Mechanics Transport Communications

Academic journal

ISSN 1312-3823

volume 11, issue 2, 2013

article № 0777

http://www.mtc-aj.com

EXAMINATION OF LAYER OVERLAID WITH ADDITION OF TiN NANO PARTICLES

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Key words: *nanomaterials, nano modifiers, nano technology, TiN, overlay welding, TIG, modification, metallography, micro hardness*

Abstract: *On plates of low carbon steel, there layers with nano modifier TiN + Cr are overlaid by TIG method using additional wire. Metallographic examinations on the structures of specimens from surfaced welds with and without introduction of nano modifier are conducted; the microhardness is measured in the base zone, heat affected zone and weld seam metal. Conclusions are made about the influence of the nano modifier on structure and microhardness.*

Introduction

Recently, with the development of nanotechnology, the ability occurs to modify the metal of the seam with nanometre-scale particles during the processes of welding or overlay welding. The introduction of nano dispersed materials with unique physical chemical and mechanical properties in the fused steel furthers the modification of the metal, steers the redistribution of harmful impurities, decreases the grain size, and leads to formation of a zone or a layer with increased strength, micro hardness, and wear resistance [1, 2]. The influence of the iron cladded nano modifiers TiCN, TiCN and Y2O3 in welding of low carbon steel is examined [3]. It is found that the employment of nano modifier alters the micro structure of the welded joint and improved strength properties and Vickers micro hardness in width and height of the weld are registered.

Nano modifiers used

An alternative to the presently used modifiers are some high-melting compounds (nitrides, carbides, carbonitrides, borides, etc.) as nanopowders obtained through plasma-chemical synthesis and having a small particle size (4-100 nm). The IMSETCH-BAS is conducting research on the impact of various types of nano modifiers on the performance properties of steels and cast irons. The following nano modifiers are used in the experiments: TiC, TiN, TiCN, SiC, etc. [4,5]. The nano powders TiCN, TiC, TiN are manufactured by the company Neomat CO, Latvia and the Institute of Theoretic and Applied Mechanics CO PAH. The powders are passivized with oleic acid for prevention of atmospheric influence. In order to facilitate the wettability, the powders are cladded with Ni, Cr, Fe, Al, Cu, etc. in advance. The cladding is carried out through mechanochemical processing in planetary mills or in special tanks by electroless method [6, 7]

The nanomaterial used for the present development is TiN cladded with Cr.

Preparation of the specimens

The specimens used are plates with thickness 4[mm] made of steel S235JR according to DIN17100/Rst 37-2; EN10025/ S235JR. The chemical content is shown in Table 1.

The surfaced of the plates are abrasively cleaned and degreased.

Table 1. Chemical content of steel S235JR

C max	Mn max	S max	P max	Si	N max
0.17	1.40	0.040	0.040	0.15 – 0.25	0.012

Method of overlaying

According to the technology developed, the TIG method is applied for overlay welding, i.e. arc overlay welding in inert gas with unmeltable electrode, using welding wire coated with nano material.

Shielding gas

The inert shielding gas used is argon according to BSS EN ISO 14175 designated as I 1.

Welding wire

The welding wire selected for TIG welding is DT-SGMo according to DIN 8576 with nominal diameter 1.6mm, which is appropriate for overlay welding of specimens of the steel used.

A new and original technology for cladding nano- and ultra-dispersed powders on the welding wire is created [8]. The cladding consists of several operations that ensure uniform distribution of the powders upon the wire's surface. Herein the selected welding wire is used coated with a layer containing nano-modifier TiN +Cr and binding agent.

Equipment and mode of surfacing

The experiments are carried out using equipment Fronius Magic Wave 2500 (Fig. 1). That is designated for TIG welding and surfacing.

Fig. 1. Impulse equipment Fronius Magic Wave 2500 designated for TIG welding and surfacing.

Fig. 2. Surfacing of test specimen

The following welding mode is used:

Welding current I = 90A; voltage U = 12V.

Technique of welding

The equipment used for surface welding is shown in Fig. 2. The additional wire is fed in the zone of the weld bath at a certain distance out of the arc. The wire is fed at angle 30 - 45° to the surface of the welded workpiece. The welding torch and wire move from left to right (for right hand working welder).

Experiments

Two types of test specimens of the following designations are surfaced:

Specimen No 1: Reference, made with welding wire without coating.

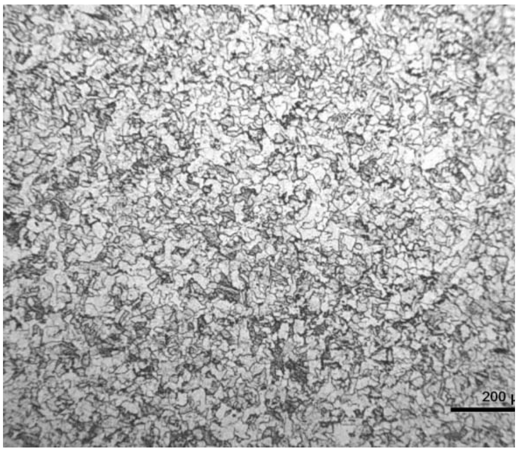
Specimen No 2: Made using welding wire coated with a layer containing nano-modifier TiN +Cr and bonding compound.

Metallographic analysis

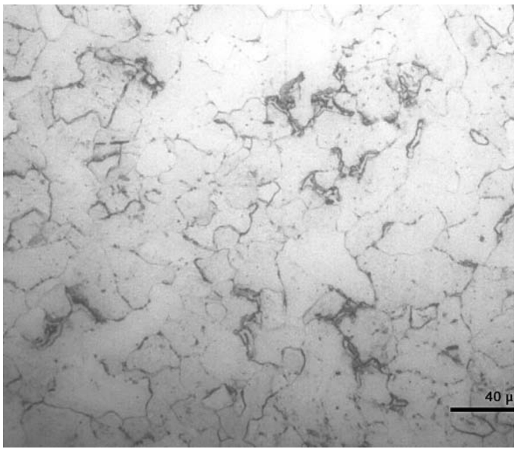
The specimens from overlaid welds are prepared for metallographic examinations according to the methodology developed. The micro-structure is observed using metallographic microscope PolyvarMet from ReichertJung Co. with maximum magnification 1000 x provided with digital camera and computer with display.

In Figures 3 and 4 the metallographic images of the different zones are shown in different magnifications: No 1 without nano-modifier, and No 2 with nano-modifier. The structures of the different zones in two magnifications are shown.

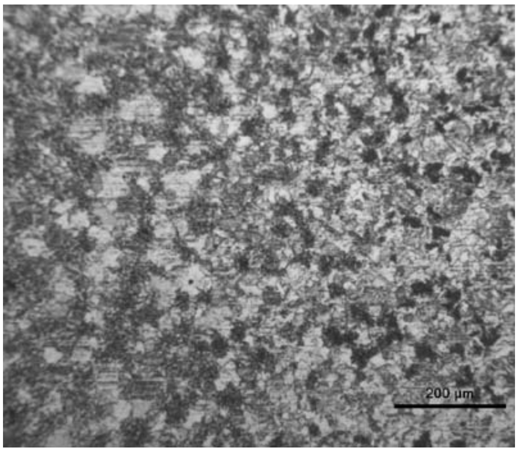
The examinations indicate that the micro-structure of the base metal zone in both specimens is ferrite-perlite (with a small amount of perlite) and does not vary substantially. In both specimens there perlite clusters are observed within the transition zone between the base metal and heat affected zone. The microstructure in the heat affected zone consists of ferrite with beynitic sectors. The microstructure in the heat affected zone of both specimens is beynitic; however in specimen No 1 it is rough beynitic with precipitations of Widmanstatten ferrite, and in specimen No 2 it is fine ferritic.



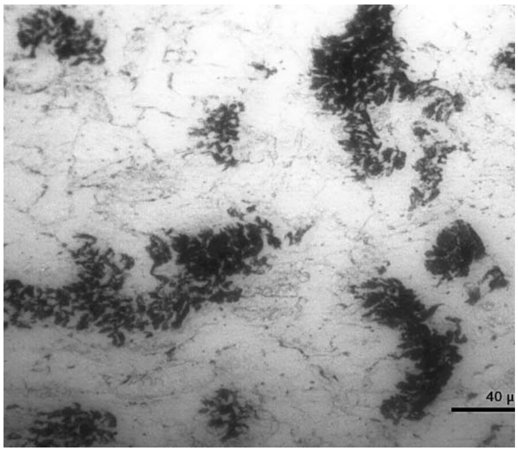
Base metal



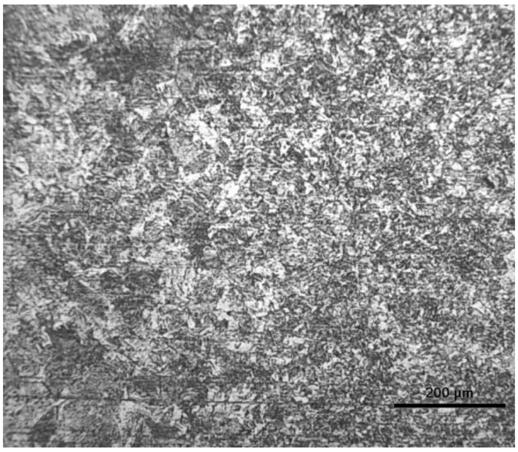
Base metal



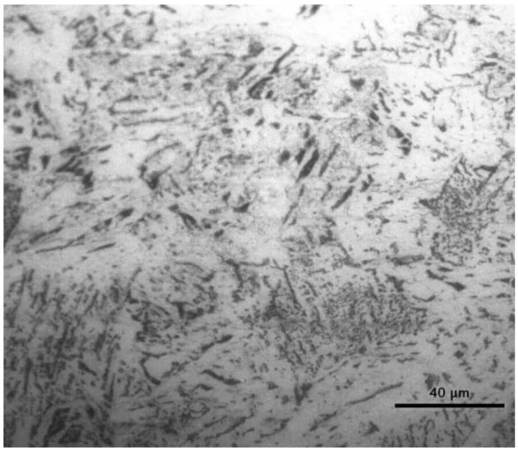
Heat affected zone – base metal



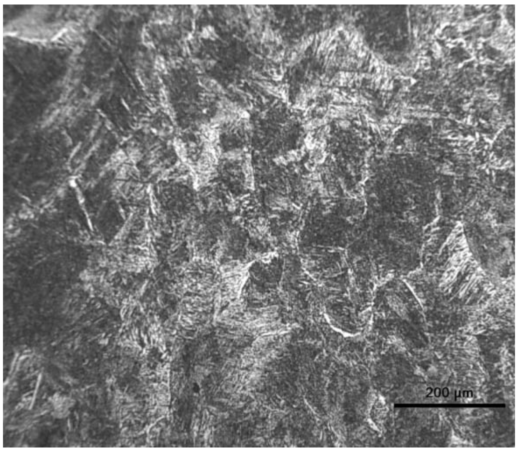
Heat affected zone – base metal



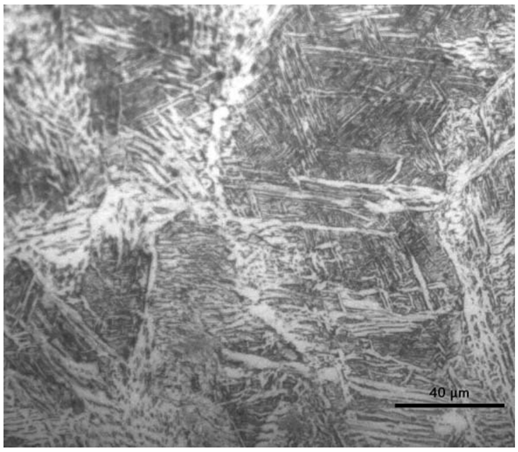
Heat affected zone



Heat affected zone

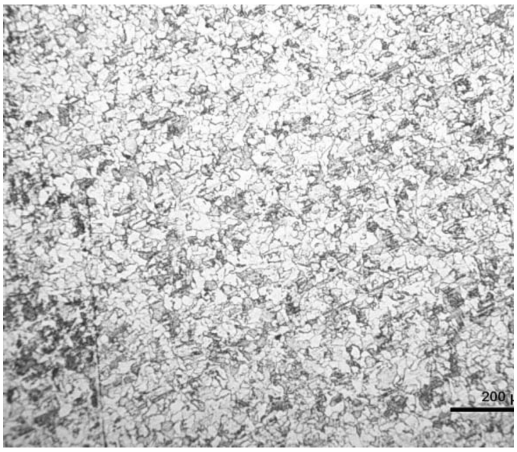


Weld seam

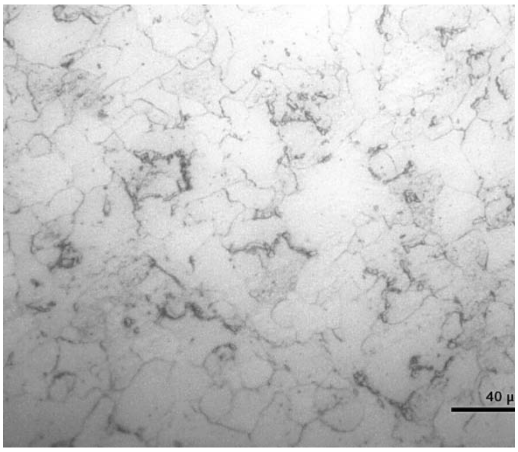


Weld seam

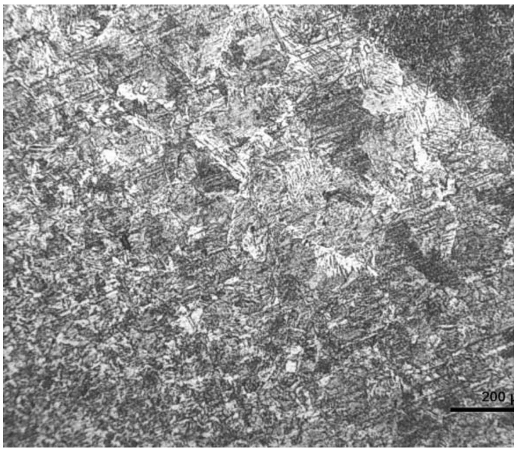
Fig. 3. Micro structure of Specimen No 1 without nano-modifier. Zones of the surfaced joint in two magnifications.



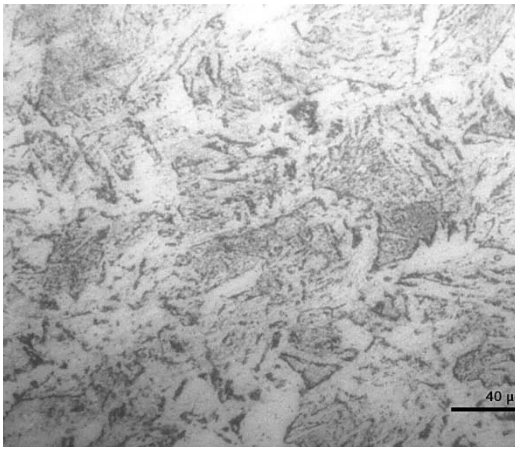
Base metal



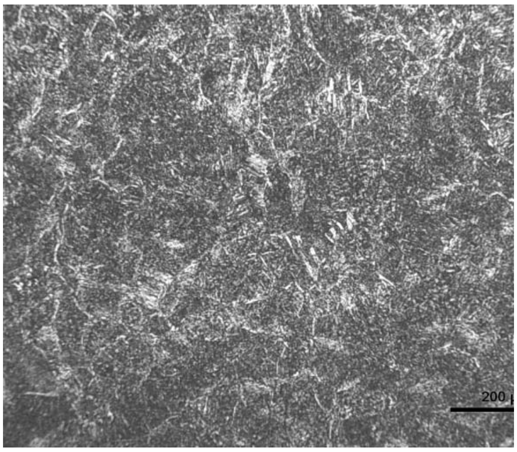
Base metal



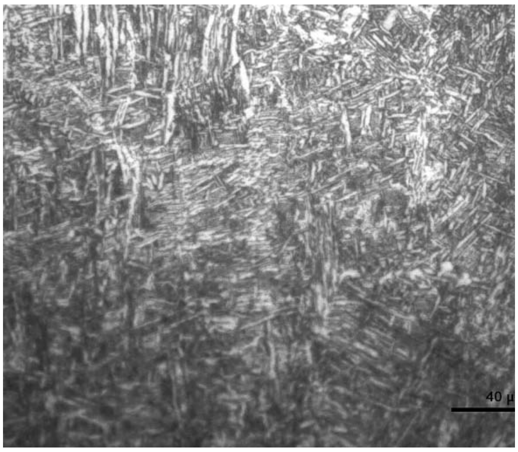
Base metal – heat affected zone – weld seam



Heat affected zone



Weld seam



Weld seam

Fig. 4. Micro-structure of Specimen No 2 with nano-modifier. Zones of the surfaced joint in two magnifications.

Measurement of Vickers micro hardness

The micro hardness is measured using micro hardness measuring device MicroDuromat 4000 according to Vickers' method with loading 50 g and duration 10s.

The measurements of the micro hardness in the weld zone from the surface to the inside indicate that in specimen No 1 without nano modifier (Fig. 5) there the hardness is almost unchanged with value around 276 kg/mm2; and in Specimen No 2 with nano modifier

(Fig. 6) it decreases from the surface to the inside from 368 kg/mm2 to 295 kg/mm2, as the average value in the core is 295 kg/mm2. The average value of the core is achieved at depth about 450 from the surface.

Conclusions

The introduction of nano modifier TiN + Cr through coated additional wire in the process of TIG overlay welding of specimens with thickness 4 [mm] of low carbon steel S235JR results in:

- Grain refinement of the structure in the weld zone; and
- Increasing the microhardness of the surface layer of the weld seam with 23%.

The examination indicates that the zone of influence of nano particles is about 400-450μm extending from the surface to the core of the overlaid specimens. The micro structure in the rest zones remains unchanged.

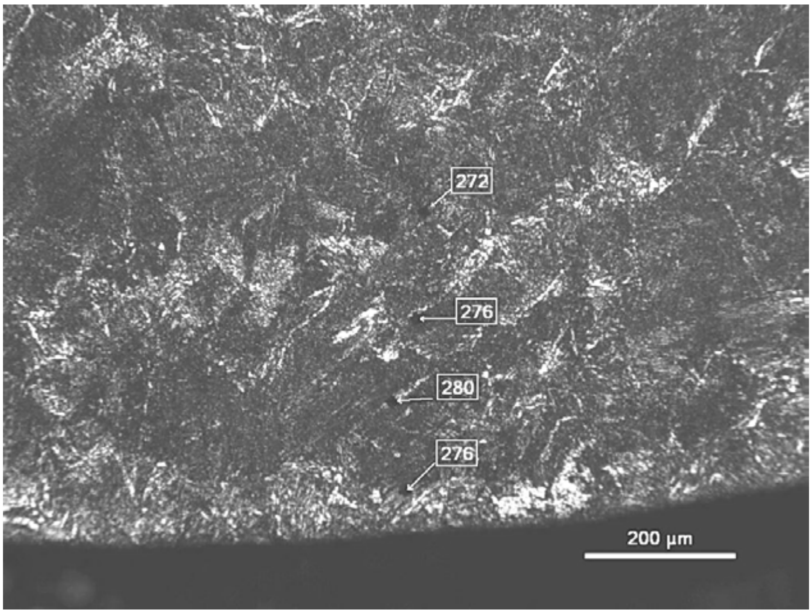


Fig. 5. Specimen No 1. Recesses from micro hardness measurements.

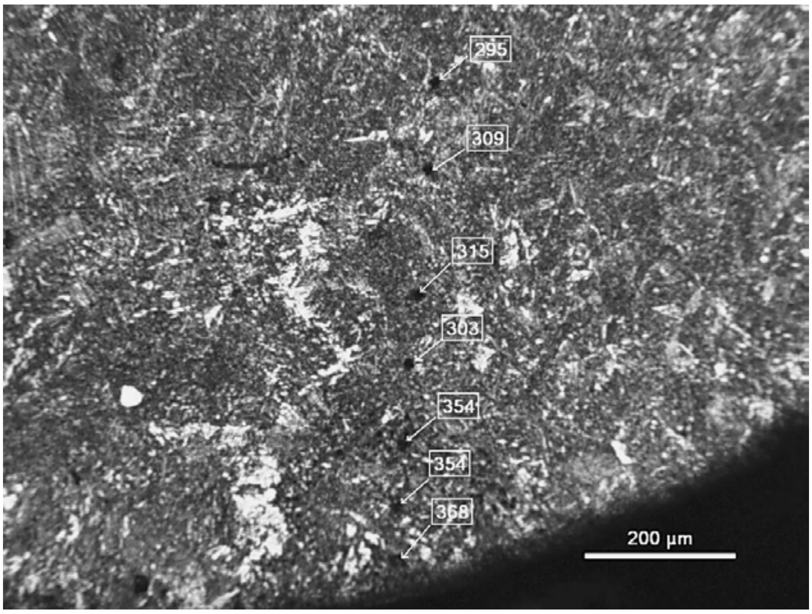


Fig. 6. Specimen No 2. Recesses from micro hardness measurements.

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