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STUDY OF THE PROCESSING OF SMALL DIAGNOSTIC CREATIONS ON A FLUID SOURCING BY SPIRAL SURVIVALS

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Abstract. The article considers the features of the drilling process where there is a change in temperature, hole diameter, and displacement relative to the axis and the impact on the tool, when machining holes with high-speed steel drills there is wear of the transverse edge which is completely rounded to create a conical surface. There is a decrease in the negative value of the front corners on the transverse edge of the decrease in axial force, which led to a decrease in the intensity of wear of the transverse edge. In order of increasing axial force, respectively, and the intensity of wear of the transverse edge, were sharpened and recommended sharpening methods that provide high performance of the drill, the greatest stability, increased drilling accuracy, as well as the lowest cutting force. The analysis of influence of technological methods and ways and equipment on accuracy and quality of deep openings of small diameter is carried out. The effects of the method of lubricating coolant supply on the tool stability and processing productivity are investigated. The analysis of processing on the metal-cutting equipment with constructive development of the device is executed. Also, the stress-strain state of the drilling process by the finite element method with the analysis of external influences on the twist drill is carried out. The results of the research substantiate and recommend technological methods that reduce the deformation of the tool and, as a consequence, increase the quality and accuracy of the dimensions of deep holes of small diameter.

Keywords: cutting process, deep drilling, deep openings processing, stability, finite element method, cutting process modeling.

Problem formulation

In recent years, in all the branches of machine building industry, the parts that have deep openings are widely used. The mass consumers of such parts are general and special machine building, shipbuilding, aircraft engineering, oil and chemical engineering, instrument making, and others. Details with deep openings are found in a variety of shapes, are manufactured by different methods, with different accuracy and purity of treatment, in a wide range of diameters and lengths. Drilling of small diameter holes is one of the hard-performed operations in automated production. With high technological reliability, the treatment with spiral drills is characterized by the most important features: insufficient strength of the tool on the bend, as a result of chips accumulation in the drill grooves there is a significant increase in forces and torque. During long, long-term deep openings drilling of small diameter on unchanged cutting modes, the torque reaches a critical value, which leads to the instrument destruction and product irreparable damage. In connection with this, there is a need to control the machine performing elements trajectories with the tool periodic removal from the cutting zone, that is, control parameters the drilling process without destroying the tool to provide the required amount of drill output from the processing area. The next important problem is in deep drilling process is that a small axial twist drill resistance and high friction in the cutting zone promotes adhesion friction forces at a greater deepening tool to the workpiece, and the temperature in the cutting zone [1].

Recent research and publications analysis

Preliminary analysis and study of literature in the automation development, improve methods and ways of processing small diameter holes in deep drilling and original equipment designs, found that the equipment for automation of drilling is extremely complicated, cumbersome and does not have sufficient reliability [1]. However, existing designs of machines are far from exhausted by the reserves of productivity and quality at high cost. For these reasons, such equipment has not received mass application. While being flexible production systems at high cost, they have some advantages over the rigid cycles of machining aggregates and automatic lines. It is known that modern electronics have high performance and reliability. This fact contributes to a new look at the tasks, since it was possible to introduce complex mathematical algorithms for managing non-stationary processes. It should be noted, and the fact that modern computer technology has high potential for solving complex mathematical modeling of dynamic processes, is the use of electronics in modern designs modular machine tools and automatic transfer lines making them more flexible and adapted for the treatment of deep holes. This approach allows solving numerical problems that do not have an analytical solution.

Taking into consideration the definition of algorithms based on the mechanics study in the drilling process, as well as the process dynamics management on the basis of reducing destabilizing factors, it is possible to formulate and solve the optimization system synthesis problem during the apertures processing.

Therefore, there has been a new trend of precise execution channel openings and their location relative to the contour details spiral drills provided by the elements formation on the cutting tool part and additional movement imposed on it for crushing chips in the cutting zone, which greatly improves the twist drills working conditions [2].

In practice operating the axial tools, including for the deep holes treatment, workability tool is largely determined by instrumental stuff, geometric parameters of cutting wedge, cutting mode and method of deployment and attachment tool [3], [4].

Analyzing the nature and causes of wear and damage to the drill, they can be divided into the following groups depending on the destruction nature:

a) plastic deformation and wear on the back surface (occurs at very high cutting speed);

b) crater wear - the most common type of wear (occurs on the front surface of the tool due to the critical temperature in the cutting zone).

c) impregnation (occurs when treating low-carbon or stainless steels);

d) the main cutting edge chipping (may be due misalignment axis and axis of the drill tool rotation, drill drainage caused by excessive departure, feed or depth of drilling, drill insufficient stiffness due to improper mounting and ill-precision spindle or regulation).

Existing methods aimed at achieving optimal parameters for the instrument initial state in order to improve its performance [4] (strength, efficiency, productivity, etc.) can be divided into stages:

- the choice where the development and improvement of existing instrumental materials, methods of application of strengthening in the tool cutting part surface are substantiated, which provide increased durability and efficiency;

- design, where the improvement and optimization of the geometrical parameters in the tool cutting part are carried out;

- operation, where optimization of cutting modes is carried out.

While cutting and deforming the material layer in the cutting zone, the following physical phenomena are present: contact surfaces formation, deformation, heat formation, chip formation, wear of a cutting tool, surface formation, etc. These phenomena lead to the emergence of a continuous chips stream, the cutting zone heating and the transfer of a certain amount of heat to the processing area.

Studies of the heat sources origin and the flows distribution and heat losses during cutting materials were undertaken by such scientists as Y. G. Usachov, N. I. Reznikov, A. M. Danelyan and others.

In recent editions devoted to the thermophysics process of cutting metals, there was a research separation. In particular, the work of A. N. Reznikov, L. A. Reznikov [5] is devoted to the general thermophysics of cutting processes, and in the work of P. A. Yudkovskii etc. [6] the process of heat formation in shallow drilling is first studied.

Thus, when studying the latest cutting-edge research on the processing of deep-diameter openings, it can be argued that this is a rather complicated process and requires considerable attention [7]–[11]. Since the system the machine-tool-tool-component (MTTC) with a deep drill of small diameter is the most difficult conditions-works in the system tool. Insufficient cooling of the instrument, the closed volume of processing at times reduces the stability of the drill. The low machining precision, namely the removal of the drill from the axis and the diametric error, leads to an unplanned drill fracture.

Increasing the MTTC system hardness and improving the processes of drilling deep small diameter openings thanks to the constructive device development and the use in the drilling a lubricating fluid proposed method is one of the pressing tasks in mechanical parts processing of all machine building branches, the solution of which will increase the machining accuracy, drill durability and, as consequence, the productivity in processing the deep openings of small diameter.

The purpose of research

The main purpose is to obtain high accuracy of execution and quality for small-diameter openings at deep drilling, analyzing the technological methods influence and methods; namely, the effect on the supplying method the lubricating coolant stability and performance of the treatment; to carry out the processing analysis on metal cutting equipment with the constructive device development, as well as to conduct a stress-deformed state in the process of drilling finite element method.

Main material presentation

The treatment of small diameter holes in deep drilling is the multitude parametric processes influenced by many variables and constant factors (viscosity, hardness, thermal conductivity, adhesion activity, other properties of the cutting tool and workpiece). Also important are the cutting modes parameters, which in turn have a significant impact on the cutting process. Therefore, for greater rigidity of processing, the study was carried out on the horizontal milling machine the model 6M82, and the device design for directing the tool and the cooling system.

For processing, a workpiece was used for the instrumental alloy steel of the type HVG with the design dimensions 350×500×50 mm and the cutting tool (a spiral drill) Ø 8.7 mm from high-speed steel P18.

The research was carried out under the following cutting modes:

- working feed S: 0.10, 0.15 0.20, 0.30 mm/rev;
- rotational speed n: 600, 700, 800, 925 min;
- cutting speed V: 16, 18, 19, 21 m/min;
- supply of LCF by watering 14 l/min, under pressure: 0.5, 1, 5 MPa.

The research is carried out by processing methods with centering of the hole and cooling and without centering and without cooling.

The fixing of the drill 1 is carried out in the collet cartridge, and the workpieces 4 to the table of the machine tool 6 with the help of a universal-clamping mechanism 5. For measuring the temperature indices, the holes were drilled at a certain interval in the preforms and the thermocouple sensors were installed (Fig. 1).

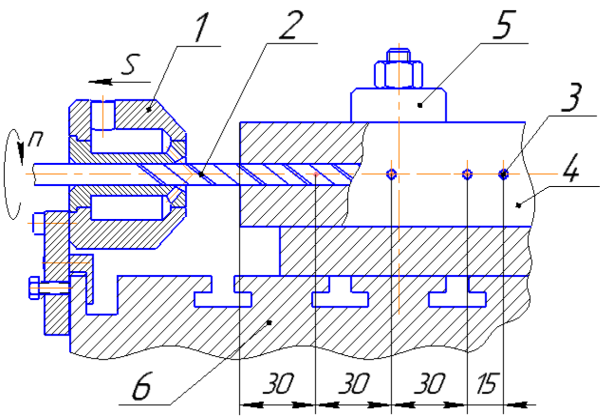


Fig. 1. Treatment scheme with placement of thermocouple

The supply of MOR through device 1 to the cutting zone is carried out by pressurizing water at various angels ($\alpha = 30°$, $\alpha = 60°$, $\alpha = 90°$) from the back of the tool face. The rational application of LCF allows, in some cases, to increase the stability of the cutting tool from 1.5 to 2 times.

After measuring the temperature in the processing preform zones, a cut along the aperture axis is made to facilitate measurement of the diametric errors and displacement relative to the axis (Fig. 2, Tab. 1).

a

b

c

Fig. 2. Hole treatment: a – the workpiece base; b – the beginning of the processing; c – the measurement of temperature during the drilling

Table 1

Results of measurements

	Without centering				With centering and cooling			
Drilling depth, mm	**30**	**60**	**90**	**105**	**30**	**60**	**90**	**105**
Temperature, °C	63	90	101	106	23	67	74	82
Diameter of the hole *D*, mm	8.8	8.8	8.9	9	8.8	8.8	8.85	8.9
Offset relative to the axis *b*, mm	0.1	0.2	0.4	0.65	0.05	0.1	0.15	0.2

Investigation of the LCF influence on the cutting tool stability at different pressures and flow rates relative to the time at different speeds of rotation is shown in Fig. 3, where: 1 – watering at a flow rate of 15 l/min; 2 – supply of LCF under pressure of 0.5 MPa at a flow of 10 l/min; 3 – supply of LCF under pressure of 1 MPa at a flow rate of 12 l/min; 4 – supply of LCF at a pressure of 3 MPa at a flow rate of 15 l/min.

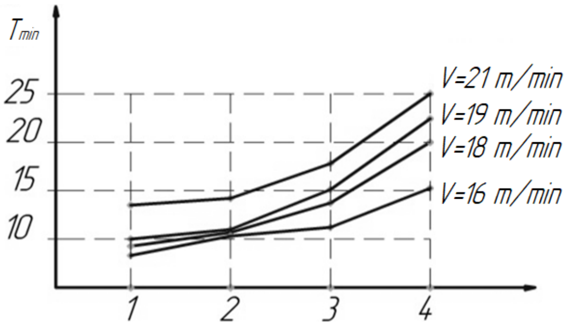


Fig. 3. Graph of the impact of the LCF on the stability of the drill

Since cutting is a complex process and it is difficult to predict the effect of all physical phenomena at the depth of drilling (30, 60, 90, 105 mm), we are therefore conducting modeling of the cutting process by finite element analysis in DEFORM software (see Figs. 4–7, Tab. 2).

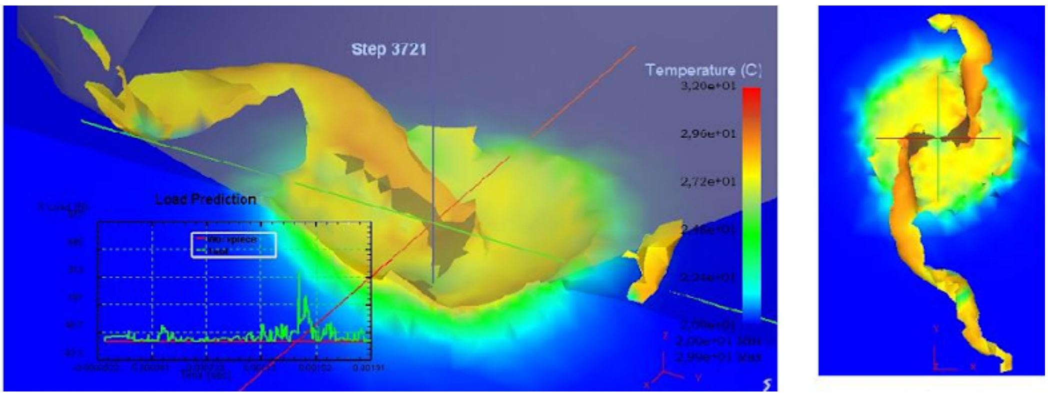


Fig. 4. Temperature fluctuations in the cutting zone (min = 20°C, max = 30°C) without centering and cooling

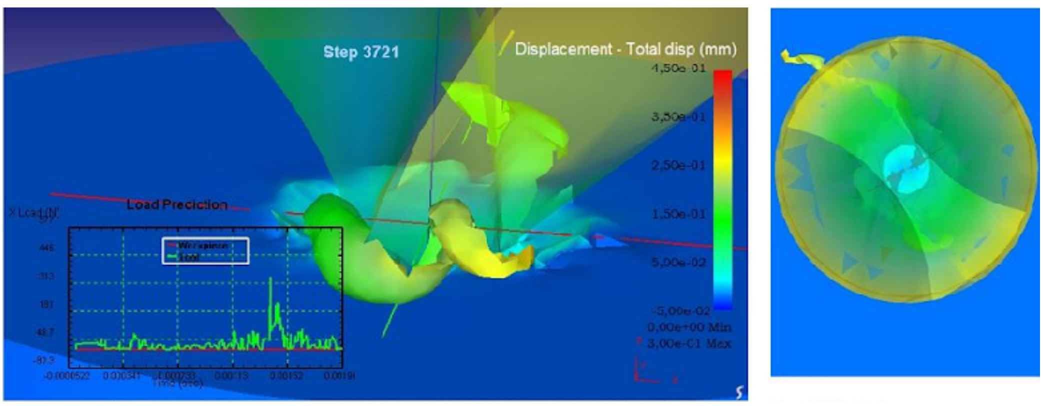


Fig. 5. Total displacement in the cutting zone (min = 0 mm, max = 0.45 mm) without centering and cooling

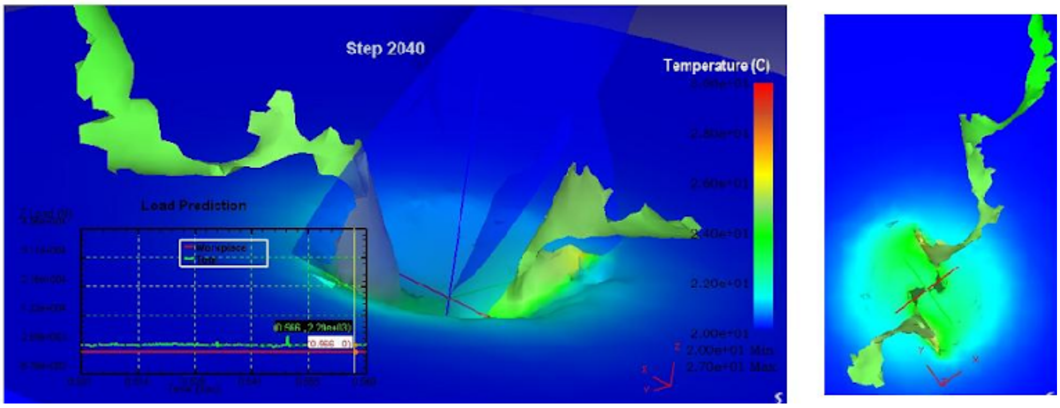


Fig. 6. Temperature deformations in the cutting zone (min = 20°C, max = 27°C) with centering and filing of LCF

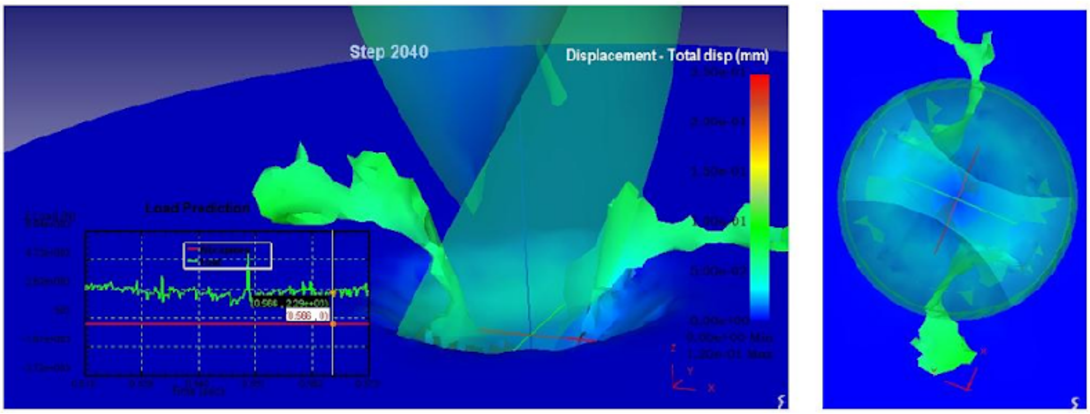


Fig. 7. General displacements in the cutting zone (min = 0 mm, max = 0.12 mm) with centering and filing of LCF

Table 2

Results of measurements

	Without centering				With centering and cooling			
Drilling depth, mm	**30**	**60**	**90**	**105**	**30**	**60**	**90**	**105**
Temperature, °C	39	63	72	80	29	60	66	79
Diameter of the hole *D*, mm	8.70	8.83	8.85	8.90	8.7	8.83	8.85	8.90
Offset relative to the axis *b*, mm	0.05	0.1	0.2	0.3	0.02	0.1	0.2	0.3

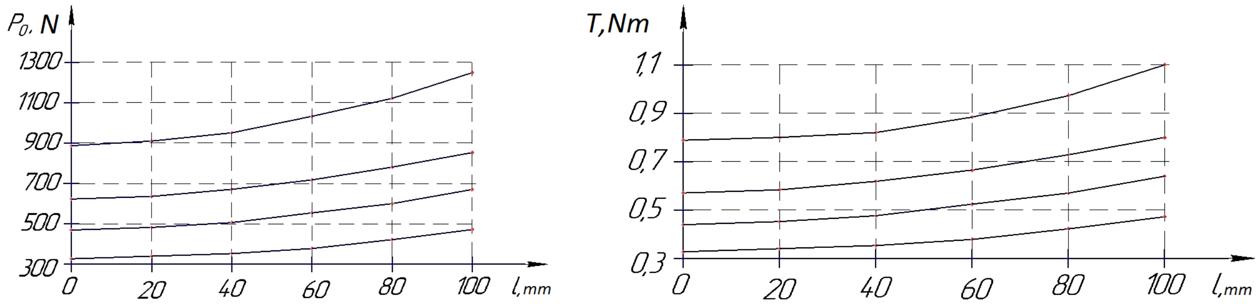
During the study there was an increase in temperature, the opening diameter, and displacement relative to the axis, which significantly affect the tool wear on the back surface in the corners. In the processing, with the gradual deepening into the drill, the forces and torque increase (Fig. 8, Tab 3), the effect of which is reducing the drill diameter. Demolition in the corner from the side of the rear surfaces occurs gradually narrowing to the drill axis. And the main cutting edge on the rear surface gradually decreases to the axis, but near the lateral edge it grows again.

When processing the holes with the drills of the fast-cutting steel, the transverse edge that completely curtails to create a conical surface wear out. Reducing the negative value anterior angles value on the transverse edge of the axial force decreases, which leads to a decrease in the wear the transverse edge intensity. In order of increasing the axial force, respectively, and the intensity of wear of the transverse edge, the sharpening methods form a series: screw, plane, conical. With the increase in the convexity of the transverse edge and the decrease in the negative values of the anterior angles, the accuracy of the drilling increases and the axial forces decrease. Sharpening on a cone has the advantage in constructive simplicity of machine tools and gadgets. But the front angles on the transverse edge achieve a large negative geometric identity in their sharpening. The main disadvantage of the screw sharpening is the kinematics complexity of form-forming movements and the increased wear of the abrasive wheel. The three-dimensional sharpening is a common method for the geometric identity of their sharpening. The main disadvantage of the screw sharpening is the complexity of the kinematic form-forming movements and the increased wear of the abrasive wheel. The three-dimensional sharpening is the general method of plane drill sharpening, the individual cases of which are two-and one-ply sharpening. Independence between the rear angles in the normal section on the second and third planes allows obtaining the optimum geometry of the transverse edge and increasing the angle of the cutting wedge. Such sharpening ensures high drill performance, the greatest stability, increased accuracy of drilling, the least power of cutting.

Table 3

Power characteristic at different processing modes

S, mm/rev	0.10	0,15	0,20	0,30	0.10	0,15	0,20	0,30
V, m/min	16	18	19	21	16	18	19	21
n, min^{-1}	600	700	800	925	600	700	800	925
l, mm	Axial force Po, N				Torque T, Nm			
0	336	482	623	892	0,331	0,456	0,572	0,787
20	342	489	632	906	0,337	0,463	0,581	0,800
40	358	512	662	949	0,352	0,484	0,608	0,873
60	384	551	711	1020	0,379	0,521	0,653	0,899
80	422	604	780	1119	0,415	0,571	0,717	0,987
105	470	673	869	1246	0,463	0,636	0,799	1,099



a b

Fig. 8. Dependence of the axial force (a) and torque (b) on the drilling depth at different cutting modes

Conclusions

The research results of processing small diameter drilling holes are given in Tables 1 and 2. According to the results, the greatest stability of the drill is observed when the MW is applied at a pressure of 3 MPa at a flow rate of 15 l / min, but a further increase in the supply of MW under pressure does not increase its stability. It was also found that the growth of axial force and torque when increasing the depth of drilling significantly depends on the correct method of sharpening the tool flat sharpening on one plane, in which there is a separate sharpening of the drill, does not always ensure the complete identity of their sharpening. The transverse edge with such a sharpening method is straight-forward with fairly large negative front angles on it, but in general the wear of the drill is sharpened on one plane, occurs fairly evenly along the entire edge, which allows wide use of this method.

As well as the use of MHP when drilling holes helps to improve chip removal and reduces the temperature in the cutting zone, according to these technological methods, the tool deform is reduced and, consequently, the size accuracy in the deep openings of small diameter is increased.

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