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WEAR-RESISTANCE STUDY OF NANO-MODIFIED COATINGS BY TIG SURFACING PROCESS

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Abstract: *A series of cored wires for TIG (tungsten inert gas) surfacing have been designed and elaborated, which contain various content types of nano-modifiers in various percentage content. Nano-modified coatings were deposited through weld overlay on samples of construction steel. The investigation reveals the influence of various nano-modifiers on the wear-resistance of weld overlay coatings.*

Keywords: *wear resistance, nano-materials, TIG welding, surfacing, cored wire.*

1. INTRODUCTION

Amid the global economic crisis, the necessity for a more efficient use of materials is particularly relevant. In response, the authors are searching for new applications of the latest scientific achievements. One of the directions, in which some researchers focus their efforts, is the application of nanotechnologies to obtain metals and alloys with improved performance characteristics.

The addition of small amounts of highly heat-resistant nanopowders to traditional metals and alloys reveals opportunities to improve their performance and expands their area of application.

The materials thus obtained are known as metal matrix nano-composites (MMNCs) [1]. A number of studies deal with the effect of titanium-containing nanopowders on the characteristics of the metal after weld overlay. In most cases, the materials used are titanium carbonitride [2], and silicon carbide [3]. It is found that the increased amount of titanium-containing inclusions changes the microstructure of the metal and its mechanical properties (hardness, wear resistance) are improved. Good results are obtained when nano-modifier additives are introduces during the processes of casting [4], or welding [5-7]. The improved properties, such as increased hardness and considerable strength, are probably due to the finer grain structure and the redistribution of internal stresses in result of the addition of nano-modifiers. For this purpose, the nano-powders usually used have size of several tens of nanometers [8]. The mechanical properties of the weld overlay metal coating are maximally improved at medium concentration levels of nano-modifiers [9-13].

2. TECHNOLOGY FOR MANUFACTURE OF NANO-MODIFIED CORED WIRES FOR TIG WELD OVERLAY

Two types of nano-modified cored wires for TIG welding are developed made of steel tubes with dimensions Ø2.5 mm and length 400 mm, which are filled with powder mixture. The filling of the first group of wires has soft matrix of iron powder modified with nano-sized powders of TiN, SiC, and TiCN. The second group has pre-stressed matrix of powdered Astalloy (Fe + 3 % Cr + 0.5 % Mo) and nano-sized powder of Al_2O_3 added in different percentage.

For better moistening and assimilation, the nano-sized powders used were activated in a vibratory mill.

The tubes were cut to the required size and degreased. The weight of each tube was measured using analytical balance "Metler" with accuracy to ten-thousandths of gram, both prior to and after filling with the powder mixture. The tubes were filled through vibration upon the scheme shown in Figure 1. The ready cored wires were labelled for identification (Fig. 2).

Figure 1. Vibration filling of cored wires

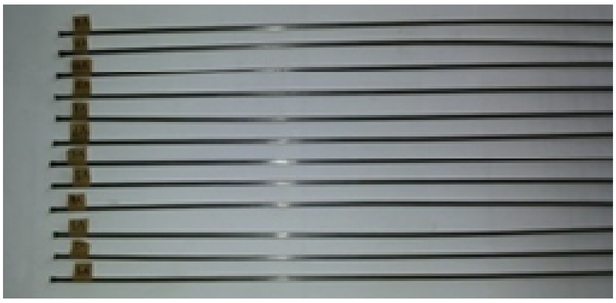

Figure 2. Ready cored wires

Table 1 shows the content of the two groups of cored wires used for weld overlay of test sample plates.

Table 1. Content of cored wires

Group	No	Content of the cored wire
I	1	Fe
	2	Fe + 1.5 % TiN
	3	Fe + 1.5 % SiC
	4	Fe + 1.5 % TiCN
II	5	1 % Al_2O_3 + Astalloy
	6	2 % Al_2O_3 + Astalloy
	8	3 % Al_2O_3 + Astalloy

3. WELD OVERLAY OF TEST SAMPLES

The weld overlay coating was deposited using inverter welding machine Stel 161N with welding current 80A.

The welds are longitudinal and each weld overlaps two thirds of the previous one. The welding speed is 3.6 m/h and each stroke is paused for about 10 s before welding the next one. The weld overlay coating is deposited in three layers. Prior to deposition of each layer, the surface is cleaned with wire brush.

The sample plates for weld overlay are made of steel 235 JR with dimensions 125 × 60 × 4 mm (Fig. 3). The surface of the plates is cleaned by grinding.

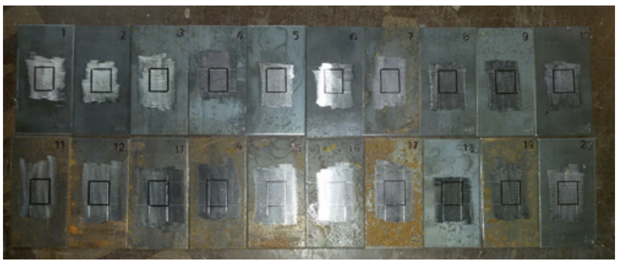

Figure 3. Plates prepared for weld overlay of coatings

4. TESTING OF WELD OVERLAY COATINGS FOR WEAR RESISTANCE

The coatings deposited through weld overlay are tested and assessed for wear resistance using the own original methodology of the authors [14,15]. It consists in measuring of the mass wear of samples during a number of abrasive wear cycles and calculation of the intensity of wear and the wear resistance for the travelled path of abrasion. The comparison upon the parameter wear resistance is carried out at constant testing conditions.

The methodology of testing for wear resistance is based on measurement of the total loss of mass of the tested sample under precisely fixed parameters of abrasion: normal loading, speed of sliding, contact surface, friction path, type, size and hardness of abrasive particles. The measured mass wear is the base for estimation of the characteristics of wear, i.e. speed of mass wear, intensity of mass wear, and wear resistance.

The test samples are square plates with a side of 15 mm. The samples are cut through water-jet cutting to avoid the effect of heating. The methodology is realized through tribotester [16].

In Figure 4 is shown graphically the dependence of the wear on the number of cycles of abrasion and the mass wear of coatings deposited through TIG weld overlay using with nano-modified cored wire of the group I (Table 1).

The diagram in Figure 5 illustrates the wear resistance of weld overlay coatings.

It is obvious that the results obtained using cored wires from the group I are very close to each other, as the best wear resistance is achieved in coatings deposited using cored wires containing Fe + 1.5 % SiC. Here the addition of nano-sized powders has only a slight effect on the wear resistance.

In Figure 6 is shown graphically the relation between the number of cycles of abrasion and the wear of coatings deposited through weld overlay with cored wires from group II, and Figure 7 displays graphically the wear resistance of those coatings.

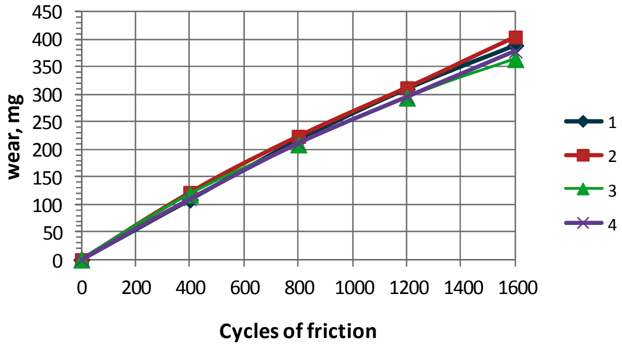

Figure 4. Dependence of the wear on the number of abrasion cycles of coatings deposited using cored wire of the group I

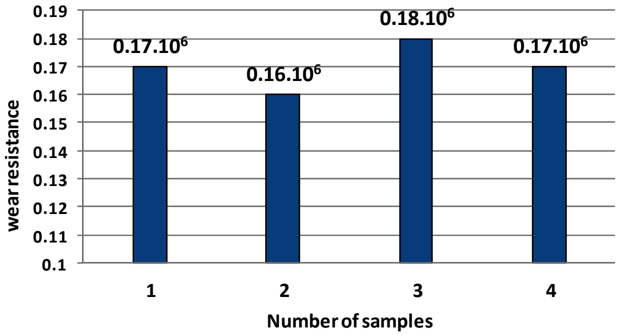

Figure 5. Wear resistance of coatings deposited using cored wire of the group I

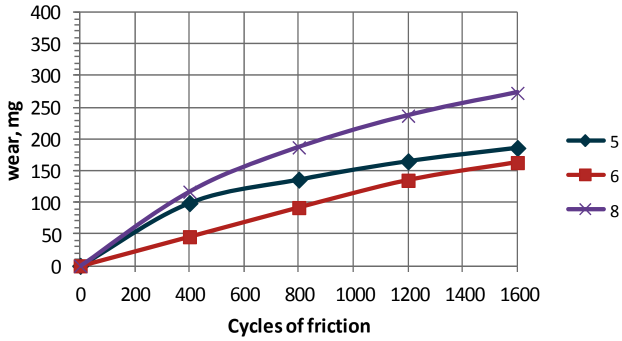

Figure 6. Dependence of the wear on the number of cycles of abrasion for coatings deposited using cored wires of the group II

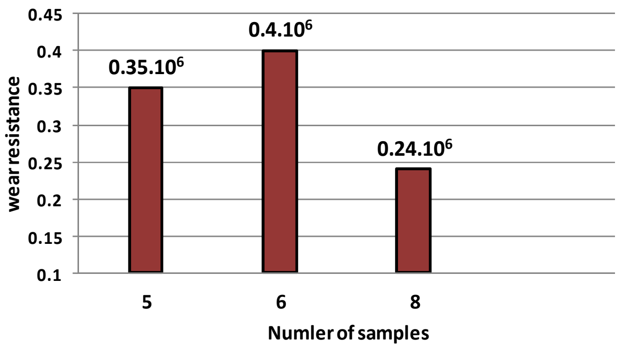

Figure 7. Wear resistance of coatings deposited using cored wires of the group II

Obviously, the best wear resistance is achieved in the coating deposited using cored wire with Astalloy matrix and nano-modifier of 2 % Al_2O_3.

5. DISCUSSION

1. Developed is an innovative technology for manufacture of nano-modified cored wires for TIG welding.
2. The addition of nano-sized powders to “soft” matrix of carbonyl iron has an insignificant effect on the wear resistance of coatings deposited through weld overlay.
3. The coatings deposited through cored wire weld overlay with “pre-stressed” matrix of Astalloy display considerable change of wear resistance depending on the quantity of nano-modifier added.

6. CONCLUSIONS

The experiments for manufacture of cored wires modified with nano-powders and the testing of coatings deposited through TIG weld overlay for wear resistance prove that the most promising results are achieved when using “pre-stressed” matrices, i.e. such with higher initial hardness, that are considerably influenced by the added nano-modifiers.

The highest wear resistance is achieved in the coating deposited through weld overlay using cored wire with Asalloy matrix and 2 % Al_2O_3 as nano-modifier.

The obtained results are a good basis for further research on selection of new combinations of pre-stressed matrices and nano-modifiers.

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