ACADEMICIA

ISSN: 2249-7137 Vol. 11, Issue 3, March 2021 Impact Factor: SJIF 2021 = 7.492

ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

DOI: 10.5958/2249-7137.2021.00920.4

THE MAIN PARAMETERS OF THE CUTTING PROCESS AND TECHNOLOGICAL FACTORS AFFECTING THE RELIABILITY OF THE AXIAL TOOL

Tolibjon Umarov*; Davron Bekturov**

[1]Professor,
Tashkent Technical University named after Islam Karimov,
Tashkent, UZBEKISTAN

**Master student,
Tashkent Technical University named after Islam Karimov,
Tashkent, UZBEKISTAN

ABSTRACT

This article discusses the main parameters of the cutting process that affect the reliability of the axial tool. The stability of the technological process of machining is largely determined by the quality characteristics of the tool used: its design, tool materials and modes of its operation, which are determined at the design stage of the technological process. A drill with MNP (multi-faceted non-resurfacing plates) of a new design was developed at the Department of Engineering Technology of the Tashkent State Technical University named after I.A.Karimov, and the study was carried out on the same drill. According to the research carried out: when processing steel 12X18H10T, the specific energy consumption of the cutting process with a drill with MNP is more than 5.0 times lower than that when processing with a twist drill, and when drilling steel 45, it is almost 2 times lower.

KEYWORDS: *Process Mechanics, Drills With MNP, Built-Up Zones, Chip Shrinkage, Friction Coefficient, "Column" Formation, Energy Consumption, Hole Length, Specific Energy, Rotational Speed, Cyclic Load*

INTRODUCTION

Tool wear and durability are closely related to tool reliability. For each tool and each combination of parameters of cutting conditions, there is a wear value that determines the limit of economic durability. In this case, the level of tool reliability is the higher, the more stable the cutting process in a given operation. The cutting process (as well as its stability) is simultaneously influenced by many factors: the physical parameters of the tool and machined materials (their strength, hardness, thermal conductivity, etc.), cutting modes (cutting speed, cutting depth, feed), cutting temperature (as a result of the above parameters), coolant.

MATERIALS AND METHODS

Technological characteristics of the drilling operation. Drilling is one of the widespread operations in mechanical engineering. In the total machine-tool park of machine-building plants, drilling machines make up 10-20%, in bridge building, crane building and also in agricultural engineering, drilling machines make up 40-50% of the machine-tool park. Drilling operations have the following varieties: drilling holes in solid metal; reaming holes pre-drilled with a smaller drill; countersinking holes cast or punched; deployment of precise holes; deep drilling and deep reaming. An essential feature of the process of drilling holes in solid metal with twist drills is the variable cutting speed along the cutting edges of the tool. The speed is maximum at the periphery at the cylindrical surface and approaches zero at the core of the drill, where the cutting edge has a bridge and its effect is no longer equivalent to that of the cutting tool. By increasing the cutting angle from the periphery to the center, the deformation of the chips along the blade towards the center increases. On the lintel, the deformation is even more significant. Drilling chips are separated by two tapered spirals. In shavings, as well as in turning, crumples in the contact surface and shifts are observed.

When using assembled drills with MNP, it is possible to increase the productivity of the drilling process by an average of 5-6 times in relation to a high-speed tool.

Analysis of literary sources and industrial practice show that there is no coherent system of data and recommendations for the use of drills with mechanical fastening of carbide inserts, and the industry has not accumulated experience to optimize their design. There are practically no data on the dynamics of the drilling process with MNP drills.

The generalization of the research results shows that in the proposed drill designs, the cutting process in the central part of the tool is difficult. This zone determines the value of axial and radial forces during drilling, regulates wear. It is not possible to find fundamentally new solutions that exclude such a significant influence of the transverse cutting edge, rake and clearance angles on the dynamics of the drilling process in traditional designs of two first drills. In this regard, drills with indexable cutting inserts are, perhaps, the only type of tools in the design of which, to some extent, it is possible to provide cutting conditions acceptable for carbide.

The process of drilling with a tool equipped with replaceable carbide inserts is similar to boring in terms of force effects. Experimental verification of the equation that establishes the relationship between the displacement of the cutting edge of the tool, the axial and radial components of the cutting forces Px, Py shows that with an increase in the speed and depth of cut, the machining accuracy increases, and with an increase in feed, it decreases. So, in the case of a cantilever bar for boring, the displacement of the cutting edge of the tool Δr depends on two components of the cutting forces.

$$\Delta r = f(P_x, P_y) = A_x P_x + A_y P_y, \qquad (1)$$

where

$$A_x = -1.5 \cdot \frac{L_a}{L} \cdot \frac{L^3}{3EJ_x}, \quad A_y = \frac{L_a}{L} \cdot \frac{L^3}{3EJ_x},$$

L_a - distance from the point of application of cutting forces to the axis of the mandrel;

L - mandrel length.

Operators Ax, Ay have different signs, so the total tool displacement may coincide with the direction of Py, or it may be directed in the opposite direction, or be absent altogether when AxPx = AyPy.

The presence of the force component Py leads to the appearance of transverse bending stresses in the horizontal plane, and the component Px leads to eccentric buckling. The combination of unbalanced forces causes elastic deformations in the holder. In this case, the radial vibrations of the tool lead to breakage of the cutting edges and errors in the dimensions of the hole being machined. In such a situation, the main link that compensates for the radial forces is only the cantilever holder, the elastic characteristics of which should provide a margin of resistance to its complex bending and torsion.

Drills with MNP, as a tool with two cutting blades, are divided into two groups. The first group consists of tools working on the principle of dividing the cutting width, the second - on the principle of dividing the feed. The designs of both groups of instruments are widely described in the literature [1,2]. For drills of the first design, one plate is located closer to the center, and the second to the periphery of the drill, providing overlap along the entire diameter of the hole being machined. For drills of the second, both plates are located symmetrically relative to the axis of the drill. In theory, the cutting edges are in all cases positioned such that to ensure a balance of forces, the resultant force at the peripheral cutting edge is parallel, equal in magnitude, and oppositely directed to the resultant force at the inner cutting edge. Regardless of the selected shape of the cutting edges, their angular positions and length are calculated in such a way that the cutting forces act in parallel and mutually perpendicular directions [3]. As a result, for drills with MNP, the ratio Ax Px = AuPy should be maintained. In practice, this ratio is not maintained. This is due to the following reasons.

First: The cutting process is carried out at different speeds along the cutting edge. The mechanics of the cutting process are considered separately for low and high cutting speeds, because anomalous phenomena occur in all zones of speed variation. The result of the temperature-rate factor is the simultaneous existence of built-up zones and zones with different coefficients of friction in a carbide drill. In the transition zones, the process is unstable and in them it is practically difficult to provide equivalent operating conditions for both edges and, accordingly, the balance of forces. Since the build-up process is not stable, the size and shape of the build-up are continuously changing over time. The actual rake angle changes accordingly. This is evidenced by a significant variation in parameters with changes in chip shrinkage, friction coefficients and actual rake angles. Schematic view of Px; Pz; $\xi = f(V)$ for the zone of low and high velocities is shown in Fig. 1. Drill with MNP structurally, the drill is made in such a way that, in contrast to the spiral, a hole is left in the central part, the minimum diameter of which is

0.7 ... 1.2 mm. As a result, in the process of work, a column is formed, which periodically breaks.

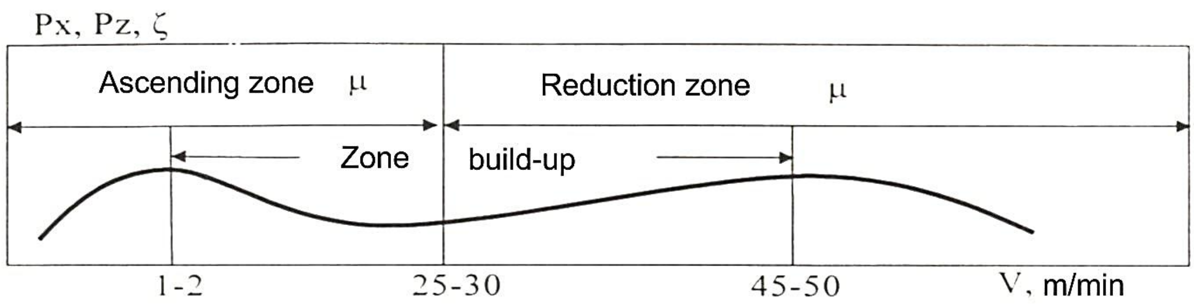

Fig. 1. Schematic representation of the effect of cutting speed on cutting forces and chip shrinkage.

Consequently, the zones without build-up, inherent in ultra-low cutting speeds (V = I… 2 m / min), are absent in drills with MNP.

Second. Differences in the wear of individual parts of the cutting edges, the processing of inhomogeneous materials, inevitable errors in the manufacture and installation of cutting inserts, as well as inaccuracies in the manufacture of the drill body lead to a redistribution of the load and can disturb the balance of forces [3]. Drills, in addition to torque and axial force, experience a bending moment. As a result, a single cutting edge in split feed drills will practically take up the entire load on the tool. Drills with MNP do not have guiding elements, like twist drills for deep drilling, therefore, the disturbing force resulting from an imbalance of forces, except for the rigidity of the drill body itself, has nothing to compensate for. An oscillating system is created, and the drilling process can proceed under interrupted cutting conditions with vibrations.

Third. The design of the cutting part of drills with MNP determines the constancy of cutting angles in a static coordinate system. The actual angles in the kinematic coordinate system will change along the cutting edge depending on the feed [4].

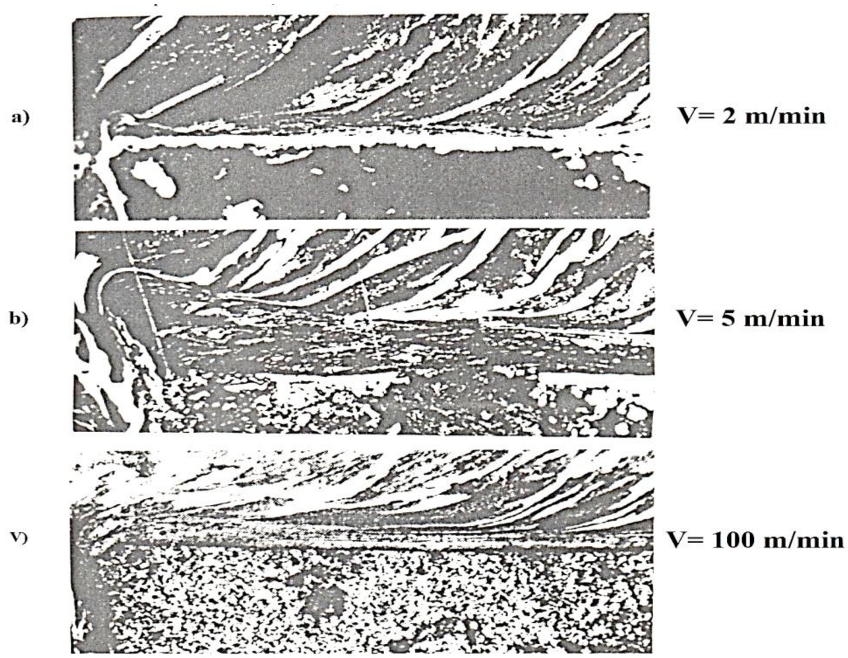

Fig. 2. Micrographs of the cross-section of the roots of the shavings recorded during turning of steel 40 at different cutting speeds. (γ= 10^0, s= 0.285 mm / rev).

$$\gamma_s = \gamma + \mu_s \quad (2)$$

$$\mu_s = arctg\frac{S_0 \cdot \sin\varphi}{\pi d}, \quad (3)$$

where

φ - angle in the plan;

S_0 - feed, rpm;

d - drill diameter.

RESULTS AND DISCUSSION

It follows from formulas (2) and (3) that the kinematic angles are always greater than the static ones. However, for a MNP drill, the change is less than one degree. If an insert with a positive rake angle is used, then this change can be ignored. A number of designs and technologies for the manufacture of drills with mechanical fastening of cutting plates have been developed at the Department of Mechanical Engineering Technology of the Tashkent State Technical University. During the development and manufacture of drills of new designs, the rich experience described in foreign literature was used. Drill manufacturing technology developed at Tashkent State Technical Universitywas based on the use of CNC lathes and milling machines.The most important and distinctive features of the investigated type of drills with MNP structures of Tashkent State Technical University from drills available in the industry and offered by firms are the following:

1. Standard three-sided hard-alloy plates according to GOST 19048-80 are used as cutting inserts.

2. The base plane of the cutting inserts is turned at an angle of -5 ...- 7 °.

3. The central column is formed by displacement of the plates above the axis of symmetry by 0.25 ... 03 mm.

4. The planes of the chip flutes are located above the axis of the drill, which significantly increases the size of the core and, accordingly, increases the rigidity of the tool.

Experiments were carried out to study the peculiarities of the cutting process when drilling with MNP drills and the possibilities of their design.

In the process of cutting with MNP drills, a series of instantaneous radial unbalanced forces arise, leading to dynamic instability of the drill. This kind of instability under conditions of rapidly changing forces imposes its own limitations on the design of drills. Insufficient knowledge of the process of drilling with MNP drills has led to the fact that today there is a large range of designs of this tool, even within one firm, which, nevertheless, does not meet the requirements of accuracy and productivity of machining. It is interesting to analyze the specific energy consumption spent on hole processing. The cutting work per hole is determined by the formula:

$$A = 9{,}8 \cdot \frac{2\pi n}{60} M \frac{L}{nS} \quad , \qquad (4)$$

where

M - cutting moment, Nm;

n - tool rotation frequency, rpm;

L - hole length, mm;

S- feed, mm / rev.

Hole volume:

$$W = \frac{\pi \cdot d^2}{4} L \, , \qquad (5)$$

then the specific work of cutting will be:

$$A_{уд} = \frac{A}{W} = \frac{8M}{d^2 \cdot S} \quad , \qquad (6)$$

In fig. 3. illustrationthe diagram of the maximum specific energy consumption when processing steel 45 and 12X18H10T with a twist and drill with MNP is presented. The diagram shows that when processing 12X18H10T, the specific energy consumption of the cutting process with a drill with MNP is more than 5.0 times lower than those when processing with a twist drill, and when drilling steel 45, it is almost 2 times lower, i.e. the efficiency of using a drill with MNP significantly increases with a decrease in the machinability of the material (total energy costs when machining one hole with a twist drill are equivalent to machining five holes with a drill with MNP when cutting 12X18H10T and two holes when drilling steel 45).

The peculiarity of the flow of contact processes during the operation of the drill with MNP and the formation of cutting forces is largely determined by the absence of a bridge[5]. The "column" formed in this case should be chipped without reaching too great a length. The destruction of the "column" occurs due to fatigue loads, which are formed according to the following scheme. A drill with MNP has two symmetrically spaced plates that form a gap δ, i.e. the diameter of the "column" will be determined by the value δ. The cutting edges of the installed plates protrude from the body by the value, *k*, and the body itself has a jumper in the form of a sharp wedge located asymmetrically relative to the tool axis (Fig. 4). The "column" formed during the drilling process when drilling a hole with a depth of k will have a cylindrical shape. In this case, the forces acting on it in the form of a torque will not have a cyclic component [6].

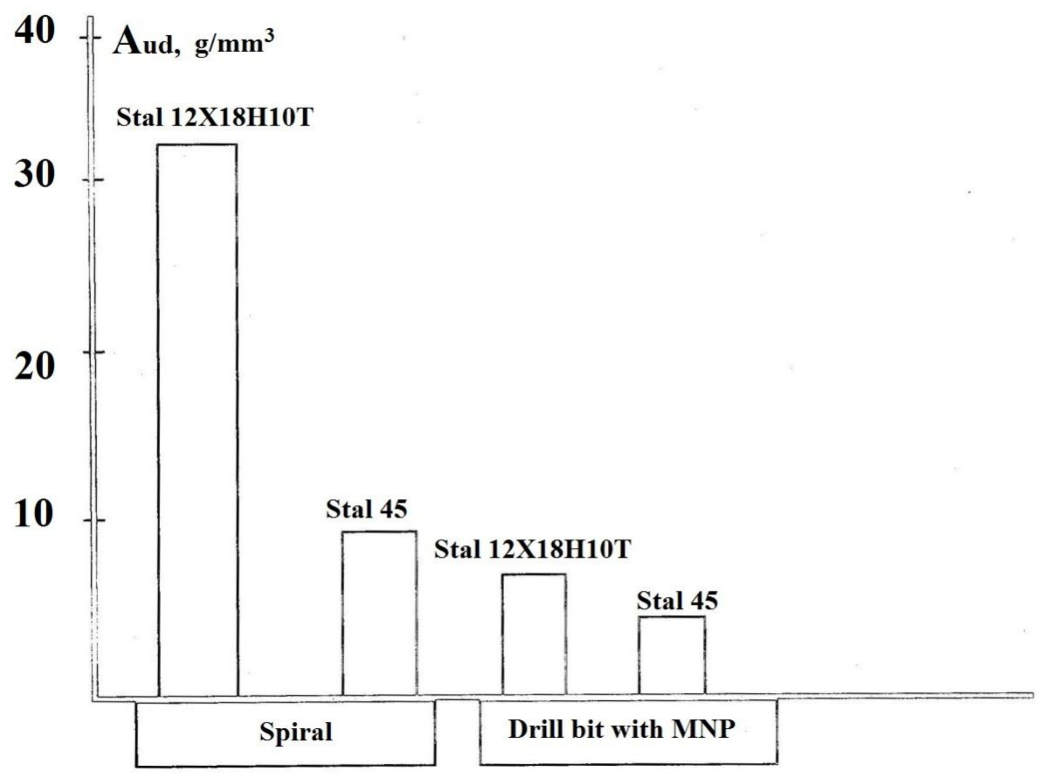

Fig 3. Specific cutting work diagram during operation twist drills and drills with MNP.

With further drilling, the top of the "column" will begin to interact with the asymmetric jumper of the body, the resulting force will begin to bend the "column", and taking into account the rotation of the tool, it will have a rotational character.

The rotational speed of the bending force is equal to the rotational speed of the tool. The number of cycles perceived by the "column" can be determined:

$$N = \frac{l - R}{S} n \ , \qquad (7)$$

where

l - the total height of the "column",

R- plate overhang;

S- minute feed,

n- spindle speed.

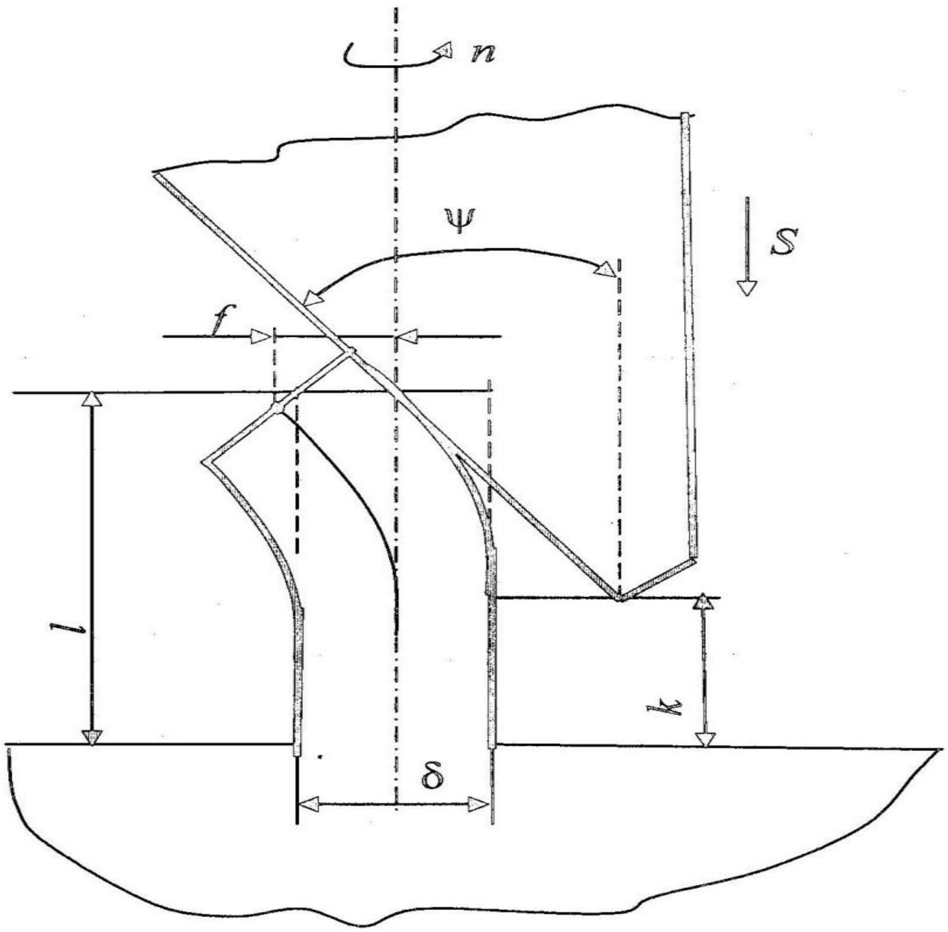

Fig. 4. To the calculation of the maximum height of the central "column".

The number of cycles of oscillation of the central column establishes the relationship between the tool feed and the dimensions of the column itself, which must be known when constructively choosing the radial arrangement of the cutting inserts, especially with their asymmetric arrangement.

The amount of deflection of the "column" relative to the axis of rotation of the tool can be determined by the formula:

$$f = (l - k) \cdot tg\psi, \quad (8)$$

where

ψ - the angle of inclination of the asymmetric body jumper.

The "post" can be thought of as a cantilever clamped beam. The radial force can be determined:

$$P = \frac{3EJf}{l^3}, \quad (9)$$

where

E - modulus of elasticity of the processed material:

$J = 0{,}05\delta^5$ - moment of inertia of the "column" section.

As a result of the bending of the "column" in the section of the base, stresses arise, the average value of which can be determined:

$$\sigma_{cp} = \frac{24EJf}{\pi\delta^3 l^3}, \quad (10)$$

or

$$\sigma_{cp} = \frac{1{,}2EJ\delta^2}{\pi l^3} = \frac{1{,}2E\delta^2}{\pi l^3}(l - k) \cdot tg\varphi. \quad (11)$$

The cyclic load arising from the bending of the "column" is characterized by a symmetric loading diagram with an asymmetry coefficient R = -1. In the presence of an initial crack located radially from the surface to the center of the "column", the change in the stress intensity factor will be:

$$\Delta K_1 = \gamma \frac{P}{\delta^{1.5}}, \quad (12)$$

$$\gamma = 1{,}72\frac{\delta}{d} - 1{,}27,$$

where

P - radial load;

δ - the diameter of the rod;

$d = \delta - 2a$;

a - crack length.

The fatigue crack growth equation is:

$$\frac{da}{dn} = A \cdot (\Delta K)^m . \qquad (13)$$

In expanded form it will look like:

$$\frac{da}{dn} = A \cdot \left(\gamma \frac{P}{D^{1,5}}\right)^m = A \cdot \left[\left(1{,}72\frac{\delta}{\delta - 2a} - 1{,}27\right) \cdot \frac{3EJf}{l^3 \delta^{1,5}}\right]^m$$

$$\frac{da}{dn} = A \cdot \left\{\left[\frac{1{,}72}{(\delta - 2a)\delta^{0.5}} - 1{,}27\frac{1}{\delta^{1,5}}\right] \cdot \frac{3EJf}{l^3}\right\}^m ,$$

or

$$\frac{d \cdot a}{\left[\frac{1{,}72}{(\delta - 2a)\sqrt{\delta}} - \frac{1{,}27}{\delta^{1,5}}\right]^m} = \left(\frac{3EJf}{l^3}\right)^m dn .$$

After simplification, we get

$$\frac{(\delta - 2a)^m \delta^{1,5} da}{[1{,}72\delta - 1{,}27(\delta - 2a)]^m} = \left(\frac{3EJf}{l^3}\right)^m dn , \qquad (14)$$

where:

A, m - constants of the equation of fatigue crack growth,

a - average crack length.

Solving equation (14), it is possible to determine a= $f(h)$, while destruction can occur at

$$a \geq a_{kp} . \qquad (15)$$

a_{kp} - the critical crack length is determined from the equation:

$$K_{1c} = \gamma \frac{P}{D^{1,5}} = \left(1{,}72\frac{\delta}{\delta - 2a_k} - 1{,}27\right)\frac{P}{\delta^{1,5}} , \qquad (16)$$

where

K_{1c} - material viscosity

From (12) the critical crack length is equal to:

$$a_k = \delta\left[0{,}5 - \frac{1{,}72 \cdot P}{K_{1c} \cdot \delta^{1,5} - 1{,}27 \cdot \rho}\right] \qquad (17)$$

The number of loading cycles before the destruction of the "column" can be determined by jointly solving equations (10) and (14), i.e.

$$n = \left(\frac{l^3}{3EJf}\right)^m \delta^{1,5} \cdot \int_0^{a_k} \left(\frac{\delta - 2a}{0,45\delta - 2,5a}\right)^m da, \text{ and}$$

$$a_k = \delta\left(0,5 - \frac{1,72 \cdot P}{K_{1c}\delta^{1,5} - 1,27P}\right). \quad (18)$$

CONCLUSION

The solution of equation (17) is possible by a numerical method or by expanding the integrand into a Maclaurin series. The following conclusion can be drawn from the system of equations (18):

- with a decrease in the minute feed and an increase in the spindle rotation frequency, the number of cycles per unit length of the drilled hole increases and, as a consequence, the length of the "column" decreases;

- with an increase in the strength properties of the material being processed, the breakage of the "column" is carried out at its smaller length, i.e. the drilling process is more stable;

- the angle of inclination of the asymmetric body jumper should be performed as much as possible;

- the gap between the plates should be kept as minimal as possible.

REFERENCES:

1. Handbook of a mechanical engineer in 2 volumes. Ed. Kosilova A.G. - M .: Mechanical Engineering 1987, 846 p. silt

2. Knowler L., Howell J., Gold B., Coleman E., Moun O., Knowler V. Static methods of product quality control. from English. 2nd Russian ed. - M., Publishing house. standards, 1989.-96s.

3. Catalog "Cutting and auxiliary tools" by SandvikKoromant. Moscow representative office of the "Sandvik" concern. 1984 p. 32.

4. Umarov T. New technological possibilities for increasing the operational reliability of tools for machining holes. // J. Composite materials. 2002. No. 1. from. 36-38.

5. Umarov T. Reliability of drills equipped with hard alloy plates. // J. "Metalworking". Saint-Petersburg, Russia). 2002. No. 5. pp. 5-6.

6. Umarov T. Investigation of the variation of the durability of first drills by the method of imitation modeling of the wear process. // J. Bulletin of Tashkent State Technical University. 2004. No. 1. p. 127-131.

7. Tursunbaev, S. A., Zokirov, R.S., & Turaev, H. U. (2017). The effect of machining aluminum alloy parts using high-speed lathes on the service life of the cutter. In ENGINEERING TECHNOLOGY AND TECHNOLOGY (pp. 159-163).

8. Umarov, T.U., Tursunbaev, S.A., & Mardonov, W.T. (2018). New technological possibilities for increasing the operational reliability of tools for processing composite materials. In ENGINEERING TECHNOLOGY AND TECHNOLOGY (pp. 70-74).

9. Umarov T., Muhammadov Az.A. Improving the level of reliability and quality of high speed steel tools in the conditions of mass production. // J. Bulletin of Tashkent State Technical University. 2002. no. pp. 68-74

10. Tursunbaev, S. A., & Khusanov, S. (2017). OPTIMIZATION OF CUTTING MODES WHEN DRILLING. In ENGINEERING TECHNOLOGY AND TECHNOLOGY (pp. 70-73).