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MECHANICS AND ENGINEERING

INFLUENCE OF THE CLEARANCE BETWEEN THE PUNCH AND THE MATRIX ON THE FORMATION OF BURR ON THE INSECT TEETH OF THE DEVELOPED SAW CUTTING MACHINE

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Abstract:

Objective. The article presents the results of an analysis of the appearance of burrs on the teeth of a saw cutting machine, the value of which is influenced by the gap between the punch (cutting knife) and the matrix, ways of removing it or reducing its geometric dimensions, it is recommended to maintain the value of the gap between the punch and the matrix and use recommendations for cold cutting technology sheet metal stamping, which corresponds to 0.03...0.06 mm for cutting saw blades.

Results. Therefore, it is necessary to maintain the optimal value of the gap between the punch and the matrix and use recommendations on the technology of cold sheet metal stamping (z=3...6% of the sheet thickness δ, if δ=0.3...3.0 mm

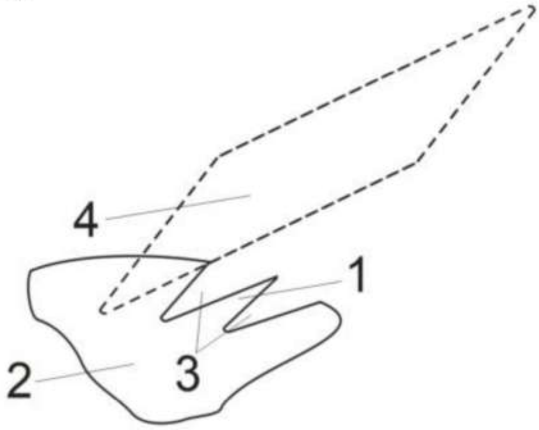
Conclusion. From the above, it can be assumed that large resistance forces inevitably cause increased wear of the die tool, which affects the cost of production. Regarding the production of saw blades for gins and linters, it should be noted that the height and shape of the burrs on the teeth, which are removed in a sand bath or by grinding, do not have a decisive role in their manufacturing technology. The most important criterion for the efficiency of producing saw blades with teeth by cutting them from sheet material is the durability of the die equipment, which depends on the optimal clearance.

Keywords: punch, matrix, burr, tooth, machine, cutting, saw blade, sand bath, gap, size.

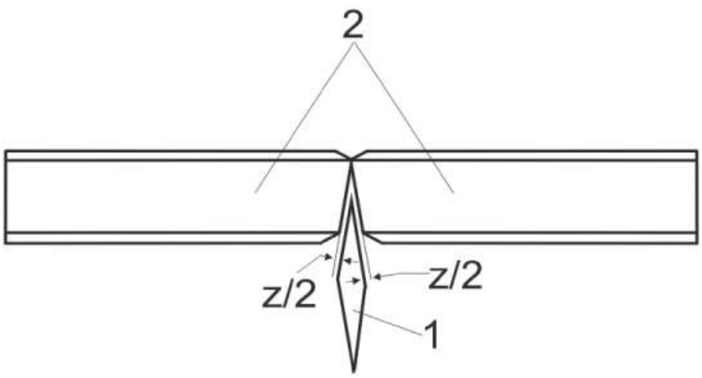
Introduction. When processing raw cotton in gins, fiber separation occurs as a result of dynamic contact interaction of saw blade teeth with the raw roller. The ginning process, other things being equal, is largely determined by the condition of the edges and working surfaces of the teeth [1], which are formed during one of the separation operations of sheet stamping, for example, during cutting on special saw-cutting machines (Fig. 1).

Picture 1. View of the developed saw cutting machine at JSC "Paxtasanoat ilmiy markazi"

The shaping of tooth 1 on saw blade 2 is carried out as a result of sequential cutting of two contours of the intertooth space 3 (Pic. 2) on a stamp consisting of punch 1 and a composite matrix 2 (Pic. 3).



Picture 2. Formation of a tooth on a saw blade by cutting out sheet material: 1 – tooth; 2 – saw blade blank; 3 – space between the teeth; 4 – transverse profile of the punch



Picture 3. Scheme of cutting sheet material on a die, consisting of a punch 1, a composite matrix 2 (top view), z/2 - one-sided technological gap

When cutting the teeth of gin-linter saws under conditions of cold plastic deformation of the metal, burrs are formed on their edges as a consequence of the force interaction of the punch (knives) and the matrix through the material being processed. The resulting burrs on the teeth of the saw blades spread to the top and to the edge of the front and rear surfaces of the tooth on the exit side of the punch.

Sharp burrs on the teeth in contact with raw cotton flakes at the time of fiber separation can significantly damage the fibers, making cuts or even cutting them, reducing the natural length of the fiber and thereby worsening their spinning properties.

In order to reduce the height and smooth out burrs, cotton factories use special sand baths [2, 3, 4]. A gin shaft with saw blades, the teeth of which have burrs, is installed in this bath. During the rotation of the shaft (the power of the electric motor and the rotational speed of the shaft are respectively 3 kW and 960 rpm), impact interaction with the mass of quartz sand occurs with the disks. Emery powder or crushed cast iron shavings can be used as abrasive particles.

A more progressive way to reduce the height of burrs on teeth is shot-impact processing with microballs measuring Ø0.3-0.5 mm [5]. The effectiveness of this technological process is ensured by the simultaneous strain hardening of a thin surface layer, which causes a sharp increase in the performance of gin saws.

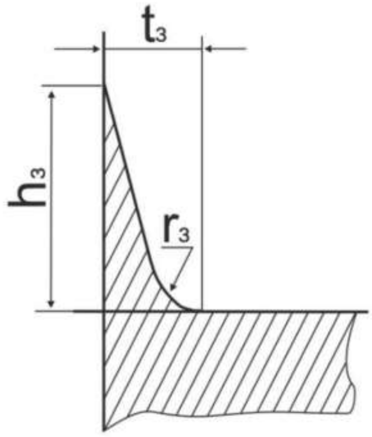
Thus, given the importance for the cotton processing process of the presence of formed burrs on the teeth after cutting, it is necessary to study the kinetics of burr formation in order to optimize this separation operation of sheet stamping and technological control of the geometric factor of the quality of saw blade teeth.

Burrs formed during cutting are protruding edge defects and form one of the quality indicators. Since deburring requires an additional operation in the technological process of manufacturing machine parts, in order to reduce the labor intensity and costs of deburring, it is necessary to strive to minimize their size.

The size of the burrs depends on almost all parameters of the cutting process. Experimental studies are often fraught with difficulties due to burr metrology, which is caused by non-uniform geometry along the edge, inaccessibility of burrs and the need for special measuring devices. In this regard, it is important to substantiate analytical models of the mechanism of burr formation on the basis of the physical essence of the processes occurring during cold sheet stamping.

According to the international standard [6], burrs are plastically deformed material formed on the edge of a part as a result of cutting or punching. A burr consists of a volume of metal beyond the edge of a part, formed as the theoretical intersection of two surfaces. Therefore, the edge is no longer a line, but a certain transitional surface.

Methods and results. Burrs are characterized by both mechanical (hardness) and geometric parameters: dimensions of height, thickness and length; shape in the transverse and longitudinal direction; location. The cross-section of the burrs formed during cutting usually have a shape close to triangular (Pic. 4) with the corresponding parameters.



Picture 4. Basic geometric parameters of the burr:
h_3 – burr height; r_3 – burr radius; t_3 – thickness of the burr root

The degree of burr removal is determined by the technological requirements for the edge of the manufactured part [7, 8, 9]. So, if the requirements are not high, then in some cases you should limit yourself to removing only the thinnest and highest part (top) of the burr, i.e. reduce the hz parameter. If the edge is subject to increased requirements for surface roughness Ra = 0.32...0.16 microns, then it is necessary to remove the burrs along with the root.

It is advisable to classify the set of parameters that influence the height of burrs during cutting, in accordance with the data of [10, 11]:

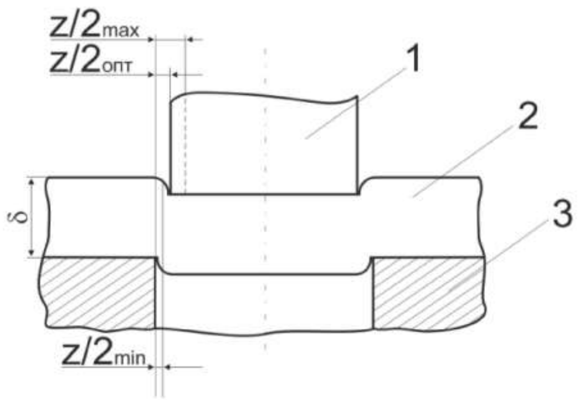
1) design parameters - the size of the gap between the punch and the matrix; design parameters of die working tools (accuracy of manufacturing and positioning during operation); cutting profile.

2) technological parameters - wear rate of the working surfaces of the punch and matrix, processing modes, lubrication during cutting.

3) physical and mechanical properties of the material being processed (elastic modulus and Poisson's ratio, yield strength, hardness).

Among the design parameters that influence the nature of the formation and size of burrs during cutting, the size of the gap between the punch and the matrix is of predominant importance. The importance of justifying this technological gap is not only to minimize the size of the formed burrs, but also to ensure the necessary durability of the stamping tool.

In Pic. 5. The cutting of sheet material and the gap between the punch and the matrix are schematically shown. When designing tools for sheet metal stamping, the gap size is determined depending on the type of material and its thickness. Thus, for thicknesses from 0.5 to 10...12 mm, the gap size is within 4...16% of the material thickness [10, 11]. The choice of the optimal (normal) gap size ensures high-quality cutting of products, the criteria of which can be: minimum cutting force and, accordingly, less energy consumption of the equipment; high quality of the cut surface of the product; maximum precision of sheet stamping and, as a consequence, the highest performance of the die.



Picture 5. Scheme of cutting at different gaps (maximum, optimal, minimum): 1 – punch; 2 – workpiece; 3 - matrix

When designing and operating a stamping tool for punching, a technological gap z is provided between the steel punch and the matrix, the value of which is determined from the dependence

z=s x, mm (1)

where: s is the thickness of the sheet material, mm;

x is a coefficient depending on the workpiece material [12].

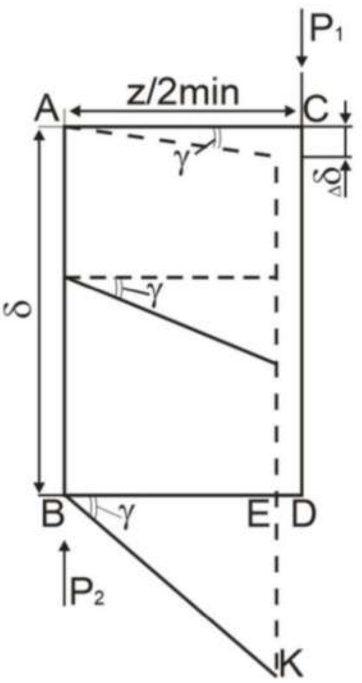
The optimal value of the gap z ensures the coincidence of the directions of the shear cracks that form at the edge of the punch and matrix blades and propagate towards each other. The shearing crack is directed along the lines of greatest shear deformation (sliding surfaces) and quickly spreads to the inner layer of the metal, forming a general curved shear surface and causing separation of the cut part. Under such cutting conditions, theoretically no burrs are formed during punching (punching).

With a small gap value z and a large thickness of the sheet material, the shear surfaces (shearing cracks) coming from the edges of the punch do not coincide with the shear surfaces that arise at the edges of the matrix. As a result, an annular bridge is formed, which is cut when the punch is further immersed with the appearance of new shear cracks, which leads to the formation of tears and a double cut with a burr [12]. It should be noted that with such a cutting scheme, the durability of the stamping tool decreases and, accordingly, the cost of manufacturing parts increases.

When the gap is greater than the maximum with very thin material (up to 1.5 mm), the metal is pulled into the gap between the punch and the matrix, followed by a break, leading to the formation of torn burrs that look like drawn edges. If the gap exceeds 30-40% of the thickness, then when cutting thicker sheet materials, strongly rounded and torn burrs are formed from tightening and breaking of the metal in the gap.

It should be noted that burrs and cut surface defects during cutting are also obtained as a result of uneven distribution of the gap around the perimeter and with large wear of the cutting edges of the punch and matrix. If the cutting edges of the punch wear, burrs form on the cut part. When the die edges wear, burrs appear around the punched hole. If the dies and punch are dull, then burrs form both on the part and around the hole in the material.

The formation of burrs during the cutting operation of sheet material is primarily associated with the peculiarity of elastoplastic deformation of the volume of metal contained within the sheet thickness δ, the gap z between the punch and the matrix and the perimeter of the cut-out contour of the product. In the process of cutting sheet metal, a complex inhomogeneous force field arises with the greatest intensity near the cutting edges of the punch and matrix. The sheet blank simultaneously experiences pressure from the punch and the matrix, which can be replaced by the corresponding resultant specific forces P1 and P2 (Pic. 6).



Picture 6. Shear deformation during cutting of sheet material and model of burr formation on saw blade teeth

Assuming that face AB is fixed, face CD, under the action of forces P1, moves as a result of shear by the amount of absolute deformation Δδ. In this case, a shift angle γ is formed, which characterizes the relative shift:

$$tg\gamma = \frac{\Delta\delta}{z} = \gamma \quad (2)$$

the last equality is acceptable due to the smallness of the angle γ.

To approximate the shear angle γ, you can use Hooke's law for shear:

$$\tau = \gamma \cdot G \quad (3)$$

where f is the tangential shear stress, N/mm2, G is the modulus of elasticity in shear (modulus of the second kind), for steel G=0.8·105N/mm2.

Since the shear deformation during cutting and punching ends with a cut, then from dependence (3) we obtain

$$\gamma = \frac{[\tau_c]}{G} \quad (4)$$

Where: [τc] – shear resistance, N/mm2.

The shear resistance of sheet steel with a carbon content of 0.8% C (U8G steel is used for the manufacture of saw blades for gins and linters) is 720 N/mm2 (hardened). Then for these values of shear resistance the shear angle will be respectively: 0.009 and 0.01125 rad or 0.52 and 0.64 degrees.

In the resistance of materials [13], the shear angle is assumed to be constant in height (across the thickness of the sheet workpiece). In reality, the shear angle γ changes with height and, moreover, the edges CD and AB move closer together by the amount DE (Fig. 5). This convergence is small of a higher order compared to the absolute shift.

Taking into account the fact that in reality the shear angle γ is variable along the height of the section and increases due to the involvement of new volumes of metal in the general scheme of plastic deformation with a fixed face AB, the theoretical height of the burr is the segment EK or DK due to the small approach of DE.

In metals, as is known, the process of plastic deformation is mainly carried out by sliding - parallel displacement of thin layers of metal grains (crystallites) relative to each other. The slip plane is usually the region with the largest plane of arrangement of atoms, and the sliding directions are those directions along which the interatomic distances are the smallest.

The shear (tangential) stress, which causes sliding of crystallographic planes, is known to reach its maximum value at α=45°. In the analyzed case of the operation of cutting sheet material during the manufacture of saw blades, the shear deformation ends with shearing when the resulting stresses reach the value of shear resistance [τc]. Taking into account the effect of maximum shear stresses at the end of the punching operation, it can be assumed that the shear angle approximately coincides with the angle value that provides the maximum shear stress, i.e. 45°. Under such deformation conditions, the maximum theoretical height of the burr hz formed into the hole after cutting (or on the edges of the teeth) does not exceed the value of the one-sided gap z. In practice, the height of the burr will be less

The commensurability of the height of the burr and the size of the gap is evidenced by the data when cutting out steel 30. With a one-sided gap of 0.075 mm (5% of the sheet thickness of 1.5 mm), the height of the burr was 0.053 mm. Apparently, this relationship is valid for steel sheet materials with sharp edges of the stamping tool. For highly ductile structural materials (copper, aluminum alloys), the height of the burr can exceed the value of the one-sided gap by 2.3...2.6 times.

When the matrix is worn (rounding of cutting edges), the height of the burrs on the hole being cut out (on the front and back surfaces of the saw blade teeth) may increase, because During plastic deformation, the metal is forced to bend around the enlarged transition surface on the cutting edge of the matrix.

If the one-sided gap is taken equal to zero, then the destruction of the material occurs as a result of a clean cut after overcoming significant compressive stresses arising from the action of the reaction force from the cutting edge of the matrix. If there is a gap between the punch and the die, the resistance to deformation decreases, because the resistance force in this case is the shear resistance, which is less than the compressive stress.

Conclusion. From the above, it can be assumed that large resistance forces inevitably cause increased wear of the die tool, which affects the cost of production. Regarding the production of saw blades for gins and linters, it should be noted that the height and shape of the burrs on the teeth, which are removed in a sand bath or by grinding, do not have a decisive role in their manufacturing technology. The most important criterion for the efficiency of producing saw blades with teeth by cutting them from sheet material is the durability of the die equipment, which depends on the optimal clearance. Therefore, it is necessary to maintain the optimal value of the gap between the punch and the matrix and use recommendations on the technology of cold sheet metal stamping (z=3...6% of the sheet thickness δ, if δ=0.3...3.0 mm.

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CONTROL OF COTTON PNEUMOTRANSPORT FACILITY THROUGH SCADA SYSTEM

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Abstract:

Objective. The article reflects the results of a study of changes in air speed and aerodynamic force on the cross section of the pipe during the transportation of cotton by pneumatic transport. It contains conclusions and proposals for the effective management of the cotton pneumatic conveying process.

Methods. Our research shows that the semi-empirical law describing the change in static pressure along a transport line, proposed by us, is well confirmed by experimental data.

Results. In pneumatic transportation of raw cotton, more than half of the installation capacity is spent on moving air. However, the percentage of energy consumption for transporting air at high flow rates is less than at low flow rates, which is also clear - relatively more effort is required to deliver an environment with a high specific gravity at high speeds. provides low speed.

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