OPTIMIZATION OF THE TECHNOLOGICAL PROCESS BASED ON THE HEAT PHYSICAL PHENOMENON

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ABSTRACT

Transformation of the properties of deformable volumes of chips, parts and contact layers of the tool is inevitable when cutting materials. An increase in the productivity of machining is directly related to tool life, all known methods of controlling which ultimately come down to creating conditions for maximum hardening of the contact layers of the tool and (or) softening of the cut layer.

Keywords: Purpose of the research: Study of physical processes in the cutting zone. It is devoted to showing what methods (and therefore thermophysical effects) can be used to ensure the operating conditions of a tool with an optimal cutting speed (and therefore with effective thermophysical phenomena),

The processes of hardening and softening, acting simultaneously, compete with each other, and the task of controlling the cutting process in one way or another is associated with a targeted impact on one of them. The significance of this issue is determined by the fact that high strain rates, $10^5 \cdots 10^6$ times higher than those developed under standard test methods, significantly (at temperatures of 600 ... 800 ° C 2 ... 5.0 times) increase the true stresses in the contact layer [4]. This phenomenon is most pronounced in the processing of highly plastic stainless and heat-resistant steels hardened during deformation [2].

An effective way to soften the material being processed is heating, the implementation of which underlies the combined cutting with additional thermal effect. Naturally, this method is most effective when processing hard-to-cut (hardened and cutting) materials. Its use in cutting conventional structural steels, as a rule, does not make sense, with the exception of processing with a tool made of mineral ceramics, which has exceptionally high red hardness [5].

All existing methods of cutting with artificial heating are conditionally divided into volumetric and local ones [5]. Bulk heating workpieces can be produced in furnaces, but more often the workpiece is cut while hot, while it has not cooled down from the previous operation . The latter case is preferable because requires additional costs for heating the material. Local ways heating are characterized by significantly lower energy costs, but compared with volumetric ones, but their implementation requires the installation of a special Basis for setting up standard t ex nological equipment about van and e.

When processing steels and alloys with increased ductility , cutting with electric contact heating is an effective and economical method . AT In this case, the localization of the introduced heat occurs in the contact area and only internal volumes of the removed layer.

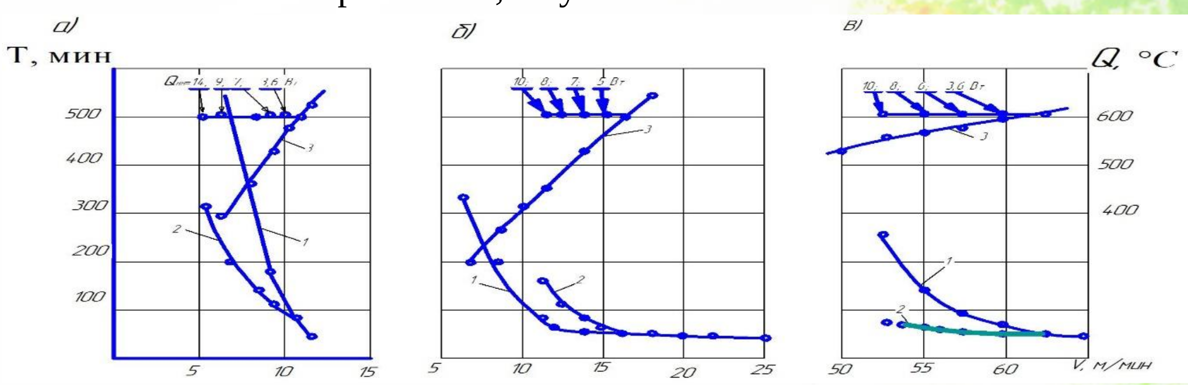
Optimization of cutting conditions with artificial heating is a multicriteria problem that is being tried to be solved from different points of view. If the minimum strength of the processed material is taken as the optimization criterion, then the optimization problem is reduced to the following:

$$\boldsymbol{\sigma = f(\varepsilon.\zeta, T) \rightarrow m}$$
$$\boldsymbol{T < T_{kp},}$$

where $\varepsilon$is the degree and is the ζrate of plastic deformation; T-temperature heating of the processed material; T_{cr} - red resistance temperature tool material.

The main limiting factor is the heat resistance of the tool material, which limits the upper allowable level heating temperature. If the dependence $\sigma = f(\varepsilon.\zeta, T)$is monotonous character, then the heat resistance temperature will determine the limit the mode of artificial heating of the workpiece. With extreme addiction the optimal conditions for artificial heating will correspond to the region of the minimum.

On fig. Figures 1 and 2 show the results of tool life tests obtained when cutting various materials in a constant temperature mode (curves 2). The temperature dependences are also shown here, reflecting the usual cutting conditions (curves 3), and the values of thermal energy (Q BB) entered at the corresponding cutting speeds to maintain the temperature constant, equal in all experiments when cutting with a tool made of high-speed steel R6M5-600 ° **C , hard alloy** VK8-8 5 0 ° C. At the same time, it is predicted the possibility of clarifying the degree influence of cutting speed on tool life depending on deformation characteristics of the studied materials. The tool life dependences (curves 1) obtained under normal cutting conditions are given for comparative analysis from these standpoints . For the same reason, the initial conditions in all experiments , they were assumed to be the same.



Rice. 1 , Influence of cutting speed on temperature and tool life from P6M5 when turning: a-VT22; b- I 2 X 18 H 10 T; in-steel 45; cutting depth 0.5 mm; feed 0.2 1 mm/rev;

I-normal cutting conditions; ***2-*** cutting at constant temperature, equal to 600 ° **C ;** 3-graph of temperature change during normal cutting ;
on the fourth line, the arrows indicate the amount of supplied heat at each cutting temperature
The fact of increasing the tool life of carbide tools with the help of artificial heating is widely known. The possibility of increasing the tool life of a tool made of high-speed steel, which is extremely sensitive to heat effects , was obtained by artificial heating. for the first time (in the literature known to the authors, such a fact cannot be established managed). However, it cannot be classified as unexpected. In the process of performing these studies, attention was paid to a sharp change in tool life with a change in temperature when cutting steel 45 and alloy V T22 (see Fig. 2a, c, curves 1). When cutting steel 12X18H 10 T in a fairly wide temperature range (450 ... 600 ° C) resistance tools made of high-speed steel remained practically unchanged (see Fig. rice. 2 o, curve 1). The latter gave reason to believe that the growth hardening, due to an increase in cutting speed, begins in be compensated to a certain extent by the development of the softening process, stimulated by a corresponding increase in temperature. In these conditions by artificially raising the temperature at relatively low speeds, when the effect of hardening is small, and the time for softening is increased, it is possible to significantly increase the resistance. Really, when turning highly ductile steel 12 XI 8 HI 0 T with a cutter made of R6M5 high - speed steel in the speed range of 12 ... 18 m / min, by artificially raising the temperature from 450 to 600 ° C, it will be possible to increase the tool life up to two times (see Fig. 2, curve 2). However, under conditions of constant temperature equal to 600 ° C, the effect is higher, the lower the cutting speed .
As is known, the ability of a material to harden is estimated by the value of the ratio of the yield strength to the tensile strength. The less this value, the more plastic material. For stainless steel it is 0.40 ... 45, for structural steels - 0.60.,.0.65 . According to the calculations of T.N. Loladee [3], the hardness in the loading zone education, calculated in terms of speed and temperature change, it significantly exceeds the static hardness of the chips, and even more so of the base material. At the same time, for steel 1X18N9T temperature increase from 400 to 600 ° C (the condition of our experiments) led to a decrease in the modified chip hardness from 380 to 330 units, or 13% pa, while the static hardness decreased from 325 to 180 units, or 45%, that is, the effect of high-speed hardening factor is very significant.
Thus, the rate factor, which intensifies the increased hardening of highly deformable steel 12Kh18N10T, is one one of the main reasons for reducing tool life. The influence of this factor is so significant that by artificial heating, which stimulates softening, it is possible to increase the durability of even a tool made of high-speed steel, which is very sensitive to temperature effects.
So, a positive effect in terms of increasing tool life when cutting with artificial heating according to the described method occurs only when turning stainless steel I 2 XI 8 H 10

T both high-speed cutting and carbide tools. Treatment of steel 45 and titanium alloy B T22 showed a negative result. However, the powers introduced into the cutting zone by the electrocontact method are lower than the natural heat flux functioning on the contact surfaces of the tool, therefore, in terms of the energy flux density, their values may be insufficient for noticeable structural changes in the secondary deformable contact layer. In connection with This suggests that another reason for the increase in resistance when turning stainless steel, its increased electrical resistance responsible for the process of heat release. Consider this question in more detail.

From the theory of electrical conductivity of metals and alloys, it is known that Pure metals have the lowest electrical resistance. Doping and induction of defects in the crystal structure lead to decrease in electrical conductivity. Highly alloyed alloys and deformed structures [5], as well as stainless steel, which consists of a highly alloyed austenitic phase and therefore has the highest electrical resistance, have an increased electrical resistance. Then, in descending order, steel 45 and B T22 are located. Stainless steel is also characterized by increased ductility; therefore, its deformed structure is characterized by a high density of defects in the crystalline structure. This further increases the electrical resistance of this material.

Figure 4 shows the results of research during deployment **holes in various materials** with carbide reamers VK8 with a diameter of 10 mm. In all experiments, by selecting the appropriate values of the power of artificially introduced heat, it is possible to increase the resistance of reamers by 2 ... 3 times compared to dry cutting. The greatest effect is observed in the processing of stainless steel. In this case the durability of the reamers increases significantly even in comparison with cutting with the use of LC. Artificial heating during deployment weakens the contact surfaces of the cut layer and creates more favorable temperature conditions for the operation of the tool, increasing the ductility of the hard alloy*

By metallographic analysis It has been established that during artificial heating, the wear mechanism of a carbide reamer changes as a result of the transition from brittle chipping to adhesive wear. It is characteristic that the consumption energy under optimal conditions does not exceed 40 W, that is, the required to supply COTS values. At the same time, the increased influence of contact processes on the total work of cutting during deployment determines the impact of electric contact heating on the accuracy parameters of the hole , reducing force fluctuations and stabilizing the process as a whole.

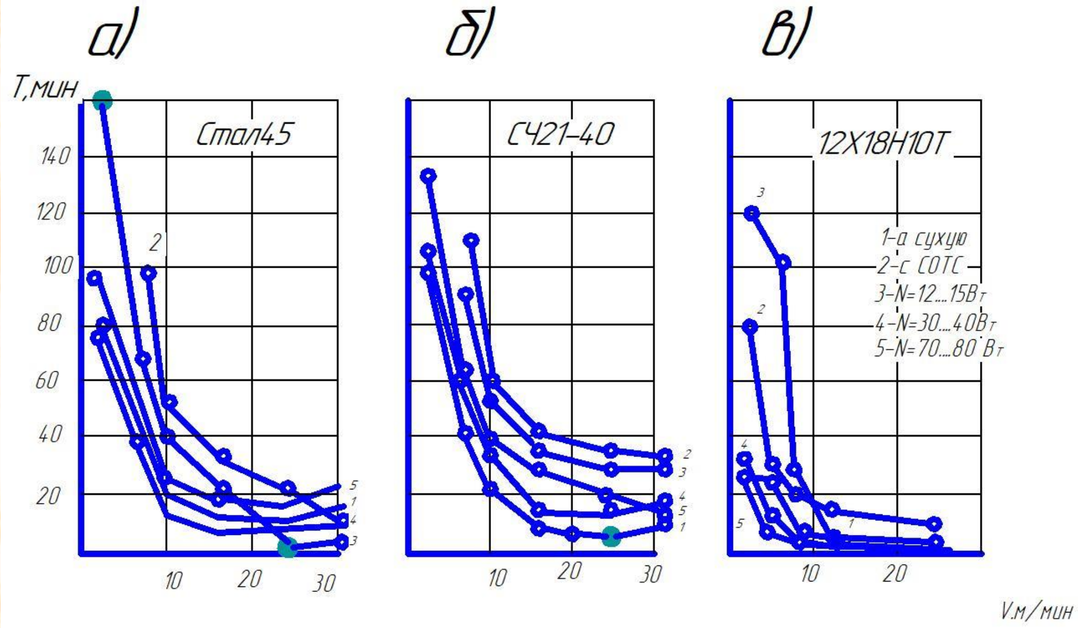


Fig 2 . The effect of artificial heating on the durability once a year from VK8, reamer diameter 10 mm, feed rate 0.05 mm/rev, cutting depth 0.15 mm .

Thus, the mechanism of the cutting process and the features of its self-organization contain significant reserves for managing output parameters. The proposed method reveals one of them.

One of the main issues in cutting with artificial heating is the search for the optimal heating temperature, which is set, as a rule, on the basis of labor-intensive experiments.

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