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FEATURES OF SIMULATION OF WEAR –OUT CRUSHING TOOL OF WOOD RAW MATERIAL CHOPPER AFTER SURFACE PLASMA HARDENING

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When using installations for crushing waste wood from furniture production, special details (knives) are used. Parts are made in the form of truncated pyramid of steel 40X – National Standard (42Cr4 – DIN, 5140 – AISI /ASTM) are used.

Such parts are strengthened by tridimensional quenching. During operation, the knives were subjected to mechanical wear-out (consumption) and dynamic loads, as a result of which there were not only intensive deteriorations of their cutting head, but also a breaking out of pieces of metal (Fig. 1).

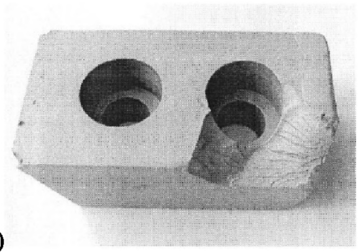
а)  б) 

Fig. 1. Wood raw material choppers:
a) after operation during hardening by tridimensional thermo-hardening;
b) with applied plasmatic track

That sort of mode of failure is typical for details which were hardening by tridimensional thermo-hardening and is due to the occurrence of significant mechanical stresses and brittle behavior (embrittlement) of metal. To avoid the occurrence of such defects in the material, it is proposed to use local surface plasma hardening of the cutting edge of the crushing tool of a chopper with a moving plasma arc.

Local surface plasma hardening most fully provides an optimal combination of the viscosity value of the core of the detail with high surface hardness. Such plasma hardening is widely used both in small-scale and single (including repair), and large-scale and mass production [1, 2]. However, the surface properties of the parts after surface plasma hardening are not well studied yet. Particularly relevant are studies of the wear resisting property of hardened parts.

A study of wear-out of knife after thermal treatment was carried out. To determine the amount of wear-out, two batches of five details each hardened with tridimensional thermo-hardening and hardened with a plasma arc were selected, which corresponded to the following operation time: No. 1 – basic part (non-operated); No. 2 – after monthly operation; No. 3, No. 4, No. 5 – after 2, 3, 4 – month operation, respectively.

Comparative profile measurements of the parts were performed on the Mistral 070705 laser scanning complex with PC- DMIS PRO Software which allows 3D monitoring with the provision of control protocols. Based on the results of measurements, the shape of the part was determined and the results were processed by SolidWorks, which built a 3D model of the part (Fig. 2).

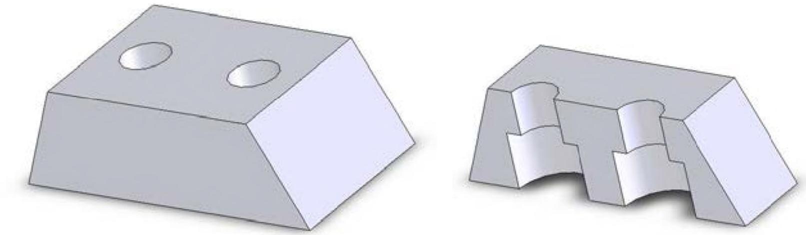


Fig. 2. Computer model of knife

Further, the part was divided by planes A-D into parts, with the separating of the studied fragment by plane T (Fig. 3).

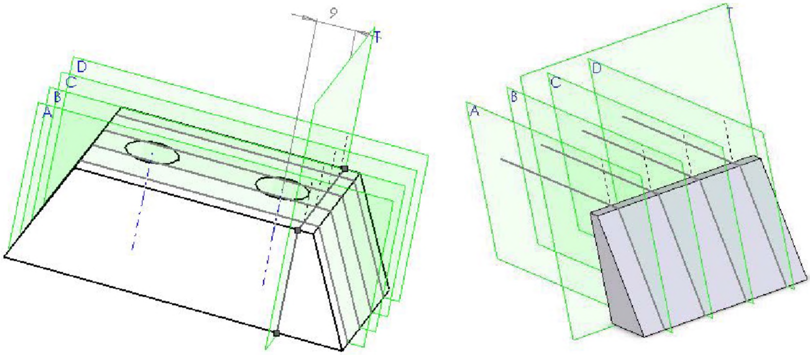


Fig. 3. Position of planar surfaces for analysis of the fragment under study

On the generated curves, a surface is plotted using the technique of "pulling" of profiles (Fig. 4).

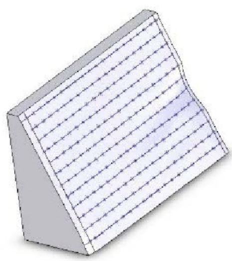


Fig. 4. Surface of fragment of detail to be analyzed

Using planes A-D, planar elements of the corresponding fragments of details were plotted. With the help of AutoCAD program the areas of the considered elements were calculated. The following formula was used to calculate the detail's wear-out factor:

$$\Phi_{nm} = \frac{S_{1m} - S_{nm}}{S_{1m}} \cdot 100\% , \qquad (1)$$

where Φ_{nm} – the relative percentage of consumption of the detail (wear-out factor), S_{nm} – the area of the analyzed section for the corresponding detail n as accordance to the plane surface m; n – the detail number ($n = 1–5$), m – the name of the corresponding plane surfaces ($m = A, B, C, D$).

Table 1. Wear-out factor of wood raw material chopper's detail

Plane „m” / Part No. „n”	**A**	**B**	**C**	**D**
1	0	0	0	0
2	0,522716	0,372987	0,291704	0,207708
3	7,328701	6,059883	5,660922	5,152895
4	9,530224	9,146942	9,312608	10,18617
5	17,91177	18,1535	17,13107	18,88431

Based on the obtained data, dependencies of relative wear-out of details hardened with tridimensional thermo-hardening and hardened by use of plasma arc (surface plasma hardening) are built (Fig. 5).

The useful life of the crushing tool of wood raw material chopper after surface plasma hardening is increased by 2.1 times as compared to tridimensional thermo-hardening method.

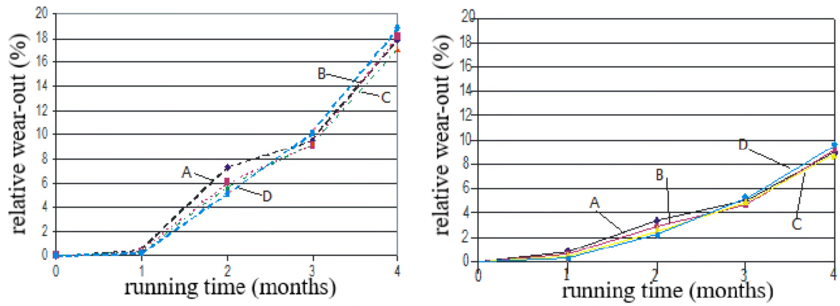


Fig. 5. Wear-out diagrams of knives hardened by:
a) tridimensional thermo-hardening way; b) surface plasma hardening way

[1]. Davis J.R. (2002). Surface Hardening of Steels: Understanding the Basics // ASM International, Materials Park, Ohio. 319 p.

[2]. Legcinskij L.K., Samotugin S.S, Pirch I.I., Komar V.I. (1990). Plazmennoe poverhnostnoe uprochnenie. Kiev, Tekhnika. 107 p.

ОСОБЕННОСТИ МОДЕЛИРОВАНИЯ ИЗНОСА ИЗМЕЛЬЧИТЕЛЯ ДРЕВЕСНОГО СЫРЬЯ ПОСЛЕ ПОВЕРХНОСТНОЙ ПЛАЗМЕННОЙ ЗАКАЛКИ

Проведено компьютерное моделирование износа ножа-измельчителя установки для переработки древесных отходов после поверхностной плазменной закалки движущейся плазменной дугой.