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INFLUENCE OF BASIC CHARACTERISTICS OF BLADE MICROGEOMETRY ON THE CUTTING ABILITY OF KNIVES

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Abstract: The article presents the results of experimental studies of methods for forming blades that provide acceptable values of indicators of the transverse microrelief, which increases the cutting ability of knives

Keywords. specific cutting capacity, microgeometric characteristic, resistance tests, micro-serration, sharpening, cut quality, durability period, blade configuration

Introduction

Uzbekistan is an agro-industrial country. It has a large production and mineral resource potential, unique agricultural raw materials, and a well-developed infrastructure. In agriculture, the main industries are the cultivation of cotton, cereals (including wheat), fruits and vegetables, melons and tobacco, sheep and livestock. In the structure of industrial production, the food industry makes up 30%, the textile industry - 21%; mechanical engineering - 14%, chemistry - 10%, metallurgy - 9%.

Since the largest percentage is allocated to the food industry, there is an urgent need “the food industry should develop on the basis of accelerating scientific and technological progress in the industry, optimizing the consumption and production of food products, enhancing the interaction of food and agricultural enterprises, increasing the efficiency of production in conditions of market relations, perfection ¬ van.

Main part

In a number of branches of the food industry, cutting machines and devices have become widespread, in which the cutting tool in the form of plate knives operates in the sliding cutting mode. Their main advantages are high performance, relative simplicity of design, and ease of use. Thin blade knives, in comparison with mass cutting tools, also help save valuable tool material, reduce waste, rejects and energy consumption of the cutting process.

However, in terms of such an important indicator as technological reliability, thin blade knives do not yet fully meet the production requirements. In practice, there are frequent cases of low quality of the cut surface, instability of the thickness of the cut blanks, insufficient durability of knives.

When processing food raw materials and semi-finished products, one of the most common technological operations is cutting. Food materials are distinguished by a complex set of technological, structural, mechanical and adhesive characteristics, therefore, the degree of technical perfection of cutting equipment and

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tools largely determines the quality, appearance and output of finished products.

In the study of the cutting ability of knives, experiments were carried out where the effect on the specific cutting ability was studied $Q_{уд}$ microgeometric characteristics of blades obtained by grinding with an abrasive wheel made of electrocorundum on a ceramic bond (sample No. 2), a circle made of elbor (sample No. 3) and brought along two edges after sharpening with an abrasive wheel (sample No. 5). In addition to the basic material for the manufacture of thin blade knives in the form of 85KhF chrome vanadium steel, which we used, in resistance tests, we selectively studied individual parameters of knives made of U8A, 2X13, 65 G steels, which are also used for the manufacture of cutting tools at many food enterprises. The hardness of the blades was 44–48 HRC.

To accelerate the resistance tests, the production load of the experimental cutting tool was used; therefore, after forming the blade in a certain way and controlling the initial parameters of the microgeometry, the blade knives were installed in the front knife frame of the A2 – XP – 2P AOZT machine. The production line produced rusks from wheat flour of the highest grade of the following names: Kirieshki, Hrustoff, Jassi Hrustoff, O'kelch, Pekariki. Exposure of rusks was 12-24 hours. Experimental knives after a certain time of work or the amount of processed semi-finished product were removed from the machine and, after controlling the parameters of microgeometry, were installed on an experimental setup to measure their specific cutting ability.

Experiments carried out in laboratory conditions have shown that the value of the specific cutting ability when the blades are blunt changes mainly due to a decrease in the feed rate U_2 samples, while the total cutting force $R=R_1+R_2$ changes slightly. The latter circumstance is due to the fact that, according to the experimental conditions $R_2=const$, but the effort R_1 slightly reduced due to the frictional wear of the micro-teeth of the cutting edge and the resulting reduction in friction on the blade.

Figure 1.a shows the dependences of the cutting ability of the main types of blades on the operating time T. Curve 1 corresponds to sample N2 (see Section 3.4), curve 2 - to sample N3, curve 3 - to sample N5. The indicated graphs were obtained using knives made of 85KhF steel.

The experimental dependences, (Fig. 1), have a very significant scatter of data, which is explained by the errors in measuring the parameters by practically uncontrollable deviations in the structural and mechanical characteristics of the processed semi-finished product.

The experimental patterns of changes in the specific cutting ability differ significantly for sharpened and finished blades. Blades sharpened with electrocorundum or CBN wheels have two distinct stages in the period of durability - running-in and normal operation. The first stage has the highest rate of decline $Q_{уд}$ (pic.1).

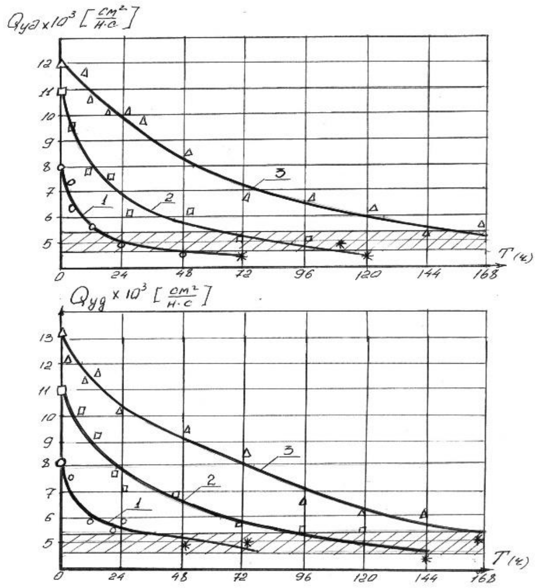

Fig. 1. Dependence of the cutting ability of knives on the duration of work. a - knives from steel 85HF; b - knives made of U8A steel.

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At the second stage, the slope of the dependence $Q_{уд}=f|T|$ significantly less. The highest rate of decline in the specific cutting ability is characteristic of the initial phase of the operation of a thin blade knife sharpened with an electrocorundum abrasive wheel.

The running-in stage is practically absent in the finished blades, because there is no inflection point for experimental dependences. With the removal of unfavorably oriented micro-teeth, burrs, as well as micro-volumes of the blade during finishing operations, which have experienced during sharpening through measured mechanical and thermal influences, i.e. which are defective. In addition, the hardening of the blade due to work hardening during debugging is of great importance. Thus, in this case, the wear of the cutting edge occurs not by chipping and breaking out of its microelements, but as a result of frictional interaction with the cut material, which, as is known, has a much lower wear rate [1].

The given graphical dependencies confirm the absence of restoration of the cutting ability of the blades at the first stage of wear (running-in), because newly formed micro-teeth during crushing of the initial micro-relief of the cutting edge were obtained at a larger width a.

It can be noted that the curves $Q_{уд}=f|T|$ for sample N3 occupy an intermediate (transitional) position between samples N2 and N5. This indicates that CBN sharpening of the cutting edge provides a better formation of the microgeometry of the blade, especially in terms of such an indicator as the stability of the cutting edge width. Experiments show that such knives have a longer running-in period. It should be emphasized that during the period of normal operation all the samples studied have the same wear rate, which follows from the close values of the slope of the experimental curves at the second stage of the resistance period $T_{см}$.

Figure 1 b shows similar dependences for knives made of U8A steel (hardness 46–48 HRC units). Comparison of these data with Fig. 1a indicates a practical coincidence (within the accuracy of the experiment) of the studied dependences.

The combination of laboratory research methods and production tests, given in this section of the work, made it possible to determine the durability period of the cutting tool, the blade of which was formed in various ways, and also to find the maximum permissible value of the specific cutting ability according to the cutting quality condition $Q_{уд}^{\min}$.

The latter indicator is of great importance for the introduction of an objective characteristic, the achievement of which a certain numerical value would indicate the need to restore the cutting properties of the tool by sharpening and fine-tuning. The use of this characteristic creates the prerequisites for a rational choice, and in the future - and reasonable rationing of the work of personnel serving the cutting equipment, and the consumption of tool materials and abrasives.

Analysis of experimental data and generalization of the production experience of a number of food enterprises shows that the period of durability of thin blade knives made of low-alloy carbon or tool steel with a hardness of 44-48 HRC when cutting rusks from wheat flour of the first and highest grade on cutting machines such as KhRP, KhRO , A2 – XP – 2П when holding the semi-finished product T = 12–24 hours is:

1. When sharpening knives with circles of electrocorundum on a ceramic bond with a grain size of 10–40 μm, hardness CM1, CM2 - about 48–52 hours.

2. When sharpening knives with circles from Elbor PP250x27x16x5 LOL16S1K7 100% - about 96-108 hours.

3. When sharpening knives according to type 1, followed by fine-tuning along two edges according to modes, about 190-220 hours.

The running-in period for sharpened knives is approximately 10-16 hours. Marked in Fig. 1, changes in specific cutting ability depending on the duration of work correlate with the kinetics of changes in the main characteristics of the longitudinal and transverse microrelief of the blades.

Maximum permissible value $Q_{y\partial}^{\min}$, as shown by organoleptic assessments of the quality of the cut surface and measuring the amount of waste and rejects in laboratory and production conditions, in the case of cutting rusks, it is (3,8-5,2)·10^{-3} $sm^2/(H_c)$. Laboratory research on an experimental setup in modes R_2=*const* and U_2 = *const* showed that such a value $Q_{y\partial}^{\min}$ can be taken as an estimate for the cases of cutting semi-finished products with plate knives on production lines for the production of sliced and packaged bread and the production of flour confectionery products. In this case, the parameters characterizing the cutting modes must be within the following limits: the size of the knife stroke - 20 - 80 mm; frequency of double strokes - 300 - 800 min; feed speed - 0.05 - 0.1 m / s.

In fig. 1 a, b experimental points corresponding to unsatisfactory cut quality are marked with a *. There were no cases of discrepancy in quality assessments when cutting with the same knife in laboratory and production conditions.

Generally, knives with a higher initial cutting performance had a longer tool life. Most of the life of knives without finishing the cutting edge falls on the running-in stage. The transition from the running-in stage to the stage of normal operation for knives sharpened with CBN is less pronounced than for knives sharpened with a vitrified alumina wheel.

The production tests carried out have shown a higher durability of blades sharpened with CBN compared to sharpening with fused alumina. This is due to the fact that the nature of the distribution of residual stresses greatly affects the wear resistance and fatigue resistance of cutting edges. Residual stresses arising after grinding remain in the surface layers of the cutting wedge for a long time and, algebraically adding up with the working (external) stresses, can increase or weaken them. There is evidence [2, 3, 4] that residual compressive stresses increase the fatigue resistance of steel up to 60%, tensile stresses reduce it. At a high level of tensile stresses exceeding the tensile strength of the material, grinding cracks and microcracks may appear, leading to a decrease in the wear resistance of the cutting part of the tool.

As a result of the formation of the cutting edge of thin plate knives by the method of multi-pass grinding with an abrasive or CBN tool, followed by finishing, it is possible to obtain a minimum blade thickness and a transverse step of micro-teeth. However, the characteristics of the longitudinal microgeometry are far from the values that provide the maximum cutting ability. In addition, it should also be taken into account that the micro-teeth of the blade obtained during sharpening are metal particles that have experienced significant thermal and mechanical stress when exposed to abrasive grains, and are plastically elongated in the direction of grinding. These circumstances explain the insufficient durability of the micro-teeth, which wear out rather quickly under the influence of technological loads.

Based on the foregoing, a comparative study of the cutting ability of several plate knives with different blade configurations and a special notch on the cutting edge was carried out. When choosing the characteristics of the notch, we proceed from the fact that the height of micro-teeth for serial cutting machines should be 1 - 2 mm, the length of the longitudinal step Sm, to ensure the condition Q = Qmax, can be in the range of 1 - 30.

A notch on the blade was applied before grinding the knife chamfers on a 3G71 sharpening machine using a diamond wheel 200 mm in diameter and 1 mm thick of the working part. Knife material - steel 85 HF, hardness - 48 - 52 units. HRC, angle of sharpening - 160. Knives with a smooth blade (Fig. 2.), sharpened

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across (1) and along (2) the cutting edge, were used as control knives. Knife 3 had a triangular notch with an apex angle of 600, a width of 2 mm at the base and a pitch of 20 mm on the blade. The cutting edge of this and all subsequent knives was sharpened across the blade. Knife 4 had a rectangular notch 1.5 mm deep, 8 mm long, located with a 20 mm pitch on the blade. The notch of the blade of knives 5, 6, 7 was made with a thin diamond wheel and had a height of 1 mm (knife 5) or 0.5 mm (knife 6) with a corresponding pitch. Knife 7 had an oblique notch with a height of 1 mm with an opposite direction in the right and left parts of the blade, as shown in Fig. 2.

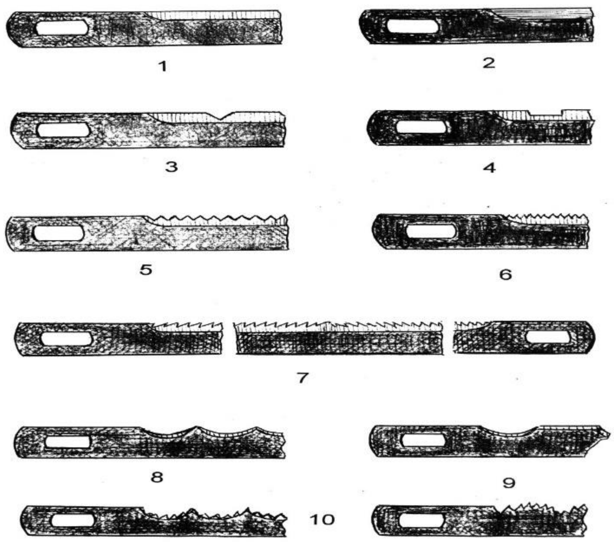

Fig. 2. Blade configuration of thin plate knives

The arcuate shape of the knife blade 8 had the following dimensions, the pitch of the teeth was 15 mm, the depth of the arc was 3 mm, each arc of the blade had two-sided transverse sharpening. On the cutting edge of the knife, 9 arcs with the indicated parameters alternated with sections of a straight blade 20 mm long with double-sided sharpening. In knife 10, an additional notch with a height of 1–2 mm was made on the arcuate sections of the blade. In this case, the sharpening of the arcs was one-sided.

Tests of knives with different configurations of the cutting edge were carried out using a laboratory stand Fig. 3.

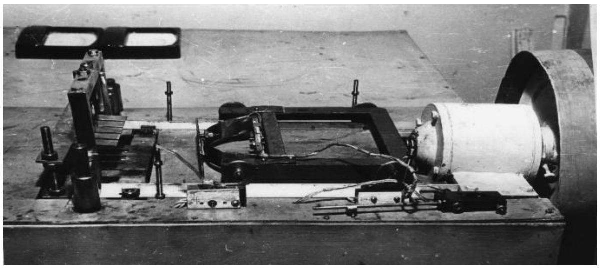

Fig. 3. Laboratory bench for testing the cutting edge of a knife.

In general, these tests showed that at T = 0, the value of the cutting ability of a tool with a notched blade is noticeably inferior to the control sample (1). This can be explained by the fact that in the presence of a notch, it is not possible to provide a minimum deviation in the width of the cutting edge. On the other hand, one should take into account the participation in the cutting process of non-sharpened sections of the blade in the cavities between the micro-teeth. However, with further increase in T, the cutting ability of the notched blades changes very imperceptibly, i.e. these knives have practically no running-in period. The difference in the value of the cutting ability of knives 3,5,6,7 is within the experimental error. After 150 hours of operation in production conditions in the A2-XP-2Π machine on cutting rusks with an exposure of 6-12 hours, the cutting ability of these knives decreased by 20 - 25%, which is associated, as shown by microscopic studies, with the deformation of the tops of individual micro-teeth.

Manufacturing tests have shown that grooved blades contribute to more chip formation, especially when cutting hard semi-finished products. In this respect, plate knives are more preferable, the blade of which is made according to the type 3,4,9, i.e. contains areas with a smooth and serrated blade.

The experience of forming notched blades using a thin diamond wheel or disk cutter shows that this technology is very laborious and requires the development and implementation of special devices. Therefore, for the production conditions of a food enterprise, we recommend simpler blade shapes - like knife 3, which has a sufficiently high cutting ability and durability, and also reduces the amount of waste in the form of crumbs.

Conclusion

Modern methods of blade formation (finishing the blades, multi-pass grinding, using CBN abrasive tools) provide acceptable values of the transverse microrelief parameters, but do not fully contribute to obtaining the required characteristics of the longitudinal microgeometry of the blade - increased values R_{max} and reduced values of the longitudinal step S_m micro-teeth, which increases the cutting ability of the knives.

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