Receiving Wear-Resistance Coverings Additives of Nanoparticles of Refractory Metals at a Laser Cladding

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Abstract. Laser cladding technology was used to conduct experiments on production of wear-resistant coatings with additive nanoparticles of refractory metals (WC, TaC). Mechanical testing of coating abrasion was made using Brinell-Howarth method. The obtained data was compared with wear-resistance of commercial powder containing WC. It was found that at a concentration 10-15% coating with nanopowder additives shows a dramatic increase in wear-resistance by 4-6 times as compared to carbon steel substrate. There were conducted metallurgical studies of coatings on inverse electron reflection. There was determined elemental composition of deposited coating and substrate, and microhardness measured. It was found that structure of deposited coating with nanoparticles is fine.

1. Introduction

Laser cladding is widely used in production of protective coatings in various industries: chemical, mining, oil and gas, and others [1]. Durability is an important parameter of protective coatings that operate under abrasive wear. There are studies on laser cladding of wear-resistant coatings with tungsten carbide additives (grain size - 100 microns) [2-4]. The main problems of these coatings are cracks and pores in the body of cladding. One of the ways to solve the problem of cracking is substrate preheating [5, 6].

In recent years interest to nanoparticle additives as a mean to improve mechanical and tribological properties of coatings began to grow. In a number of references smaller grain size was marked in the structure of coating [7, 8]. Nanoparticles prevent the spread of defects in coating, thereby improving its quality. Besides the advantages, nanopowders still have some disadvantages, in particular, there is no possibility to feed nanopowder directly to weld deposition zone since there is no special feeding device. A solution to this problem is a preliminary substrate covering with powder and subsequent laser radiation processing.

This study describes the work on the production of wear-resistant coatings with different concentrations of TaC and WC nanoparticle additives, and tests made using Brinell Howarth method. The results obtained were compared with results of tests of commercial powders Ni + 60% WC. Previously, there were obtained investigation results on reflection of inverse electrons of coating and substrate, defined mixing zone and measured micro-hardness of coatings and nano-powders without additives [9]. It was found that coating microstructure is fine-grained, and flaw-free [10].

2. Experimental setup

Experimental work was carried out using a universal laser system consisting of the following elements:

1. Robotic arm of ABB production;
2. Fiber laser of NTO "IRE-Polus" production;
3. Scanning system with processing field150x150 mm;
4. SULZER powder feeder.

Microhardness measurements were performed using Vickers method. The load during the measuring process was 100 g, the exposure time - 10 seconds. Abrasion testing was carried out using Brinell-Howarth method. The test procedure is as shown on figure 1: a rotating rubber disk 3 is pressed against the sample 2 and abrasive (river sand) pours through the feed magazine 1. The load is 15N, exposure time is10 minutes.

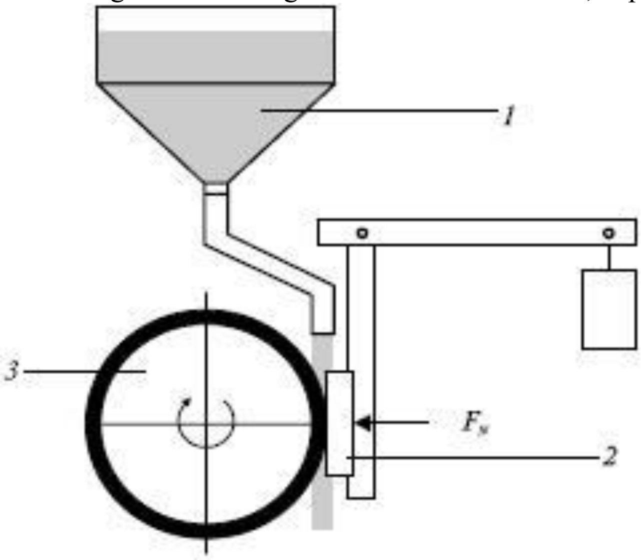

Figure 1. Overall schematic of wear testing according to Brinell-Howarth method

3. Technique of the experiment

The experiments were carried out with different types of HOGANAS powders: 1535-40, 1360. As a powder of tungsten carbide powder TP40/40 by TECHNOGENIA production was chosen. Carbon steel AISI C1030 was chosen as a substrate. Chemical composition of the substrate and HOGANAS powders is shown in Table 1.

Table 1. Chemical composition of powders 1360 and 1535-40 by HOGANAS production, and substrate.

	Ni	C	Fe	Cr	B	Si
Powder 1360	base	0.45	2.9	11.0	2.3	3.6
Powder 1535-40	base	0.03	0.14	-	2.75	2.86
Substrate AISI C1030	0.25	0.22	98	0.15	-	0.041

Mixtures of powders with different concentrations (5, 10, 15, 20% respectively) of TaC and WC nanopowders with conventional HOGANAS powders have been preliminary placed on steel substrates measured 70x15x10 mm. The layer thickness was about 1 mm.

Pre-process parameters were selected for laser cladding of nanopowders mixture and ordinary powders. Laser power was 1.5 kW, processing speed - 10 mm / sec, blooming - 20 mm, overlap factor - 35-40%. The main criterion in the selection of process parameters were as follows:

$$H \approx \frac{1}{4}L \tag{1}$$

where H is roller height, L is roller width as shown in Figure 1.

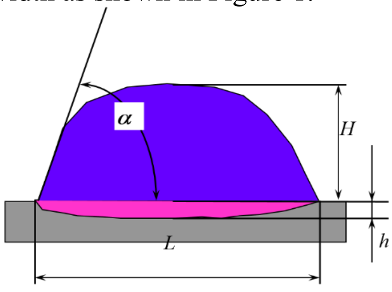

Figure 2. General view of roller and its basic geometrical parameters.

During the selection of process parameters the following values were changed:

- Radiation power;
- Linear speed;
- Size of laser radiation spot on surface of built-up sample;
- Overlap degree %.

4. Results and discussion

Samples with abrasion resistant coating containing nanoparticles of tungsten carbides and tantalum were obtained. Abrasive material for the test was river sand, which was pre-screened. Also, wear-resistance ratio was calculated. Figure 3 shows the results of wear measurement of coating with nanoparticles WC and TaC, as well as wear resistance of AISI C1030 steel substrate and ordinary commercial powder TP40/40 produced by TECHNOGENIA.

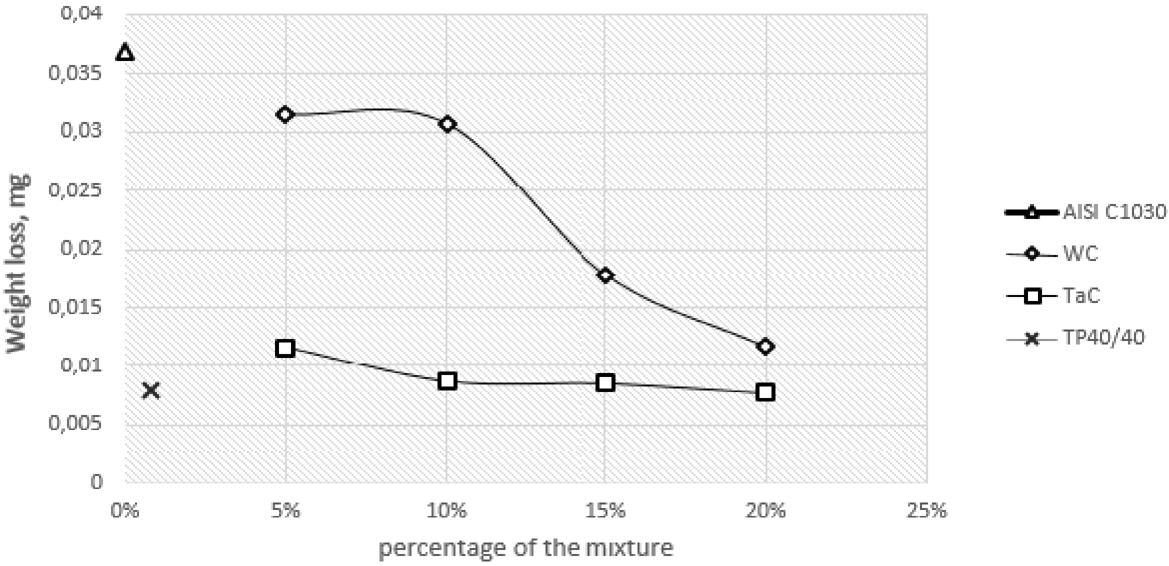

Figure 3. Measurement of wear-resistance of powders with nano-WC and nano-TaC and powder TP40/40.

As one can see on figure 3, wear of coating with nano-WC additives is lower than of TECHNOGENIA commercial powder. This may be due to the fact that during the overlaying of coating with nanoparticles, tungsten carbide begins to decompose into secondary phases, which do not increase wear resistance of the coating. Coatings with tantalum carbide nanoparticles, at 10% concentration of carbides, possess the same wear as coating with TP40/40 powder. This can be explained by the fact that during the process of cladding tantalum carbide hardfacing remains unchanged and do not break up because the melting point of TaC particles is ≈3800 °C. In future, other process parameters will be selected to obtain stable carbide phases of tungsten, which will improve wear resistance of coating.

It was observed that coating with nanoparticles of tungsten and tantalum carbides has no defects such as cracks or porosity, in contrast to coatings produced by cladding with powder TP40/40. This may be due to the fact that nanoparticles prevent propagation of defect in coating. Nanoparticles of tungsten and tantalum carbides are evenly distributed throughout the microstructure of the coating that has been defined earlier in the work [10].

5. Conclusion

This article describes an experiment on laser surface coating using nickel based powders with different concentrations of nanoparticles of tungsten and tantalum carbide as additives. There were selected technological parameters for laser surface coating: P - laser radiation power, v - processing speed and f - blooming. Power density in this experiment was 0.68-0.98 MW / cm2.

Comparative endurance tests were conducted with the same parameters for coatings containing nano-WC and nano-TaC. It was found that coatings, which contain particles of TaC, were highly durable, unlike coatings with nano-WC. This is because tantalum carbide has a high melting point of 3800 °C, while the tungsten carbide has a melting point of about 2800 °C. Thus, tungsten carbide during surface coating breaks into either tungsten and carbon, or into secondary W2C carbides. Wear resistance of coating with TaC additives increases

4 times as compared with the coating without a nanopowder additive. This is a marked influence on the wear resistance of nano-powder coating. There were conducted wear tests of coatings with conventional powders TP40/40 by TECHOGENIA production, the results were compared with test results of nanopowders. It was found that wear resistance of coatings with nano-WC is worse than of coatings with powder TP40/40, while wear of coating with nano TaC is on a level with these powders. The concentration of the tantalum carbide is 10%, while the concentration of tungsten carbides in TP40/40 is 40%.

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