Mechanics Transport Communications
Academic journal

ISSN 1312-3823
volume 11, issue 1, 2013
article № 0773
http://www.mtc-aj.com

EXAMINATION OF OVERLAID WELD CLADDING WITH ADDITION OF NANOSIZED DIAMOND PARTICLES

Plamen Tashev, Rumyana Lazarova, Seryoja Valkanov, Rositsa Dimitrova, Vladimir Petkov
weld@abv.bg, r.lazarova@ims.bas.bg, svalkanov@abv.bg, rossy@ims.bas.bg, vladimir2pe@yahoo.com

Institute of Metal Sciences, Equipment and Technologies "Acad. Angel Balevski" with Hydro-aerodynamics Centre
63, Shipchenski prohod, 1574 Sofia,
BULGARIA

Key words: *nano technologies, nano diamonds, welding, nano modifier, plating, overlay weld cladding, metallography, micro hardness.*

Abstract: *A method for deposition of chrome finish with nano-diamonds on specially prepared samples representing T-shaped weld joints with a separate cavity in the area of the root of the second seam is developed. One group of samples are prepared with chrome plating and the other group is prepared with chrome-nano diamonds (ND) plating with. The second seam is applied on the both types of samples with different plating. During the metallographic examination of the weld joints, difference was found in the microstructures of the root zone between the two types of samples. Increased micro hardness is registered in the root zone, which is supposed to contain the highest concentration of ND particles and hence to be the most strongly influenced by them.*

The nano sized particles and plating with added nano particles uncover new opportunities for creation of new technologies for permanent joining of parts and for applying finishing with special properties. This work is aimed to creating a method for plating steel with chrome finish with added diamond nanoparticles, overlay welding of the materials so obtained, and metallographic characterization of the overlay weld joint obtained.

1. Methods for preparation of chrome plating with added diamond nano particles on steel

The preliminary examinations performed include galvanic plating on steel with chrome modified with nano diamond particles. The electrolyte for chrome plating contains 220 g/l CrO_3 and 2.2 g/l H_2SO_4. The current densities used are in the range from 30 to 80 A/dm^2 and the duration of the process is from 15 to 55 min. After optimization of the results, the chosen values for the parameters of the electro-chemical process are current density 45 A/dm^2 and duration 45 min. It is found that the resulting plating have smaller grain size leading to increased micro hardness and wear resistance. The ND particles are prepared using ND detonation synthesis (NDDS) and their size is in the range from 1 to 50 nm.

The ND nano particles have specific surface area about 300 m^2/g [1, 2] and characteristic structure [3], which determine their higher adsorption properties. The method

for preparation of ND particles has a significant influence on their characteristics. The nano particles produced by detonation synthesis are purified by a quite complex scheme [4]. The activation of ND particles is performed by electroacoustic and electromagnetic method.

2. Method for overlay welding

2.1. Design and preparation of the samples

The samples for overlay welding and testing represent T-shaped corner weld joints (Fig. 1) with a separate cavity in the root of the weld seam. Initially attempts were made [6] for direct introduction of diamond particles in the resulting cavity but they did not give good results. The weld seam is carried out on two types of specimens with different plating, one with chrome plating, and another with chrome plating with ND. The specimens are made of sheet structural steel S235 with chemical composition presented in Table 1.

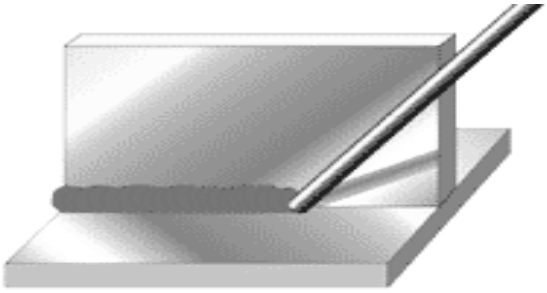

Fig .1. Design of the welded joint

Table 1. Chemical composition of steel S235

C	Mn	P	S	N
0.17	1.4	0.045	0.045	0.009

Before welding, the surfaces where the seam will be applied are cleansed in order to avoid any detrimental impact from possible dirt, corrosion, oxidation, etc. and then the plates are fixed.

The experiments are carried out using metal active gas (MAG) welding (Process 135 according to EN ISO 4063:2009). This process has a great potential for automation and is widespread in industry and construction.

2.2. Selection of shielding gas

The shielding gasses are a major factor of influence on welding in protective gas environment since they affect the processes in the arc, transfer of metal, inner appearance of the seam, weld bead shape, spatter level, etc.

For the purposes of the experiments carried out, the gas mixture used is Ferromix M 21 according to BDS EN 439 consisting of 82% Ar and 18% CO_2. The field of application of Ferromix M 21 is MAG welding of unalloyed or low-alloyed structural steels.

2.3. Selection of welding wire

The welding wire selected is G3Si1 according to BDS EN ISO 14341/2009 with nominal diameter 1.0 mm, which is appropriate for overlay welding of the steel selected and for achieving the required geometry of the seam. The chemical composition of G3Si1 is presented in Table 2.

Table 2. Chemical composition of welding wire G3Si1

C	Si	Mn	P	S	Cu
0.076	0.87	1.48	0.01	0.012	0.13

2.4. Equipment and weld mode

The experiments are carried out using Kempact Pulse 3000 equipment (Fig. 2). It is intended for synergistic welding, MIG/MAG pulse- or double-pulse welding. The standard programs are appropriate for different materials.

Fig. 2. Kempact Pulse 3000

The experiments re carried out using welding mode with parameters:
Wire feed speed, V_d= 6 m/min
Current, I = 141 A
Voltage, U = 19.7 V
Consumption of shielding gas: 9 l/min

3. Results and discussion

The general view of the overlaid weld is shown in Fig. 3. The overlaid welds are apllied with Cr coating and with Cr + ND coating.

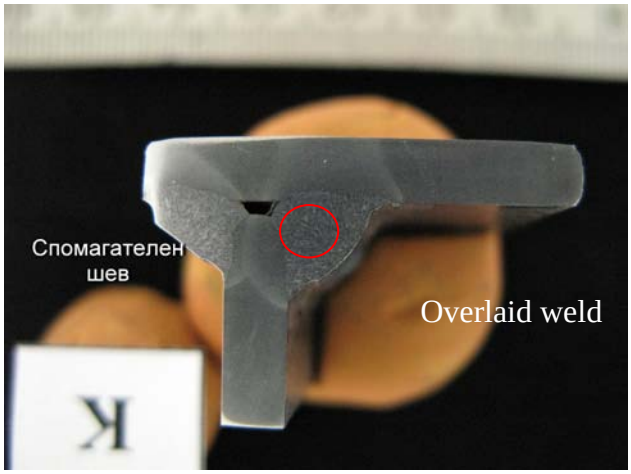

Fig. 3. General view of the overlaid weld joint

The overlaid corner weld joints are prepared for metallographic analysis using the standard procedure for wet grinding and mechanical polishing. The specimens are etched with 4% solution of HNO3 in ethyl alcohol.

The microstructures of the base metal (BM), the heat affected zone (HAZ) and the weld zone (WZ) of both the specimen with Cr plating, and the specimen Cr+ND plating are shown in Fig. 4. The microstructure of both specimens is ferritic-pearlitic, as the pearlite is distributed mainly along the grain boundary. There is Widmanstatten structure observed in the

WZ of the specimen with Cr+ND plating but it is not so well pronounced in the specimen with Cr plating.

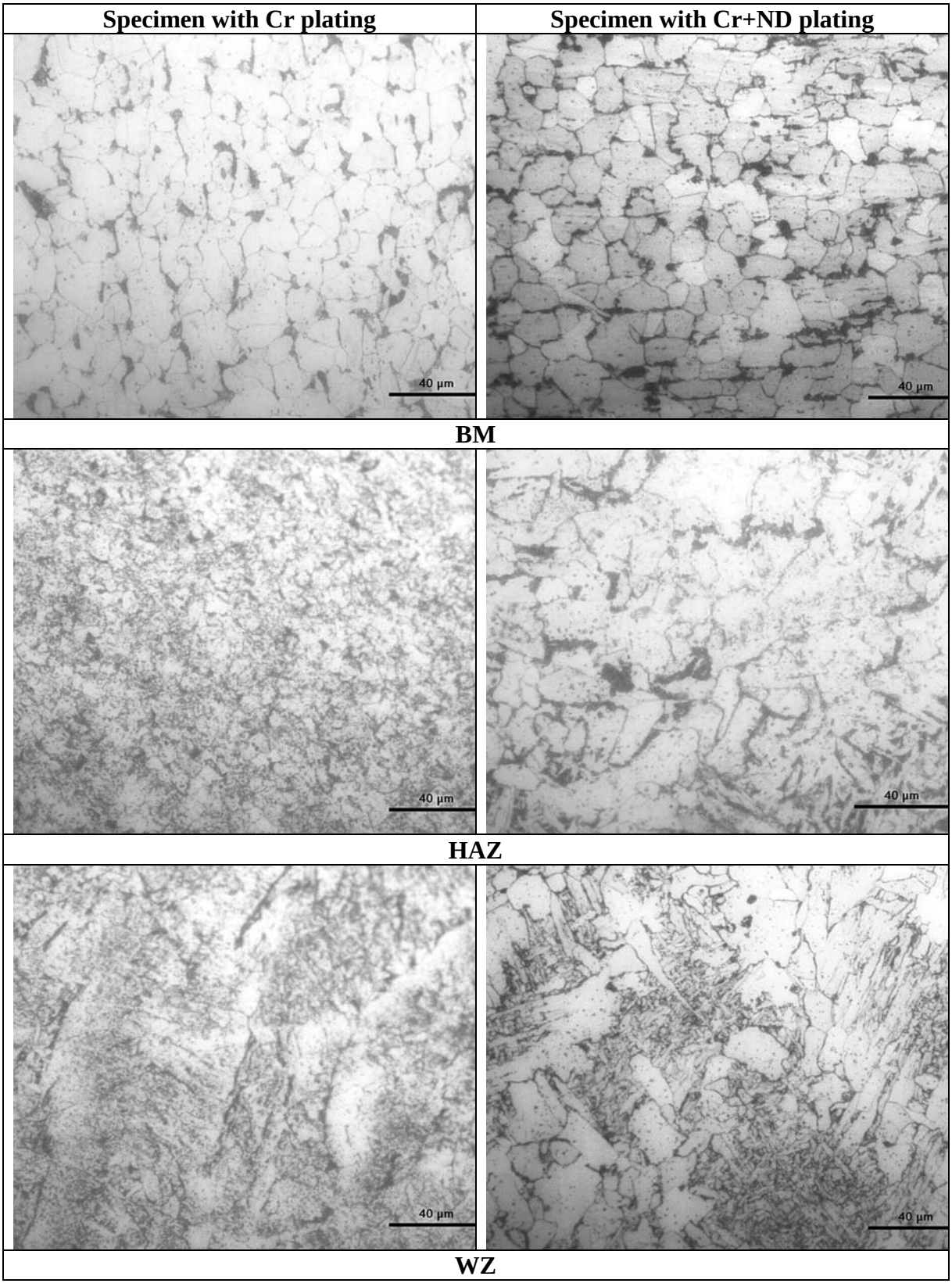

Fig.4. Microstructure of base metal (BM), heat affected zone (HAZ) and weld zone (WZ).

It has been found that upon introduction of diamond nano particles in the electrolyte, the Cr plating formed have smaller grain size, which ensures improved physical and mechanical properties [5]. The micro hardness is measured on micro specimens cut out of the different metallographic specimens using micro hardness measuring device Micro-Duromat 4000 with loading 50g, duration 10s and rate of loading 10 g/s. The area where the mictro hardness is measured is marked with red circle in Fig. 3 and the values measured are shown in Figs. 5 and 6.

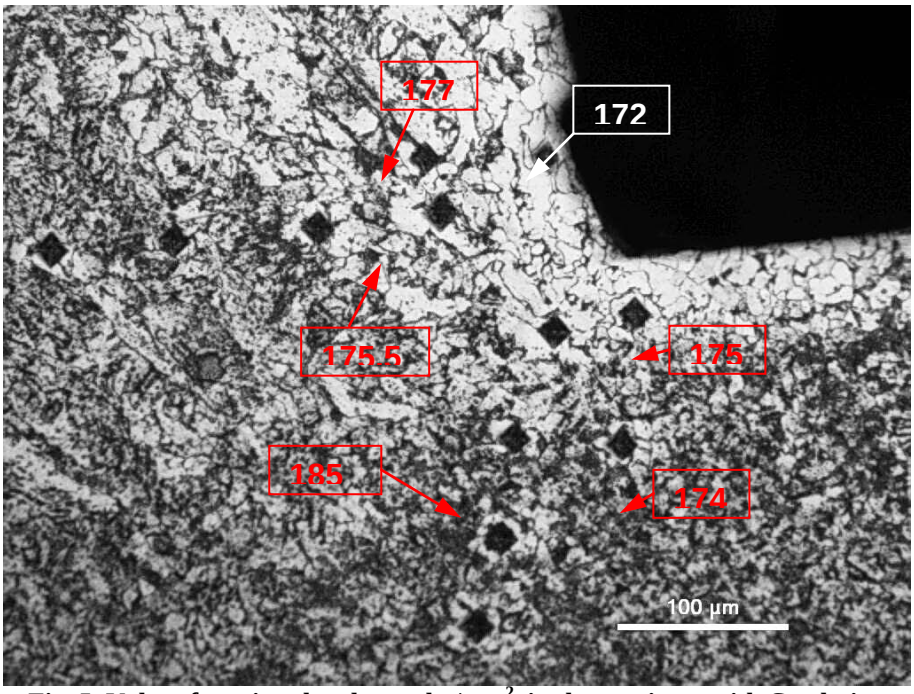

Fig. 5. Values for micro hardness, kg/mm^2 in the specimen with Cr plating

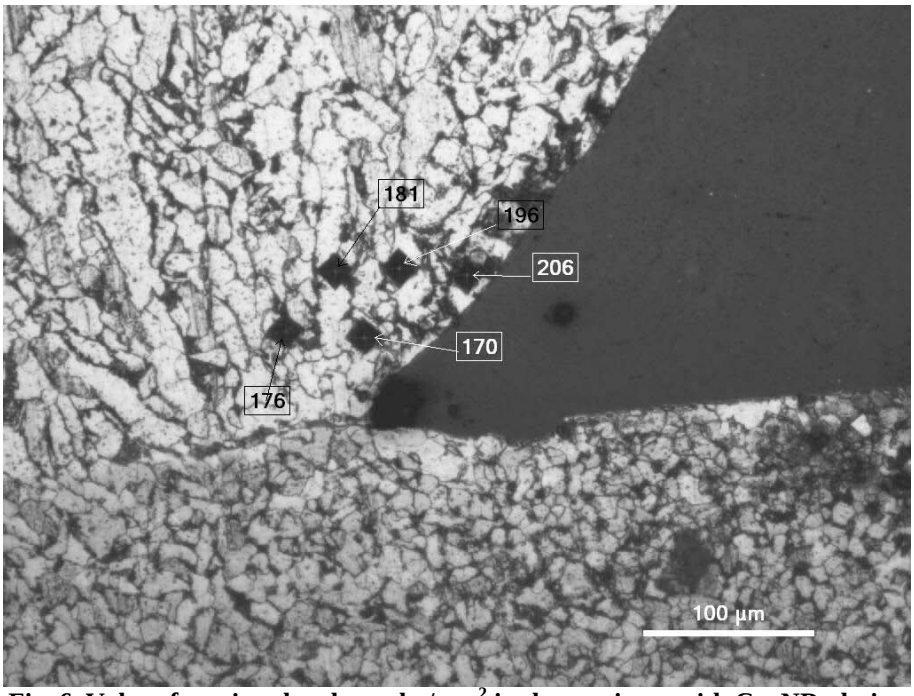

Fig. 6. Values for micro hardness, kg/mm^2 in the specimen with Cr+ND plating

In Fig. 6 the area of the overlaid weld is shown, which is supposed to contain the highest concentration of ND particles, and in Fig. 5 the corresponding area of the specimen

with Cr plating is shown. It is seen that there is an increase in the micro hardness of the specimen with Cr+ND plating with up to 30 kg/mm^2. Based on the values for micro hardness obtained we can claim that a strip about 70 wide, with higher concentration of ND particles, though not equally homogeneous is formed around the seam's root.

4. Conclusions

- A technique for electrochemical deposition of ND modified chromium plating on steel is created.
- After optimization, the composition for electrochemical deposition of chromium on a diamond nanop articles T-shaped welded joints made of steel with concentration of the diamond nano particles 25g/l, obtained with current density 45A/dm2, duration 45 min and temperature of electrolyte 50 ÷ 550 ^{0} C is defined.
- A technique for obtaining weld seam on T-shaped weld joints of steel with Cr or Cr + ND plating is created.
- It is found that the micro structure of the two specimens is ferrite-pearlite, as the Widmanstatten structure is observed in the WZ area of the specimen with Cr+ND plating; that structure is not well pronounced in the specimen with Cr coating.
- It is found that the micro hardness in the zone of introduction of ND is higher with up to 30 kg/mm^2 in the specimen with Cr+ND plating. Based on the values for micro hardness obtained, we can claim that a strip about 70 μm wide is formed around the overlaid weld seam's root with higher concentration of ND particles, which is not equally homogenous.

The study was sponsored by Contract № 6IF-02-4/15.12.2012 funded by BSMEPA through the National Innovation Fund.

REFERENCE:

[1]. Dolmatov Y. Yu., T. Fujimura, G. K. Borkat, E. A. Orlova and M. V. Veretennikova, Preparation of wear-resistant chromium coatings using different types of nanodiamonds, Powder Metallurgy and Metal Ceramics, vol. 42, No 11-12, 2003.

[2]. Mandich N. V. and Y. K. Dennis, Codeposition of nanodiamonds with Chromium, Metal Finishing, June 2001, 117.

[3]. Viet-Hue Nguen, Thi-Nam Hoang, Ngoe-Thong Nguyen, Sik-Chol Kwon, Man-Kim, Joo-Yul Lee, Cr/nanodiamond composite plating with cobalt cation additive, Transactions of Nonferrous Metal Society of China, 19 (2009), 975 – 978.

[4]. Petrov I., P.Detkov, A.Drovosekov, M.V.Ivanov, T.Tyler, O.Shenderova, N.P.Voznekova, Y.P.Toporov, D.Schulz, Nickel galvanic coatings co-deposited with fractions of detonation nanodiamond, Diamond and related Materials, 15 (2006) 2035-2038.

[5]. Kandeva M., N.Hristov, N.Tonchev, E.Assenova, Tribological Study of Cladded Bimetallic Coatings, Solving Friction and Wear Problems, 17th International Colloquium Tribology, Esslingen, Germany, 19-21 January , 2010.

[6]. Plamen Tashev, Serioja Valkanov, Peter Petrov , Emilia Balabanova, “Microstructure of gas metal arc welded carbon steel with nanoparticles” 14th International workshop on Nanoscience and Nanotechnology, NANO'2012, Sofia, Bulgaria, 22- 23 November 2012