

Reducing the number of pores in the tungsten-cobalt carbide tips of the road milling cutter in order to increase its wear resistance

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Annotation: Studies of the tip of a road milling cutter made of tungsten-cobalt alloy have been carried out. It is established that one of the factors influencing the wear resistance of the tip is the porosity of the sintered hard alloy. Laser treatment of the surface of the cutter tip was performed. It has been found that under certain laser radiation conditions, the number of pores in the cutter decreases.

KEYWORDS: WEAR, CHISEL, ROAD MILLING CUTTER, POROSITY, WEAR RESISTANCE.

Introduction

When repairing the roadway, the top layer of the asphalt surface is removed with a special technique – a road milling cutter. The milling cutter contains a drum on which the cutters are located, the number of which depends on the diameter of the drum. The cutters are positioned in such a way as to make an even cut when removing the asphalt surface. During the milling process, the drum with cutters is rotated at high speed and the asphalt layer is cut to a predetermined depth [1, 2]. In this regard, the purpose of this article is to increase the development of a technology to increase the wear resistance of a road milling cutter with a tip made of tungsten-cobalt hard alloy.

Methods and materials

The object of the study was a carbide cutter of a road milling cutter with a tungsten-cobalt carbide tip. Some of the sample tips were subjected to laser treatment of varying intensity: wavelength – 25-75 nm, power density – 20-30 Watts, spot area of the laser beam (contact) – 0.05 mm²; radiation frequency – 30 Hertz.

Wear tests were carried out on a designed installation that simulates the operation of a road milling cutter drum (Fig. 1a). The installation is equipped with a drum containing 3 cutters, positioned so that in the installation the cutters move relative to the counterbody being cut in the same way as in real conditions. That is, the cutters, making rotational movements on the drum, cut into the abrasive material (counterbody) at an angle to the normal. This arrangement of the incisors allows for an even cut, as it happens in real conditions. The tests were carried out before the incisors were sunk into the asphalt surface to a depth of 450 mm. A drum with cutters was brought to the asphalt surface using a lever system (Fig. 1b). The asphalt-concrete mixture was manufactured in accordance with GOST R 58406.2-20 (Fig. 1b). The porosity of the asphalt-concrete mixture was in the range of 1.0-2.5%. In order to speed up testing, gravel grains with an average grain size of 40 mm were used as the mineral grains of the mixture.

The wear of the cutters is controlled by the weight method, by measuring the weight of the cutters before and after the testing process. The cutter of the road milling cutter supplied by the manufacturer has a weight of 321.6 g (Wirtgen HT3/HT11). Porosity according to GOST 9391-80 was determined using a Leica DM750 microscope at a magnification of 100x.

Results and discussion

Of the 6 samples, 5 were subjected to various laser treatments. Considering the design of the test facility, each sample consisted of 3 cutters. To determine the number of pores, the concept of porosity and the research methodology according to GOST 9391-80 were used. When studying the images of micrographs with an increase of x100, it was found that the porosity decreased (Fig. 2). The range of porosity values of the samples is shown in Table 1.



Fig. 1. Installation for testing the wear of road milling cutters:

- a) – general view;
- b) – the cutter on the drum;
- c) – samples of asphalt pavement

It should be noted that comparing porosity according to GOST 9391-80 is a difficult task for samples with similar visualization of pores on the slot. The surface of the carbide cutter tip of a road milling cutter made of tungsten-cobalt alloy was subjected to low-intensity laser treatment in order to selectively excite molecules and reduce the number of pores. The ability to focus laser radiation allows you to inject energy into a specific area of the volume. The monochromacity of laser radiation makes it

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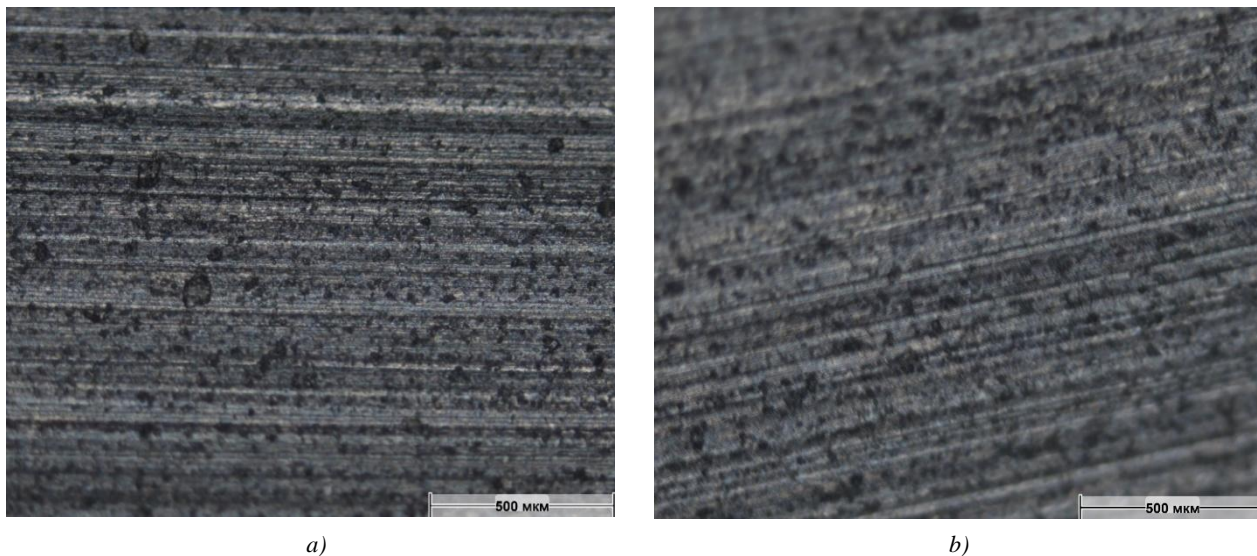


Fig. 2. The surface of the tip of the cutter x100:
a) basic; b) laser-treated

Table 1 – Range of porosity values of the samples

	Scale according to GOST 9391-80 (RU)				
	A	B	C	D	E
Basic samples	0,2-0,8	0,4	0,4-0,8	0,1-0,8	3
Laser-treated samples	0,08	0,02-0,2	0-0,1	0-0,1	2-3

Table 2 – Laser treatment modes and porosity of samples

Sample, No	wavelength, nm	power, Watts	contact spot area, mm ²	frequency of radiation, Hertz	porosity (by conductivity)
1	untreated cutter, initial condition				A 0,4
2	50	20	0,05	30	A 0,2
3	50	25	0,05	30	A 0,04
4	50	30	0,05	30	A 0,2
5	25	25	0,05	30	A 0,4
6	75	25	0,05	30	A 0,4

When compared, areas with low conductivity that are darker are clearly visible. At the same time, in Fig. 3a, crystallites are clearly visible, which are not visible in Fig. 3b. The difference in conductivity of the sites is due to the different conductivity of different carbides and the binder element. The completely black areas have zero conductivity and are most likely pores between the crystallites obtained by sintering a hard alloy.

So, sample No. 1, which was not treated with a laser, had a porosity of A 0.4. Next, the laser power was changed, with the remaining unchanged parameters, at which: at a power of 20 Watts (sample No. 2), the porosity decreased to A0.2; at a power of 25 Watts (sample No. 3) – A0.04; at a power of 30 Watts (sample No. 4) – A0.2. It was found that at a power value of 25 Watts (sample No.

3), the lowest porosity is achieved. Further, at this power value, the wavelength varied: at a wavelength of 25 nm. (Sample No. 5) the porosity was A0.4, at a wavelength of 75 nm. (sample No. 6) – A0.4. Since the change in wavelength did not lead to a change in porosity compared to sample No. 1, which was not subjected to laser treatment, rational laser treatment modes were established to reduce the porosity of the carbide cutter of the road milling cutter made of tungsten-cobalt alloy. Thus, samples No. 1 and No. 3 were tested for wear (Table 2). The test results are summarized in one table. 3. The table shows that for the production of an asphalt layer 450 mm deep, cutters No. 1 were worn out by an average of 18.2 grams, cutters No. 3 – 9.2 grams.

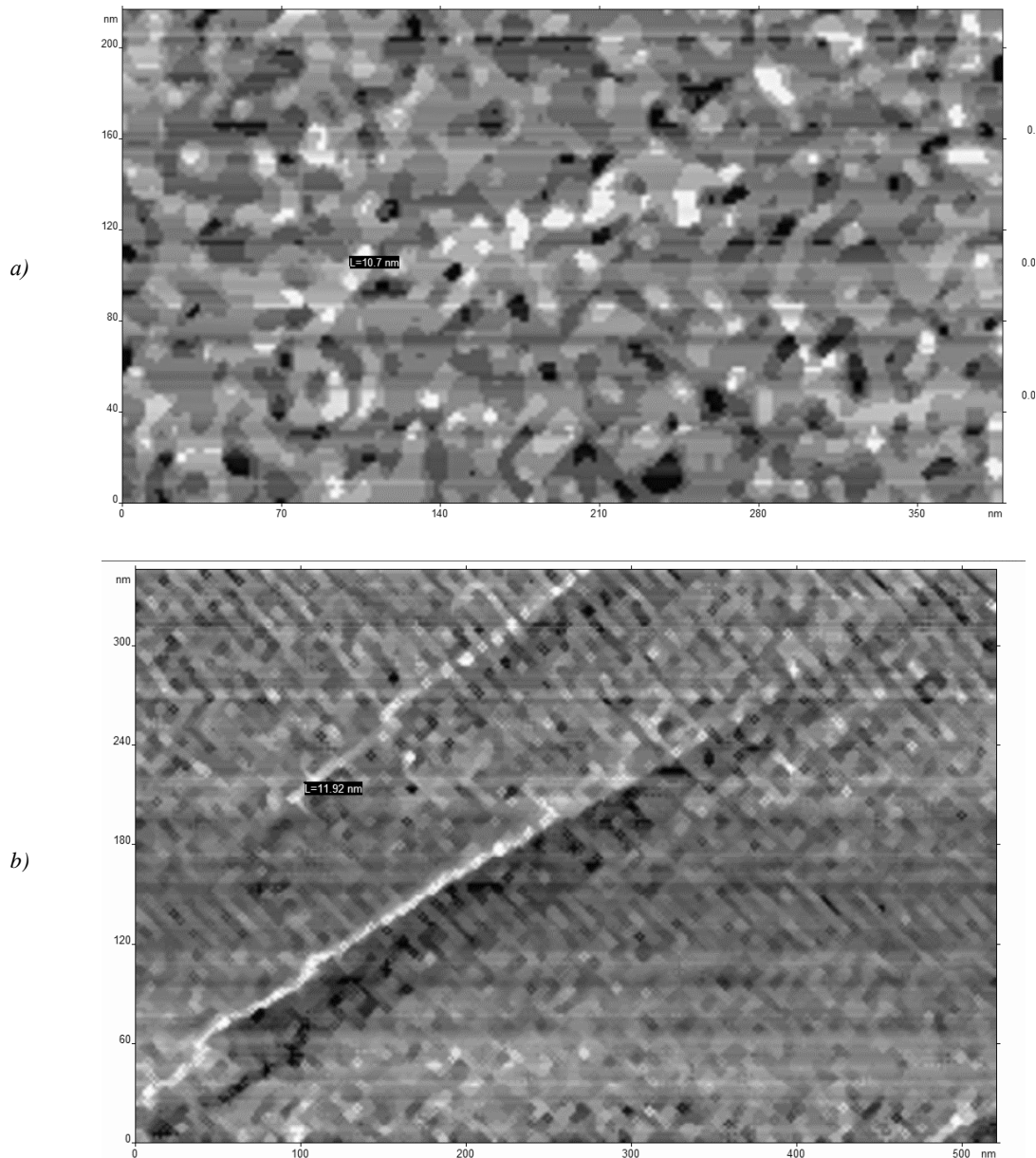


Fig. 3. Study of the conductivity of the site:
a) – sample No. 1 (Table. 2); b) – sample No. 3 (Table 2)
Table 3 – Test results for the wear of the cutters of the road milling cutter

Sample, No	Asphalt production by depth, mm	Weight after wear tests, mg			
		cutter 1	cutter 2	cutter 3	average for 3 incisors
1	450	303,3	303,6	303,3	303,4
2		306,6	306,6	306,7	306,63
3		312,5	312,4	312,3	312,4
4		306,7	306,6	306,7	306,66
5		303,3	303,5	303,4	303,4
6		303,6	303,5	303,4	303,5

According to the average values, the lowest mass loss is observed in sample No. 3. Samples No. 1 and No. 5 have the greatest mass loss, on average, therefore, the selected laser treatment mode for sample No. 5 does not lead to a decrease in cutter wear.

The main parameters of the tool's operation during the destruction of asphalt concrete are: P is the depth of loosening, V is the speed of relative movement of the cutter, t is the processing time, S is the area of asphalt concrete removed. A characteristic

feature of the asphalt concrete destruction process is the frequency of operation of the milling cutters, the variable area of the layer to be removed with one cutter, as well as the variable number of cutters simultaneously in operation, which causes a variable value of forces, moments and power required for processing. Therefore, the dependences for loosening and removing asphalt pavements were derived for one cutter based on the average values of forces, moments and power. The total length of the path of one cutter traveled in asphalt concrete is determined from the expression:

$$L_{cut} = Lnt,$$

where L is the length of the cutter path traveled in one revolution of the milling cutter drum from point a to point b

$$L = R\alpha_{cut},$$

where α_{cut} is the angle formed between the extreme points a and b , where contact with asphalt concrete occurs; n is the rotation frequency of the milling cutter drum; t is the processing time of the asphalt concrete layer.

Then, turning to the area S of the produced coating, the total length of the cutter path is determined:

$$L_{cut} = \frac{S}{6} \arccos\left(1 - \frac{P}{R}\right),$$

where P is the depth of the cutter; R is the radius of the milling cutter drum.

The pressure of the wear medium during the interaction of the working body of the road milling cutter with the abrasive material is expressed by the feed rate (S) during loosening. Which in turn is reflected in the volume of asphalt concrete removed.:

$$S_{max} = S \sin \gamma,$$

where S is the feed; γ is the contact angle.

The calculated values of the wear intensity are shown in Fig. 4.

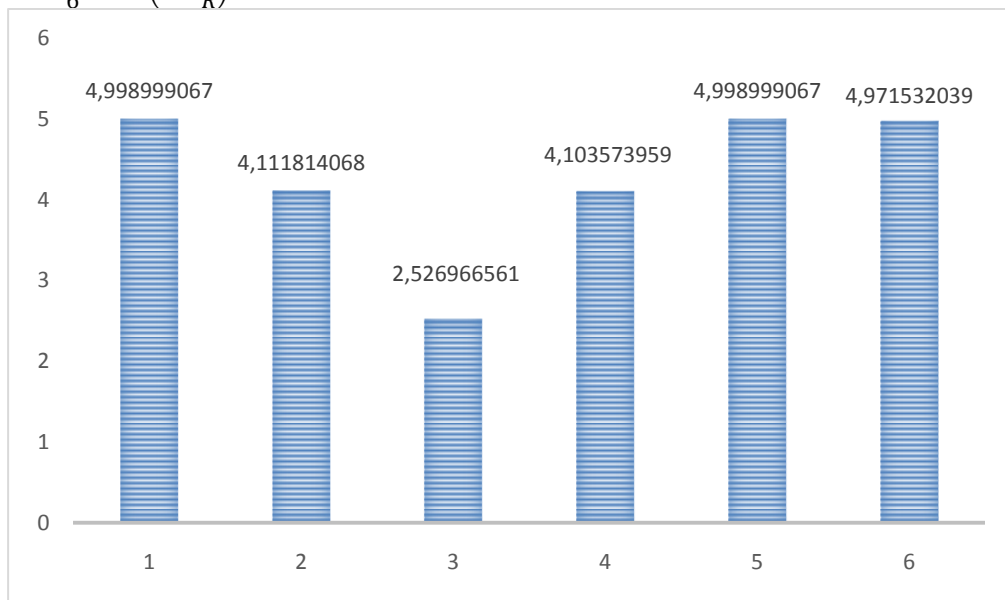


Fig. 4. Wear intensity x10⁻⁴ samples according to Table 3

Conclusion

When studying the material structure of the carbide cutter of a road milling cutter, the surface porosity was determined. The number of black spots on the laser-treated sample is significantly lower. Thus, laser treatment of a hard alloy reduces the number of pores. Wear tests have shown that the laser-treated samples have lower porosity due to the production of a 450 mm deep asphalt layer. They were worn out by an average of 9.2 grams, incisors, without additional processing – 18.2 grams.

References

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