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SCANNING ELECTRON MICROSCOPE EXAMINATION OF LAYERS WELD OVERLAID WITH NANO MODIFIED ELECTRODES

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Key words: *electrodes, manual arc weld overlay, nano modifiers, overlaid metal, scanning electron microscope, micro structure*

Abstract*: Developed are electrodes nano modified with chromium coated titanium nitride (TiN + Cr) intended for manual arc weld overlay of wear resistant layers based on electrode grade E300 and their hardness, micro hardness and wear resistance are assessed. The nano modified weld overlaid layers are examined using scanning electron microscope with X-ray micro analyzer. The data obtained is analyzed.*

1. Introduction

Against the background of tendencies for depletion of the natural resources, the necessity for introduction of metals and alloys with improved operating properties in different industrial sectors increases. Such sectors include energy, extraction of ores and other minerals, defense industry, construction, transport, etc. where assemblies and parts with higher hardness and wear resistance are required. This issue can be resolved by either creating new assemblies and parts with higher hardness and wear resistance, or restoring the worn out ones. Both ways often employ arc weld overlay of surfaces that are required to have higher hardness and wear resistance.

The relationship between the addition of nano modifiers and improving the mechanical characteristics is proved in a number of publications. In most cases the additions used are titanium dioxide, titanium carbonotride [1], silicon carbide [2]. It is found that the higher quantities of titanium-containing inclusions change the microstructure and improve the mechanical properties of the metal [3, 4]. The impact of titanium [5] on the properties of the overlaid metal at different content of manganese is also studied. It is found that the strength of the overlaid metal is increased due to the finer microstructure [5-8]. The structural changes within the overlaid metal may result in occurrence of single or group discontinuities with notional size 0.26 - 0.44 mm that are successfully registered and characterized by means of ultrasound method [9, 10]. The subject of the current report is the scanning electron microscope examination of layers weld overlaid with nano modified electrodes.

2. Background

Based on electrode grade IZA-E300, developed are electrodes for manual arc weld overlay. The electrodes are nano modified with chromium coated titanium nitride (TiN+Cr). A trial series of coated electrodes for weld overlay [11] with dimensions Ø3.25/450 mm are manufactured. Trial samples of steel S235JR shaped as straps with dimensions 250x50x5 mm are weld overlaid in order to assess the technologic properties of the electrodes, such as arc burning, quality of slag, spraying during welding, etc. In Fig. 1 is shown the appearance of the weld overlaid samples. The reference Sample 1 is overlaid with basic electrode grade IZA-300 and Sample 2 is overlaid with (TiN+Cr) nano modified electrode for arc weld overlay. Visual inspection of samples was carried out to examine the general appearance and characteristics of the weld overlaid samples. No defects are observed on the weld overlaid surfaces. The inspected sections are photographed.

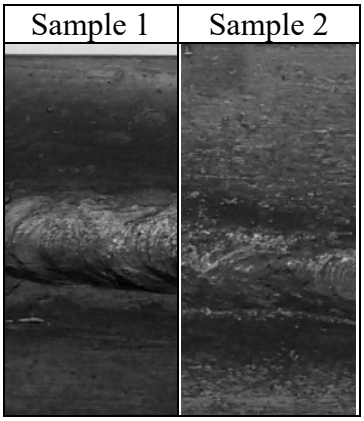


Fig. 1. General appearance of the weld overlaid samples

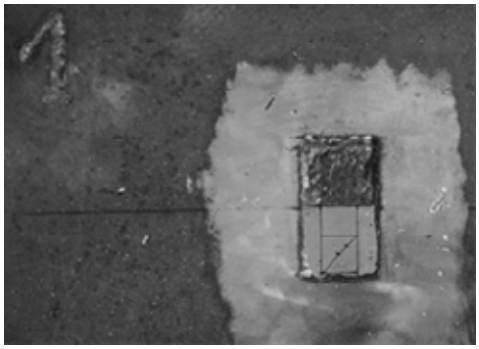


Fig. 2. Weld overlaid and polished sample

The microstructure of the overlaid first layer of Sample 2 exhibits cells with bainite and martensite structure restricted by structurally free ferrite, which proves that the modification with chromium coated titanium nitride (TiN+Cr) results in considerable grain refinement of the structure. That structural modification significantly influences the increase of hardness and wear resistance of the weld overlaid facing, which is nano modified with (TiN+Cr) [13]. After the overlay one half of the overlaid metal (OM) facing is polished, as is shown in Fig. 2.

The hardness measurements are performed by Vickers HV15/15. After ignoring the extreme deviations, the average measured values of the hardness achieved are shown in Table 1. The relative increase of hardness in regard to the reference Sample 1 is estimated [14].

Table 1. Hardness of (HV15/15)

Sample	Nano modifier	Average value of hardness $HV_{15/15}$	%
1	Reference electrode	412.1	0
2	TiN+Cr (chromium coated)	644.9	56

The increase of the average value of hardness HV15/15 is illustrated in Fig. 3.

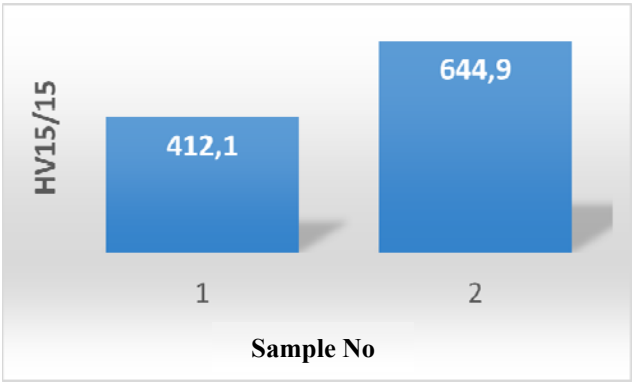


Fig. 3. Vickers hardness HV15/15 of OM

Observed is 56% increase of the hardness of the sample overlaid with nano modified electrode in regard to the reference sample. The micro hardness $HV_{0.025}$ is measured using micro hardness tester TMVS-1 with load P=0.025kg and time of loading 10 s [14]. The measurement is performed on micro slices taken from the cross section of the overlaid sample in direction from the surface of the overlaid metal to the parent metal (PM). The measurement cease upon reaching the micro hardness of the parent metal. The results from measurement of micro hardness of Samples 1 and 2 in depth are shown in Fig. 4 and Fig. 5 respectively.

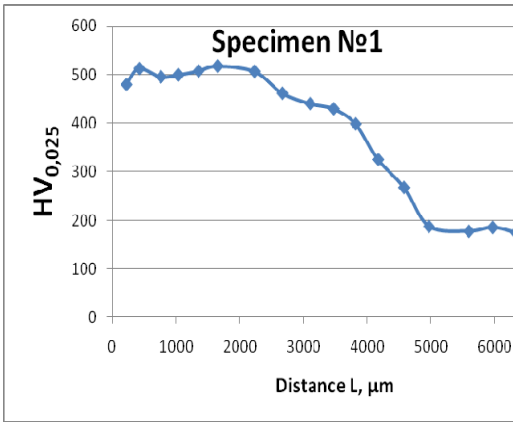


Fig. 4. Micro hardness of Sample 1 [14].

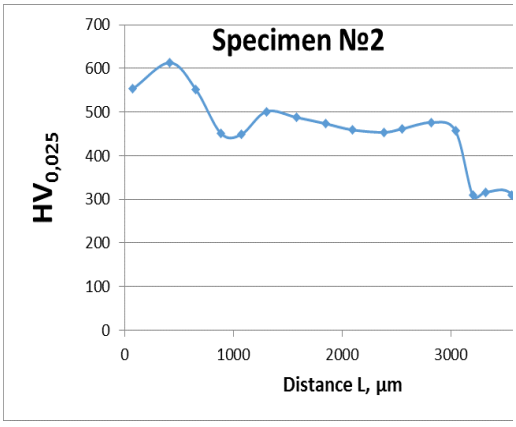


Fig. 5. Micro hardness of Sample 2 [14].

The maximum value of micro hardness measured for Sample 2 is 19% higher than that of the reference Sample 1.

The wear resistance of the facing is assessed using the method described in [14]. The results from the testing for wear resistance are shown in Table 2.

Table 2. Results from the testing for wear resistance

Characteristics	Sample 1	Sample 2
Wear m, mg	110.5	64.4
Rate of wear γ ,mg/min	38.4	22.4
Intensity of wear i_h	$2.3.10^{-6}$	$1.3.10^{-6}$
Wear resistance I_h	**$0.44.10^{6}$**	**$0.75.10^{6}$**

The results for wear resistance of samples overlaid with and without nano modification is shown in Fig. 6.

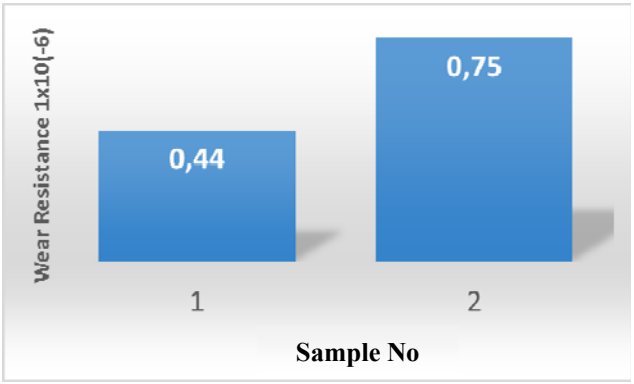


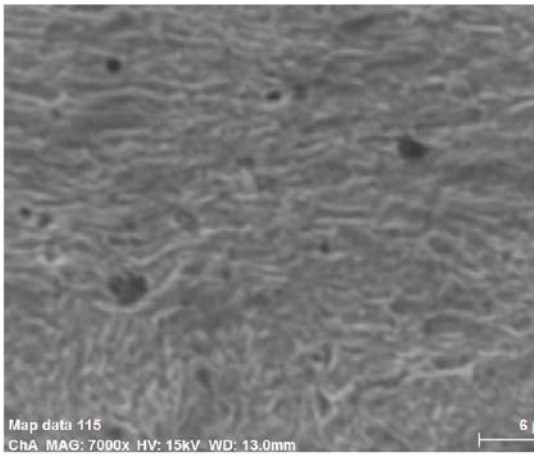
Fig. 6 Wear resistance of overlaid metal using: 1 - reference electrode (Sample 1); 2 - (TiN+Cr) nano modified electrode (Sample 2).

The facing of Sample 2 overlaid using nano modified electrode (with chromium coated titanium nitride used as nano modifier) shows wear resistance 70% higher than that of the reference sample.

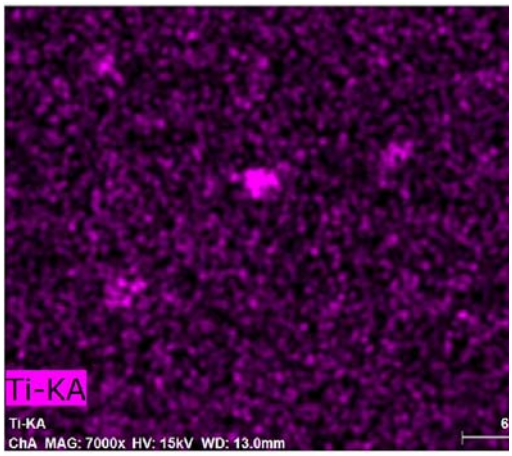
3. Results

The test specimens are examined using scanning electron microscope (SEM) with wavelength dispersive /energy dispersive X-Ray analyzer (WDS/EDS) on a JEOL - JCXA 733.

The overlaid samples are cut to pieces containing the sections of interest for observation. Metallographic specimens are cut from the overlaid surface and prepared following the standard procedure: grinding, polishing, etching, cleaning with alcohol and drying. The observation with electron microscope and microanalyzer (EMMA) does not demand any additional preparation of the slices and is carried out under standard operation conditions of the equipment. The observation is carried out in secondary electron mode. The observed areas are also subjected to X-Ray micro analysis. During the observation of the metallographic slice of Sample 2 with SEM and EDS is found that the weld beam contains particles with presence of Ti. (Fig. 7).



Sample 2, x7000, SEM



Sample 2 x7000, Distribution of Ti Ka X-Ray emission across the observed surface

Fig. 7. Sample 2, results from SEM and EPXMA

4. Conclusions

An innovative technology is worked out for manufacture of nano modified electrodes coated with chromium coated titanium nitride (TiN+C) and intended for manual arc weld overlay of wear resistant surfaces. After weld overlay of samples using electrodes with

(TiN+C) nano modified coating, the surface hardness of the samples is increased with 56% and the micro hardness is preserved to the maximum extent. The wear resistance of the nano modified facing is 70% higher than that of the reference specimen. During the observations of the metallographic slice of Sample 2 with EMMA is found that the weld beam contains particles with presence of Ti.

References

[1] Jin-Ju Park, Sung-Mo Hong, "Microstructure and properties of SA106B carbon steel after treatment of the melt with nano-sized TiC particles" Materials Science& Engineering A 613 (2014) 217-223

[2] Черепанов А.Н. и др. „О применении нанопорошков тугоплавких соединений при сварке и обработке металлов и сплавов", Тяжелое машиностроение. №4/2. 2008.С.25-26

[3] Z.Zhang, D.L.Chen "Consideration of Orowan strengthening effect in particulate-reinforced metal matrix nanocomposites:A model for predicting their yield strength"

ScriptaMaterialia 54 (2006) 1321-1326

[4] Yong Yang, JieLan, Xiaochun Li "Study on bulk aluminum matixnano-composite fabricated by ultrasonic dispersion of nano-sized SiC particles in molten aluminum alloy

Materials Science and Engineering A 380 (2004) 378-383

[5] Трошков А.С. „Модифицирование структуры наплавленного металла нанодисперсными карбидами вольфрама", Ползуновский альманах №2 2009

[6] Дроздов, В. О., А. Г. Маликов и др. Зкспериментално исследование лазерной сварки металлов с применением нанопорошковых добавок. Докл. V Всеросийской конференций „Взаимодействивие высококонцентрированных потоков знергии с материалами в перспективных технологиях и медицине". Новосибисирск, 26-29 марта, 2013, с. 97-101..

[7] Ташев П., Т.Петров, Я. Лукарски, Г.Стефанов „Технологии за внасяне на наноразмерни частици в заваръчния шев при процеси на наваряване", Инженерни науки, год.L, 2013, № 3, списание на отделение „Инженерни науки" към Българска Академия на Науките, стр. 82-93

[8] Karaguiozova Zdravka, Manolov Valentin and Tarasov Michael, Elektroless iron coating on nanosized particles, BULTRIB'11 - 8th National Conference on Tribology with International Participation, Sofia, 28.10.2011, изнесен доклад и публикация в Tribological Journal BULTRIB Vol. 2, 2012, pp. 73-79

[9] Коларов И., П. Ташев. Ултразвуково изследване на нано-модифицирани с Tin слоеве, получени чрез наваряване с тръбен самозащитен тел. Национална научно-техническа конференция „Акустика 2015" стр. 106 – 109. София. (ISSN 1312-4897)

[10] Kolarov I. Non-Destructive Testing of Surface Defects by Raylegh Wave. International virtual journal for science, technics and innovations for the industry YEAR VIII Issue 3 / 2014. ISSN 1313-0226

[11] П. Ташев, Х. Кондов, Я. Лукарски, Е. Ташева, „Разработване на наномодифицирани електроди за ръчно електродъгово наваряване, твърдост на наварения слой", Четвърта национална конференция с международно участие „Металознание, хидро- и аеродинамика, национална сигурност '2014", 23 – 24 октомври 2014 г., София

[12] П. Ташев, Х. Кондов, А. Тасев, „Технологични свойства на наномодифицирани електроди за ръчно електродъгово наваряване", Четвърта национална конференция с международно участие „Металознание, хидро- и аеродинамика, национална сигурност '2014", 23 – 24 октомври 2014 г., София

[13] Ташев П., Кондов Х., Лазарова Р., Димитрова Р., Изследване на наномодифицирани слоеве получени при ръчно електродъгово наваряване, Сборник Доклади, 28-ма Международна научна конференция на Машинно-технологичния факултет на ТУ - София „70 години МТФ“, 11 – 13 Септември 2015г., Созопол, стр.197-205, ISSN 978-619-167-178-6

[14] Tashev P., Kondov H., Tasheva E., Tasev A., Durability of nano-modified layers produced by manual arc overlay welding, The 3rd Organizers South-East European Welding Congress, “Welding and Joining Technologies for a Sustainable Development and Environment”, June 3-5, 2015, Timişoara, Romania, pp 267-271, ISBN 978-606-554-955-5.

ИЗСЛЕДВАНИЯ С ПОМОЩТА НА СКАНИРАЩ ЕЛЕКТРОНЕН МИКРОСКОП С РЕНТГЕНОВ МИКРОАНАЛИЗАТОР НА НАВАРЕНИ С НАНОМОДИФИЦИРАНИ ЕЛЕКТРОДИ СЛОЕВЕ

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Ключови думи: *електроди, ръчно електродъгово наваряване, наномодификатори, наварен метал, сканиращ електронен микроскоп, микроструктура*

Резюме: *Разработени са наномодифицирани с титанов нитрид, покрит с хром (TiN+Cr) електроди предназначени за ръчно електродъгово наваряване на износоустойчиви слоеве на базата на електрод марка Е300. Определена е твърдостта, микротвърдостта и износоустойчивостта им. Проведени са изследвания с помощта на сканиращ електронен микроскоп с рентгенов микроанализатор на наномодифицираните наварени слоеве. Направен е анализ на получените резултати.*