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INVESTIGATION OF THE INFLUENCE OF DESIGN AND CUTTING CONDITIONS ON THE ACCURACY OF HOLES WITH DRILLS WITH POLYHEDRAL NON-REGRINDABLE INSERTS

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Annotatsiya. Ushbu ishda ko‘p qirrali qayta charxlanmaydigan plastinkalarga (MNP) ega sverlo konstruksiyalarini tahlil qilishga, shuningdek, sverlo o‘qi pretsessiyasi nuqtayi nazaridan ishlov berilgan teshik aniqligiga katta e’tibor qaratilgan. MNP sverlolari yordamida teshik hosil qilish sxemalarining o‘ziga xosligi ko‘rsatilgan. Ikki turdagi sverlolarning og‘ishi kesish tezligiga bog‘liqligi tajriba asosida aniqlangan.

Kalit so‘zlar: karbid burg'ulash vositalari, polyhedral non-sharpenable plitalar (PSHP), holemaking aniqligi, burg'ulash o'qi precession, qarshilik kiyish, kesish tezligi, vositasi qattiqlik, markazlashtirish ta'siri

Аннотация. В данной работе уделено большое внимание анализу существующих конструкций сверл с многоугольными невосстанавливаемыми пластинами (МНП), а также точности обработанного отверстия с точки зрения прецессии оси сверла. Показана особенность схем формирования отверстий сверлами с МНП. Экспериментально установлены зависимости отклонения сверл двух типов от скорости резания.

Ключевые слова: Твердосплавный сверлильный инструмент, многогранные незатачиваемые пластины (ПШП), точность обработки отверстий, прецессия оси сверла, износостойкость, скорость резания, жесткость инструмента, центрирующий эффект

Annotation. Much attention in this work is paid to the analysis of existing designs of drills with multifaceted non-regrindable inserts (MNP), the accuracy of the machined hole in terms of the precession of the drill axis. The peculiarity of the schemes of hole formation by drills with MNP is shown. The dependences of the withdrawal of drills of two types on the cutting speed are experimentally established.

Key words: Carbide drilling tools, polyhedral non-sharpenable plates (PSHP), holemaking accuracy, drill axis precession, wear resistance, cutting speed, rigidity of the tool, centering effect

Introduction

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The development of carbide drilling tools aims to enhance the productivity of holemaking processes. However, due to the low brittle strength of conventional carbide tools, their durability often falls short compared to high-speed steel drills

Literature and Methods. The analysis of literary sources allows us to conclude that there is a desire to develop carbide drilling tools, the purpose of which is to increase the productivity of the holemaking process. With a low brittle strength, the hard alloy not only has no advantages over a high-speed tool, but its durability under the same conditions turns out to be even low [1].

Currently, drills with polyhedral non-sharpenable plates (PSHP) are becoming more common. Prefabricated cutting tools with multifaceted non-regrindable inserts have been used not so long ago, so there are many unexplored problems associated with this tool [2].

The wear resistance of the indexable inserts is very high, as they are made from modern grades of hard alloys with wear-resistant coatings. The problem of processing materials with increased hardness and difficult-to-turn high-alloy steels is easily solved. An additional increase in productivity is facilitated by the ability to install a high-strength alloy insert in the central seat, and a wear-resistant alloy in the peripheral seat, which allows high cutting speeds. The use of drills with replaceable non-regrindable inserts allows you to completely abandon expensive regrinding. Inserts can be changed in less than a minute, even without removing the drill from the machine [3].

Annular drills for deep drilling with mechanical fastening of multifaceted non-regrindable inserts and cutting inserts for their equipment have been developed, which increase the durability of drills, and reduce the laboriousness of the process of drilling holes of small diameter [4].

Due to the ability to replace cutting inserts without removing the tool from the clamping devices, the ability to drill on non-technological surfaces (curved, inclined, asymmetrically curved, etc.), drilling intersecting holes, have increased versatility, as they can work as a through cutter, countersink, end mill which is especially important for CNC machines.

The axial tool in the real process makes a complex movement relative to the workpiece being processed. Additional relative movements of the tool associated with deviations from the kinematic cutting scheme 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 given by the machine spindle represents precession, and the deviation of the diameter of the real hole from the size of the tool is the breakdown. The breakdown of the hole can be represented as a result of the

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complex influence of the precession of the tool axis and the natural oscillation of the tool about its axis.

If we take the value of the hole breakdown as a double deviation of the radius vector in the polar coordinate system, then its relationship with the precession value and the natural oscillation of the tool will be expressed as:

$$\Delta/2 = \eta \cdot (e_0 + e_n) \qquad (1)$$

or

$$\Delta/2 = e_0 \cos\varphi_0 + e_n \cos\varphi_n \qquad (2)$$

where: η - unit radius vector directed from the axis of rotation of the spindle to the side face of the cutting blade of the tool; e_0 - tool deviation vector relative to its own axis of rotation; e_n - vector of precession of the axis of rotation of the tool relative to the axis of rotation of the spindle; φ_0 and φ_n are the corresponding angles between the vectors (fig. 1)

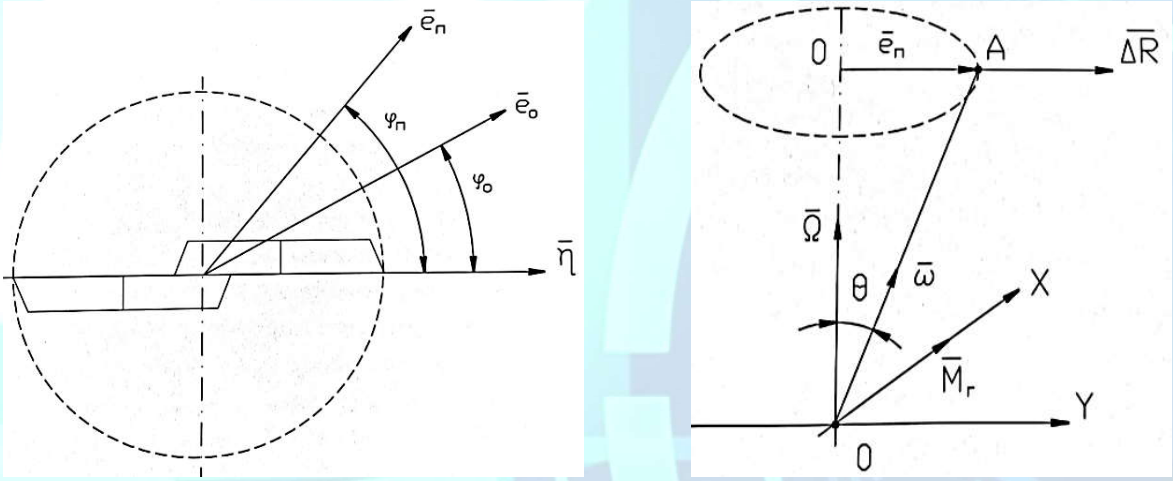


Fig.1. Schemes of vectors of deviations and angular velocities during drilling

The unit vector $\bar{\eta}$, directed from the axis of rotation to the side top of the cutting blade, determines the position of the front surface. It can be seen from the diagram that the stakeout value is influenced not so much by the absolute values of the deviation vectors as by their projections on the direction parallel to the front surface. At, in the case of their orthogonal arrangement with respect to η, the breakdown will reach a minimum.

The main reason for the occurrence of precession is the imbalance of forces in the radial direction.

Neglecting random perturbations, the main factors leading to the appearance of an unbalanced force include: the error of the angles in the plan, the asymmetry of the location of the cutting edges, the sharpening error, etc. the amount of precession is determined by the value of the unbalanced radial load and the rigidity of the axial tool. at low angular velocities, the precession value is equal to:

$$e_n = \Delta R / j \qquad (3)$$

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where: ΔR - unbalanced radial component; j - is the rigidity of the tool.

At high angular velocities, the gyroscopic moment has a great influence, the value of which is equal to:

$$M_\Gamma = J_0\omega_0 \frac{\partial\theta}{\partial\tau} = J_0\omega_0\Omega$$

where: J_0 - is the moment of inertia of the drill; ω_0 - is the angular velocity of the tool; Ω - is the angular velocity of precession.

The analysis of the accuracy of the machined hole by the magnitude of the precession of the drill axis and the proper deviation of the drill axis relative to the axis of rotation is a methodological difficulty associated with the difficulty of experimentally determining the law of change – the deviation of the tool relative to its own axis of rotation and the precession of the axis of rotation of the spindle.

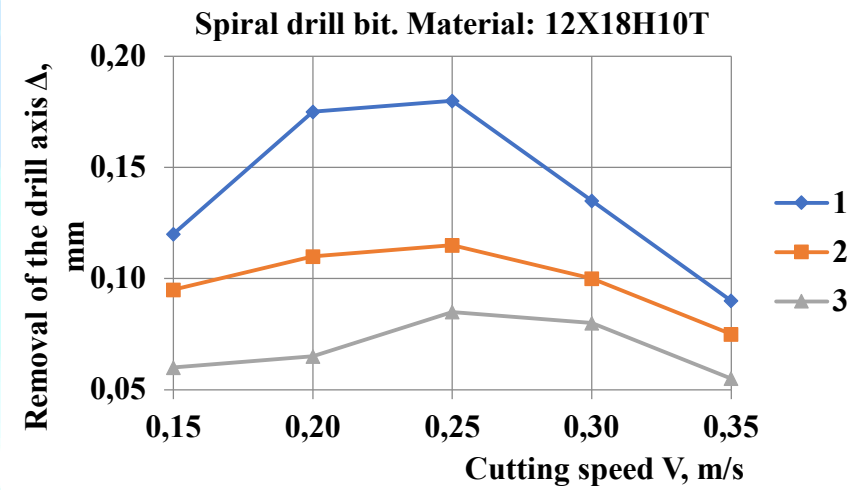
The cutting modes of drills with PSHP are significantly different from the modes for all types of drills with a jumper and guide elements. The design of drills with PSHP allows processing at significantly higher cutting speeds, which, depending on the materials being processed, lie in the limit V= 1,3...1,5 m/s, S=0,1...0,25 mm/rev. Steel 12X18N10E and steel 45 were selected for the experiment.

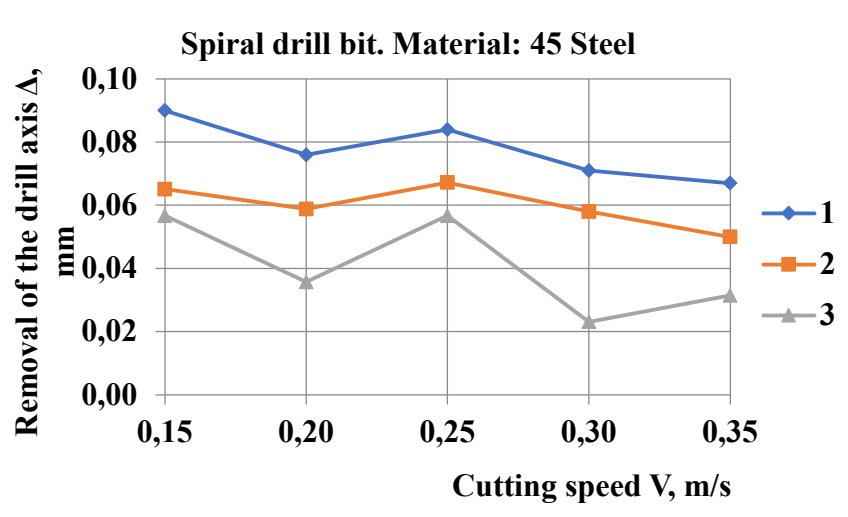
When processing holes, one of the important steps is the embedding process. Spiral drills have a more optimal geometry in terms of centering, however, drills with PSHP have advantages in terms of embedding. Indeed, a spiral drill with an angle in the plan of $2\varphi = 120^0$ is characterized by the fact that initially sections of the cutting edge with zero cutting speed and a small, and sometimes negative, kinematic rear angle are determined and it falls on the bridge of the spiral drill.

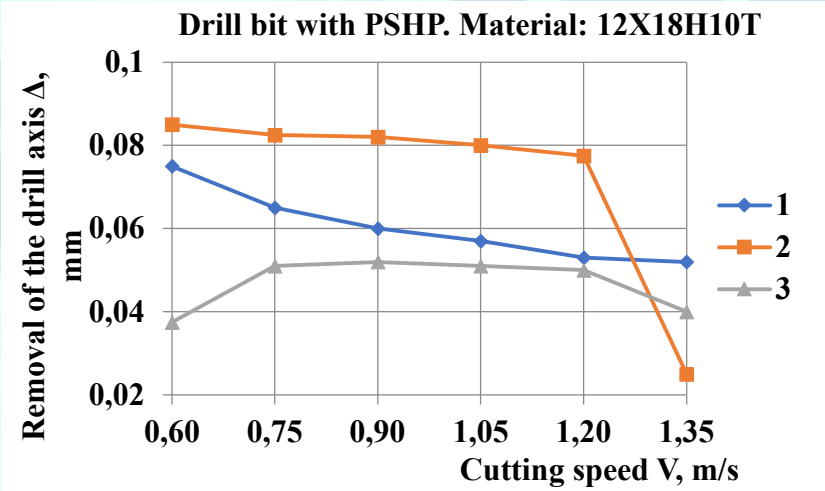
Fig.2 presents data from experimental studies characterizing the effect of rotation speed on the removal of the drill axis when processing holes in blanks made of I2XI8HIOT and steel 45 with a spiral drill and a drill with a diameter of 24,5 mm. Analysis of the research results shows that a spiral drill having $2\varphi = 120^0$ acquires the property of centering, processing materials of ordinary machinability.

Results. So, when drilling steel 45, the maximum value of the withdrawal for a spiral drill was 0,095 mm, and for a drill with a PSHP – 0,08 mm, which is practically within the range of the experimental data. When drilling I2XI8H10T, the amount of withdrawal was 0.18 mm, and for a drill with PSHP – 0,075 ... 0,08 mm, i.e. in this case, the centering effect due to the rigidity of the tool is more significant than due to the geometry of the cutting part.

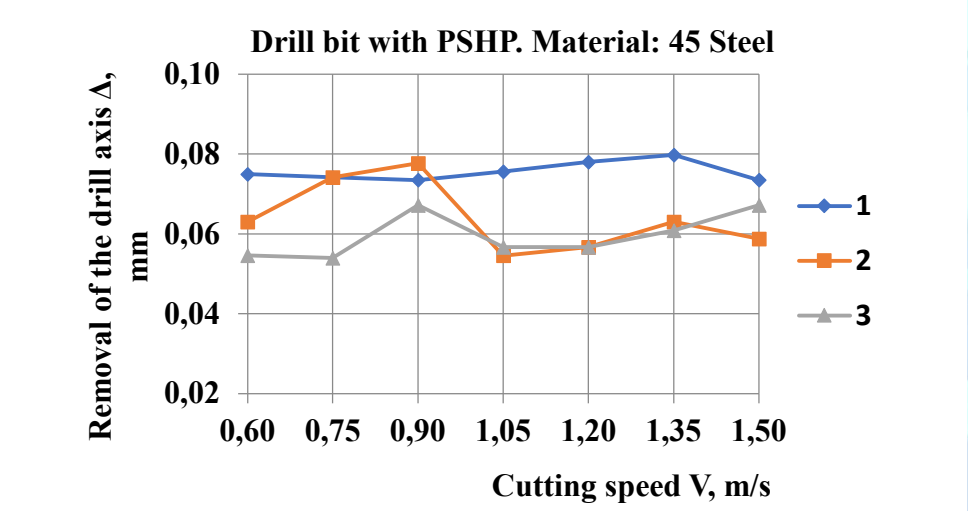
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1-the beginning of the hole; 2-the middle; 3-the end

Fig.2. The effect of the cutting speed on the removal of the drill axis when drilling in a solid workpiece

Indeed, stainless steel I2XI8H10T is characterized by a machinability almost 3 times worse (machinability coefficient $K_0 = 0,3$) compared to steel 45. Therefore, the value of the withdrawal of the drill from the MNP practically remained unchanged, while for the spiral drill it increased by 2,0 times.

The amount of drill withdrawal with an increase in the speed of rotation during the processing of steel 45 tends to decrease monotonously, manifested to a greater extent for spiral drills.

The processing of I2XI8H10T steel with spiral drills is characterized by a non-monotonic change in the amount of withdrawal, reaching a maximum in the range of 0,2 ... 0,25 m/s. The drill bit with PSHP when processing I2XI8H10T behaves identically to the processing of steel 45.

The removal of the drill axis takes different values along the length of the drilled hole. For spiral drills, the phenomenon of "copying" the cutting error on the accuracy of the hole in the middle and at the outlet is observed. In Fig.2, it is manifested in the fact that the nature of the drill axis withdrawal curve in the middle and at the output repeats the axis withdrawal curve at the input, only at a somewhat low level. This is explained by the fact that the initially drilled part of the hole performs the function of a guiding conductor sleeve for the drill during its further operation. This is possible if there is a sufficiently long calibration part, which is typical for a spiral drill. "Copying" is manifested both by the absolute deviation of the magnitude of the withdrawal, and by the nature of the trajectory of its movement relative to the axis of rotation.

In addition, the breakdown of the hole at the outlet, as a rule, exceeds that at the inlet, which is more clearly manifested when working with spiral drills and when processing stainless steel 12X18H10T. A drill bit with a PSHP is

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characterized by a more rigid body and therefore is subject to a smaller amount of elastic deformation. In addition, the most protruding tops of the carbide plates initially come out of the cutting zone, forming a relatively large (as a rule, 2φ = 160°) double angle in plan, i.e. not having a pronounced taper.

The release of elastic potential energy by the housing does not begin during the tool's exit from the cutting zone, but somewhat earlier, when the thickness of the bottom of the drilled hole cannot withstand the force of elastic deformation of the housing. The pulse of elastic energy release, accompanied by a pulse of tool elongation, leads to the ejection of the entire bottom of the hole in the form of a disk of a specific shape, the diameter of which corresponds to the diameter of the drilled hole. The axial load drop coincides with the torque drop and dynamic disturbances occur when the already processed hole is fully formed.

The technological processes of machine-building production, especially the processes of cutting structural materials, are very complex in their physico-chemical nature. There are still no accepted analytical models that accurately describe the patterns of processes [5].

Discussion Therefore, based on the data obtained, we find a curve that would best approximate the experimental points. The points on the graph show a polyline consisting of several straight segments and they correspond to a linear regression model.

Therefore, in mechanical engineering technology, models that we previously designated as empirical are very often used. Empirical models of objects and processes are the result of processing experimental data on the behavior of an object or process by methods of mathematical statistical analysis. Very often, the mathematical apparatus of regression and correlation analysis is used to build models of objects based on the results of experimental studies.

The mathematical apparatus of regression analysis allows us to evaluate unknown parameters of the regression model proposed for research; to check the statistical significance of the model parameters; to check the adequacy of the model; to evaluate the accuracy of the model.

To begin constructing an empirical model, it is necessary to have data from experimental studies of the object (Fig.2), in which each value of the input factor (X) corresponds to the value of the output factor (H), i.e. a pair of numbers (xi, yi) is known. Pairs of random variables (x, y) obey some two-dimensional probability distribution.

It is necessary to find a curve that would best approximate the experimental points. For the convenience of further investigation of the object, this curve should have a single formula (function) for its description. Fig.2 shows broken lines

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consisting of several straight segments and described by a corresponding number of linear models. This is extremely inconvenient for research. It is necessary to find a curve that best describes all experimental points. Such a curve is called a regression curve, or a regression curve Y by X.

Conclusion An expression that establishes a relationship between a random dependent and a deterministic independent variable is a regression equation.

The model based on the regression equation is a regression model.

With the help of known methods of constructing regression models, we obtain models describing the amount of drill withdrawal with a change in cutting speed.

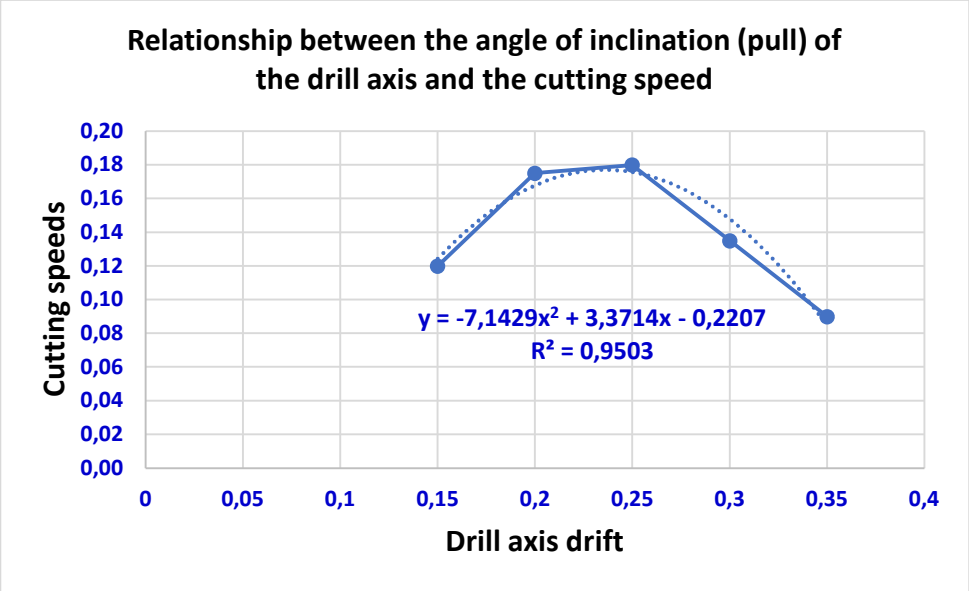


Figure 3. The relationship between the inclination angle (rake) of the drill axis (x) and the cutting speed (y)

The graph shows the relationship between the angle of inclination (withdrawal) of the drill axis (x) and the cutting speed (y). The values of the angle of inclination of the drill axis are indicated on the x-axis: 0.15, 0.20, 0.25, 0.30, 0.35. The values of the cutting speed are indicated on the y axis: 0.12, 0.18, 0.18, 0.14, 0.09.

Based on the schedule, the following conclusions can be drawn. With an increase in the angle of inclination of the drill axis (x), the cutting speed (y) decreases. This means that a steeper angle of inclination of the drill axis leads to a lower cutting speed.

It is also noticeable that the values of the cutting speed (y) at the angles of inclination of the drill axis (x) 0.20 and 0.25 are the same, and at an angle of 0.18 much higher. This may indicate the presence of an optimal angle of inclination at which the highest cutting speed is achieved.

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From the graph, it can be concluded that the choice of the angle of inclination of the drill axis has an impact on the cutting speed, and the optimal angle can help achieve a more efficient drilling process.

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