cone to the axis of the drill). The shaping parameter is the angle of rotation of the drill around the axis of the head.

The complete copying method differs in that the back surface of the drill and the working surface of the grinding wheel completely coincide in shape (FIGURE 4, b). In this case, there are no forming movements and processing is carried out, for example, by plunge-cutting due to transverse feed.

With full copying, the contact area between the circle and the drill is much larger than with bending. Therefore, special precautions are taken to avoid burns.

The back surface of the drill can be formed using a uniform or combined method.

RESEARCH RESULTS

A design of a spiral drill with a special sharpening of the cutting part (Patent the Republic of Uzbekistan No. 0595. Drill. BI №. 2, 2002) for the conditions for drilling holes in sheet materials [2] was developed at the Department of Engineering Technology of Tashkent State Technical University. The dynamics of drilling with drills with a special V-shaped sharpening of the cutting part due to the absence of a transverse cutting edge is determined by the gradual incision of the peripheral part of the drill with the formation of a truncated cone in the center of the hole. The uniform distribution of the radial components of the cutting forces holds the drill stem in the strictly axial direction, which ensures the conditions of self-centering after several revolutions of the tool.

Based on geometric analysis and experimental studies, it was found that with a V-shaped sharpening of the cutting part of the drills, the effective rake angle is significantly improved even compared to V.I.Zhirov's undercut.

V-shaped sharpening of drill bits improves hole accuracy and reduces vibration. The construction of the drill is shown in FIGURE 5. [9]

In order to determine the possibilities of using the developed drill, we studied the accuracy of hole machining when drilling sheet materials of steel - 3, with a thickness of t = 1 mm and duralumin grade - D16 with a thickness of t = 5 mm with drills from high-speed steel P6M5, with diameters of 9, 13 and 22 mm and compared with hole accuracy with machined standard drills.

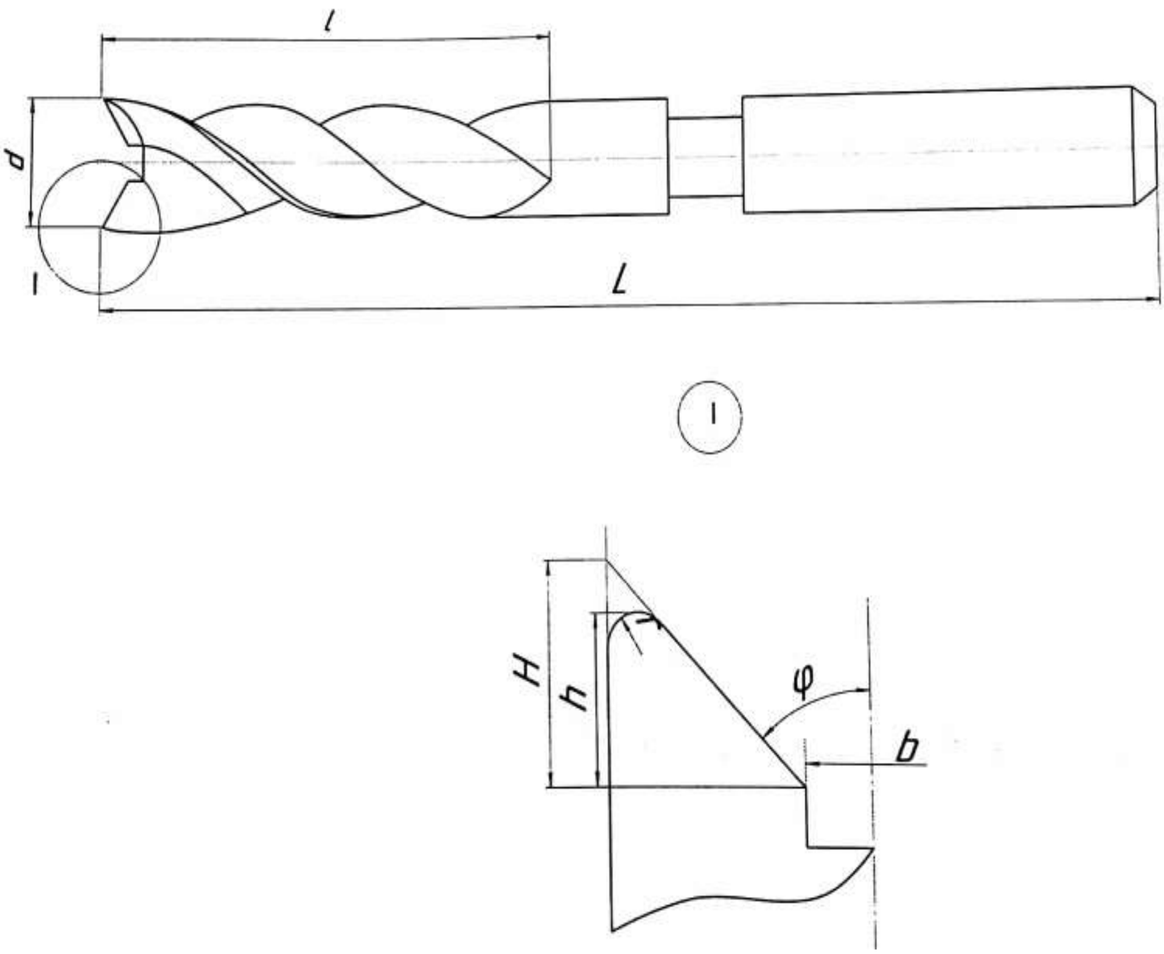

FIGURE 5. Drill for processing holes in sheet materials: 1-working part, 2-neck, 3-shank, 4-chip cutting grooves, 5- two grooves.

Drilling was carried out on a model 2P135 vertical-drilling machine with cutting conditions: n = 1200 rpm S = 0.12 mm / rev, for all drill diameters. After drilling the holes, a measurement was made along the x n y axis in two sections using a Vernier caliper with a division value of 0.01 mm. Then determined the average error of the hole for each investigated diameter of the holes.

FIGURE 6. Shown a diagram of measuring the accuracy of holes in two mutually perpendicular diameters [1].

The average hole error was determined by the formula:

$$\Delta d = ld_y - ld_x \quad (1)$$

The results of the study showed that when drilling with a newly developed drill, the process is more stable (without burrs and residual burrs, when the drill leaves the hole) and the manufacturing accuracy is increased compared to standard

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drills (table 1, 2).

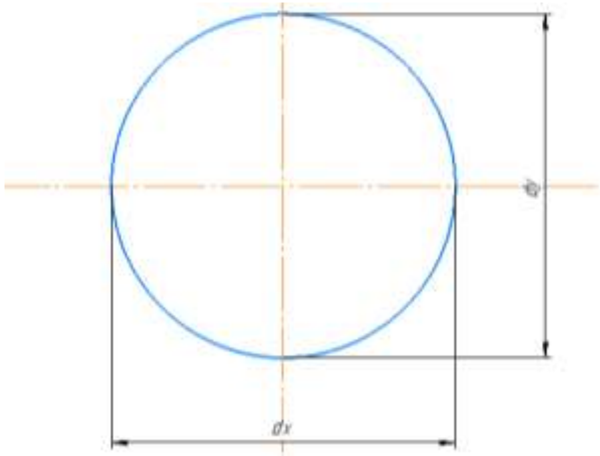

FIGURE 6. Diagram for measuring the hole after drilling: d_x -deviation from the correct cylindrical shape: in the horizontal direction, in mm; d_y- deviation from the correct cylindrical shape in the vertical direction, in mm.

TABLE 1. Results of research on drilling of special drill and standard drill

№	Processed ial	Drill eter in mm	Special drill				Standard drill			
			dy1	dx1	dy2	dx2	dy1	dx1	dy2	dx2
1	Duralumin D16	22	21.90	21.95	21.89	21.96	22.15	22,20	22,18	22,25
	Steel-3		21.95	21.96	21.98	21.94	23,72	23,99	24.09	23,50
2	Duralumin D16	13	13.10	13.12		-	13,21	13.51	13,0	12,95
	Steel-3		13.08	12.95	12.93	13,05	12.88	12,91	12,71	12,92
3	Duralumin D16	9	9.53	9.30	9.40	9.35	9,47	9.36	9,50	9.39
	Steel-3		9,25	9,15	9.20	9.16	9.45	9.42	9,43	9,42

TABLE 2. Results of research on drilling of special drill and standard drill

Diameter 0	Special drill		Standard drill	
	Ad1	Ad2	Ad1	Ad2
9	0.23	0.05	0.11	0,11
13	0,02	-	0.30	0,05
22	0,05	0,07	0,05	0,07
Average	0.10	0,06	0,153	0,076
Total average error Δ	0.08		0.115	

a)

b)

c)

FIGURE 7. General view of the "heel" (a); the appearance of the hole at the exit of the drill (b) after drilling with a special drill; (c) a standard drill. The processed material is sheet steel D16, a drill 0 13 mm from P6M5.

FIGURE 7. shows photographs of the shape of the holes at the inlet (FIGURE 7, a) and at the outlet (FIGURE 7, b) of a new drill and at the output (FIGURE 7, c) of a standard drill.

In view of the foregoing, drilling holes in sheet materials is associated with certain difficulties when inserting and exiting the drill from the material. Significant deformations along the axis of the drill (buckling of the material to be processed when the drill exits the hole, burrs and burrs, etc.) do not allow a quality hole to be obtained, and require additional processing, such as blacksmithing. FIGURE 7 a shows the "heel" obtained when a special drill emerges from the hole, and in FIGURE 7 into the external view of the hole when drills exit the holes made with special and standard drills, respectively.

FIGURE 8. Chips obtained as a result of drilling with a special drill with a diameter of Ø 9 mm. Material: Aluminum D16

FIGURE 9. Chips obtained by drilling with a conventional drill with a diameter of Ø 9 mm. Material: Aluminum D16

FIGURE 10. General view of the installation when drilling galvanized sheet material with a special drill

CONCLUSIONS

1. Analysis of the schemes, sharpening of drills showed that the design of drills with a V-shaped cutting part can be operated according to traditional schemes on existing equipment.

2.The process at the beginning of hole processing with new drills is more stable and occurs without deformation of the workpieces.

3.The accuracy of hole processing with new drills is 40-60% higher than with hole processing with traditional drills.

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