TECHNOLOGY HIGH-SPEED SHARPENING CARBIDE TOOLS

ТЕХНОЛОГИЯ ВЫСОКОСКОРОСТНОГО ЗАТАЧИВАНИЯ ТВЕРДОСПЛАВНЫХ ИНСТРУМЕНТОВ

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Abstract: *Modern machines allow to position cutting tools relative to the workpiece with an accuracy of 1 micron, but increasing of producing detail accuracy can be achieved only by an increase of sharpness of the cutting tool, which will guarantee allow to cut required metal pads of the size of 2 ... 5 microns, and will reduce the time spent on finishing operations. Existing manufacturing techniques and sharpening of cutting tools let to receive the sharpness of the blade up to 10 microns. A further increase of sharpness is only possible with the use of high-speed sharpening.*

Modern machines allow to position cutting tool relating to workpiece within the accuracy of 1 µm, but fabrication operation accuracy increase can be achieved only with increasing of sharpness of cutting tool that will guaranteed allow to cut necessary metal pad of size 2…5 µm, and also will allow to decrease time spending on finishing operations. Existing fabrication and sharpening technologies of cutting tool allow getting blade sharpness up to 10 µm. Further increasing of sharpness using existing technologies and equipment is impossible [3, 4, 5].

Existing equipment of aerospace enterprises with metal cutting tool doesn't supply stable quality and production of processing key details of aircraft engine and rockets. That's why production of engines comes to individual (selective) selection while assembling engine components. That is existing technologies, wherein cutting tool, process conditions and metal-working machinery, do not make it possible to get stable sizes and quality of work pieces surface in full. The best accuracy that enterprises can really reach in cutting edge machining is approximately 10 µm.

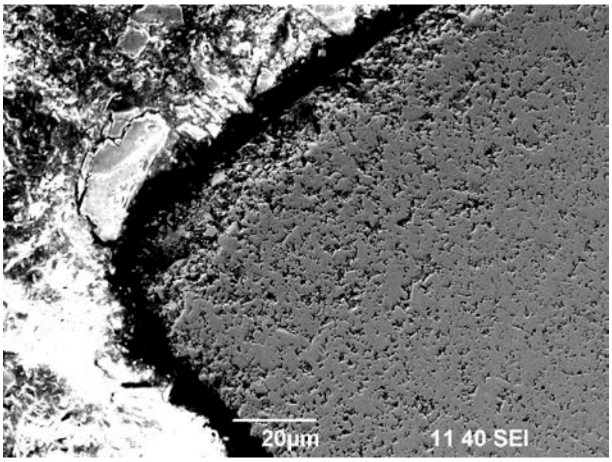
While making turbine blade disk many spark-out operations are utilized at manufacture. It is related to the fact that existing machines and software allow to position cutting tool in relation to work part with accuracy of 1 µm, however, metal cutting tool that is used for treating heat resistant alloy, has sharpness (cutting blade corner radius) of 10…15 µm. For reaching required manufacturing accuracy machine operator has to size details many times, at that, while moving cutting tool for 10 µm, it is pressed into the detail, however, there is no cutting action because of its fragility. The machine operator has to increase depth of cut and repeat the action, at that during another approach cutting edge cuts into the detail and cuts metal pad to excess that can lead to defect of the detail. Using existing metal cutting tool it's almost impossible to get required accuracy.

Of all the details of aircraft engines, building from heat-resistant alloys, 20% satisfy requirements of manufacturing accuracy, defect list is compiled for 50% of the details (at that their value decrease for 1/3) and 30% are completely discarded. Taking into account this fact, engine builds by selective method with the fittest sizes. In the most cases during engine repairing it's impossible to change worn part for a new one, because while producing the standardization is not providing. For standardization it's necessary to increase accuracy of manufacturing that will lead to increasing of details number that fit to size requirements.

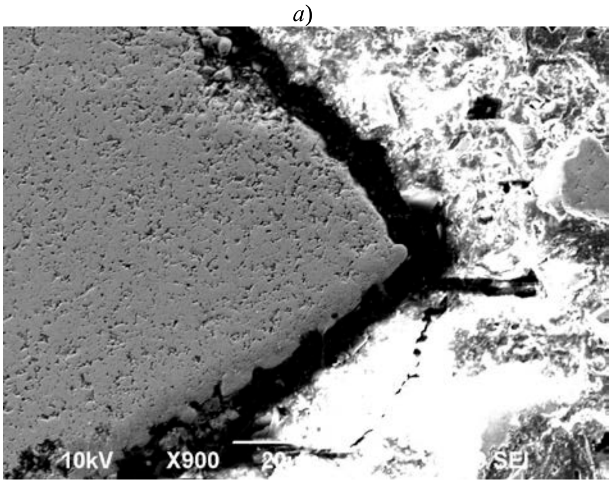
For cost savings and increasing in performance of aircraft details manufacture from heat resistant alloys, it's necessary to solve scientific and technical problem of cutting tool development with the blade corner radius less than 1 µm (super blade). This tool will let to decrease number of details with damages, decrease defective goods on account of accuracy increase and production efficiency.

Classical methods and mode of sharpening with using of finishing operations allow to get the blade with sharpness not less than 5…6 µm (illustration 1,a). Machining was at the sharpening mode of V=30…40 m/s, S=1…1,5 m/min and t=0,01 mm/ double stroke.

High speed machining was at the sharpening mode of V=260…280 m/s, S=1…1,5 m/min and t=0,01 mm/double stroke it allows to get the blade with sharpness of 1…2 µm (illustration 1,*b*).



a)



b)

Fig.1. *Blade carbide cutting tool, from:*
a) the classical sharpening with finishing operation;
b) high speed sharpness

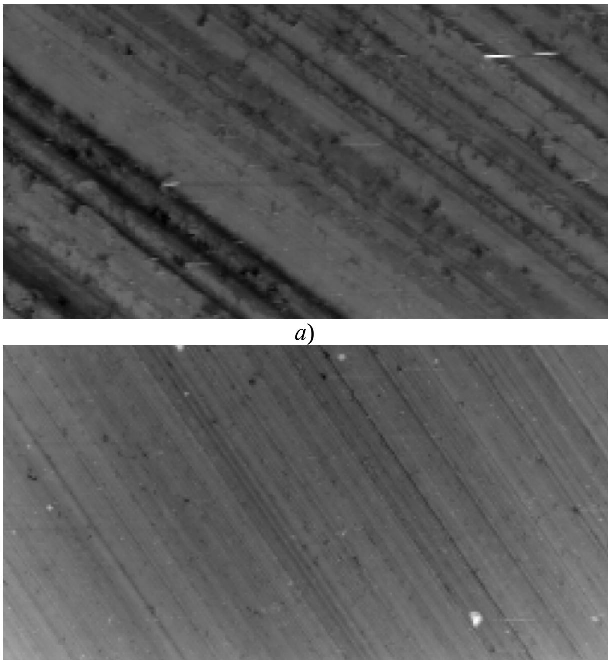
Researches were conducted on a scanning electron microscope Jeol JCM-5700. X-ray analysis is shown in Table 1. Error measurement is from 0.32 to 0.47%.

Table 1

Element	Classical sharpness	High speed sharpness
	Mass %	Mass %
C	18.77	14.84
O	2.25	-
Co	5.49	6.06
W	73.49	79.09
Total	100.00	100.0

Table 1 shows that for a classical sharpening WC content (tungsten carbide) is about 92%, and Co (cobalt) is about 5.5% and O (oxygen) is about 2.25% that confirms the formation of oxides on the surface of the cemented carbide. Changes in the chemical composition say about high temperatures and may be cutting forces while sharpening. Thus at high speed sharpening WC content (tungsten carbide) is about 94%, and Co (cobalt) is about 6%, which corresponds to the initial composition and to the GC1105 alloy condition (Sandvik Coromant). At the same time on the tested surface oxides are not observed.

Parameters of surface and quality of sharpening are shown in figure 2 and table 2.



a)

b)

Fig. 2. *The machined surface obtained:*
a) the classical sharpening with finishing operations;
b) high speed sharpening

Table 2

Parameter	Classical sharpening	High speed sharpening
The average value of the microrelief	3,496 µm	0,350 µm
The maximum value of the microrelief	5,105 µm	0,393 µm
The minimum value of the microrelief	1,910 µm	0,323 µm
Blade corner radius	8…10 µm	0,8…2 µm

Main researches in this work are related to obtaining high-quality blade carbide cutting tool that provides an opportunity of sharpening different steels used in the aviation and aerospace industries with the potential accuracy of the technological system. We considered steel 12X18H10T and alloy VT3-1.

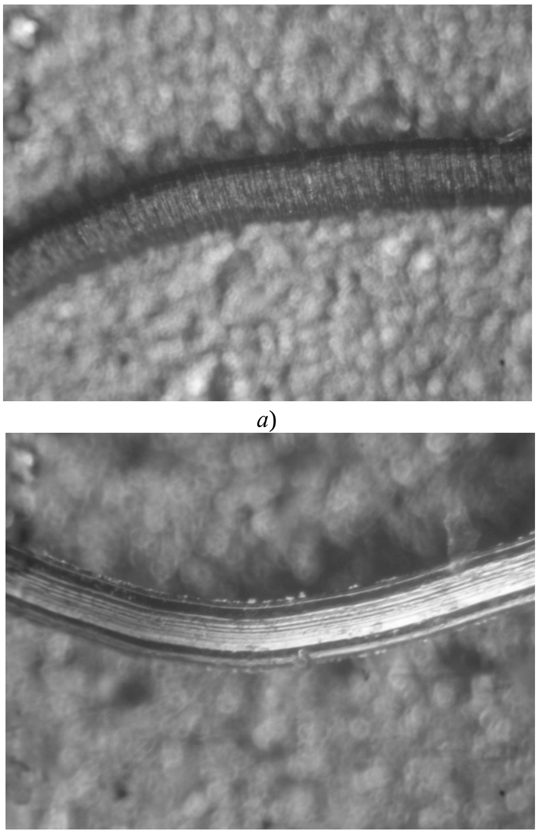
Using of carbide with a corner radius of less than 1 µm, on turning operations it is possible with cutting depth not less than 2-3 µm. To confirm this assertion, researches were conducted at the outer turning of parts: from steel 12X18H10T, HRC 41 ... 42; titanium alloy VT3-1, HRC 39 ... 40 (initial diameter D = 42,8 mm and the length L = 20 mm) on the lathe with CNC EMCO 450 Concept Turn. Turning was carried out with sharpened carbide blade CNMG 120408 alloy 1105 Sandvik Coromant (the sharpness of the blade is 0.8 ... 1 µm) at cutting speeds V = 60 and 120 m / min, feeding S = 0,05 and 0.08 mm / rev and the depth t = 3 µm.

The results of the researches:

1. Turning was provided at the cutting depth of 3 µm and control of the size of the parts was made every 10 passes, and the obtained size was monitored and compared with the required nominal. According to the obtained measurements was developed characteristic curve of resistance of carbide. The magnitude of technological wear of the plate is assumed equal to 10 µm in all cases.

2. Dependencies of resistance of cutting tools for turning steel 12X18H10T has the form: T = 0,000 • V2 - 0,338 • V + 50,6; when turning VT3-1: T = 0,000 • V2 - 0,25 • V + 37.

3. Figure 3 shows a cutting formed as a result of processing. The type and shape corresponds to the normal type of chips. The length of microcuttings is 5 ... 10 mm. Cauterizes and annealing colors are not observed one the cuttings, that indicates small value of the contact temperatures.



a)

b)

Fig. 3. *Cuttings, obtained by treating:*
a) top surface, x500; б) cutting chip surface, x500

4. The quality of the detail treated surface that is determined with the height of the irregularities is sufficiently high. The magnitude of irregularities (surface roughness) is in the range of Ra = 0,08 ... 0,12 µm. The accuracy in size is Δ = ± 0,25 µm (deviation of the actual size from the nominal size).

Working accuracy and machined surface quality is a logical and appropriate because working accuracy and surface quality is 5-8% of the depth of cut.

References

1. Yanyushkin A.S., Lobanov D.V., Kuznetsov A.M., Stlidzan M.V. Analysis of methods for determining the radius of rounding cutting // Proceedings of the Bratsk state University: Series of the Natural Sciences and engineering. V. 2. Bratsk: BrSU, 2006. P. 256-260.

2. Yanyushkin, A.S. Technology instrumental supply of products from composite non-metallic materials. / A.S. Yanyushkin, D.V. Lobanov ; Bratsk. - 2012. - 296 p.