

Multi-layers castings

J. Szajnar, P. Wróbel, T. Wróbel*

Silesian University of Technology, Foundry Department
Towarowa 7, 44-100 Gliwice, PL

* Corresponding author. E-mail address: tomasz.wrobel@polsl.pl

Received 30.07.2009; accepted in revised form 31.08.2009

Abstract

In paper is presented the possibility of making of multi-layers cast steel castings in result of connection of casting and welding coating technologies. First layer was composite surface layer on the basis of Fe-Cr-C alloy, which was put directly in founding process of cast carbon steel 200–450 with use of preparation of mould cavity method. Second layer were padding welds, which were put with use of TIG – Tungsten Inert Gas surfacing by welding technology with filler on Ni matrix, Ni and Co matrix with wolfram carbides WC and on the basis on Fe-Cr-C alloy, which has the same chemical composition with alloy, which was used for making of composite surface layer. Usability for industrial applications of surface layers of castings were estimated by criterion of hardness and abrasive wear resistance of type metal-mineral.

Keywords: Cast steel, Composite surface layer, Padding weld, TIG

1. Introduction

In the last years in machine-building industry is required a large number of castings with special properties, for example high abrasive wear resistance and heat-resisting. These elements are produced from expensive and difficult to available materials. However in many cases high properties are necessary for surface layers of castings. Therefore unprofitable is founding of complete element with expensive alloy additions i.e. Ni, Cr, Mo or Ti [1÷3].

In methods of surface layers production on special attention deserves founding method. This method of preparation of mould cavity is the most economic methods of enrichment of casting surface [1, 2]. Modern technologies of surface engineering are connected with manufacturing of composite surface layer on casting surface sectors, where are very difficult conditions of working. These surfaces perform technical and useful requirements and moreover increase life of casting. In case of strengthening of complete surface, favourable is founding of complete casting from highly alloyed material. Then parameters

of founding technology of composite surface layer are nearly identical with manufacturing of usual casting [1÷3].

The other method of increase of hardness and abrasive wear resistance is application of surfacing by welding and thermal spraying technology. Welding technology may be used to surface hardening by remelting with energy of electric arc, plasma stream or laser beam. Often, for this aim is used welding technology for example TIG – Tungsten Inert Gas also known as GTA – Gas Tungsten Arc. In this technology to remelting is used heat of arc, which glow between non-consumable tungsten electrode and remelted material. Padding welds is creating in result of intermix of base metal and weld deposit, which is introducing in arc area in form of casting rod, monolithic or flux-cored wire. The weld area is protected from atmospheric contamination by a shielding gas – usually an inert gas such as argon or seldom helium [4÷6].

First time, connection of both presented coating method to forming of surface properties of cast steel castings, is presented in paper [7].

2. Range of studies

The main aim of studies was obtainment of multi-layers cast steel castings with directional increase of hardness, by connection of casting and welding technology.

Casting of cast carbon steel 200-450 (tab.1) with composite surface layer on the basis of Fe-Cr-C alloy (tab.2) was material to studies. Padding welds were put on test-castings with use of TIG – Tungsten Inert Gas surfacing by welding technology with filler in form of flux-cored wire, which was made by authors of paper. The components of flux-cored wires were low-carbon steel (C = 0,2%) tubes ϕ 5mm and powders on Ni matrix of sort Castolin Eutroly 16223 (tab.3), Ni and Co matrix with wolfram carbides WC of sort Castolin Eutalloy 10611 (tab.4) and on the basis on Fe-Cr-C alloy with granularity 1mm, which has the same chemical composition with alloy, which was used for making of composite surface layer.

Table 1.
Chemical composition of cast carbon steel 200-450

Mass contents in %				
C	Mn	Si	P	S
0,60	1,25	0,60	0,03	0,03

Table 2.
Chemical composition of Fe-Cr-C alloy

Mass contents in %				
C	Cr	Si	P	S
8,65	66,50	0,75	0,02	0,01

Table 3.
Chemical composition of powder on Ni matrix

Mass contents in %.					
C	Cr	Fe	B	Si	Ni
0,3	7,0	3,0	1,3	3,1	reszta

Table 4.
Chemical composition of powder on Ni and Co matrix with wolfram carbides WC

Mass contents in %					
C	Cr	Co	B	Si	Ni
0,1	25,0	27,0	1,7	1,1	reszta

Surfacing by welding of castings surface was realized with use of welder device CastoTIG 2002 AC/DC with reversed polarity of direct current on non-consumable electrode with following parameters:

- current intensity $I=60[A]$,
- arc voltage $U=20[V]$,
- surfacing by welding velocity $V=0,1[cm/s]$,
- diameter of non-consumable electrode (W+2%ThO₂) ϕ 3,5mm,
- rate of flow of shielding gas – argon $Q=10[l/min]$.

Usability for industrial applications of test-castings were estimated by criterion of hardness, which was measured on ultrasound MIC2 hardness tester with load 49N and abrasive wear resistance of type metal-mineral, which was measured on the basis of ASTM G 65 - 00 standard [8].

Moreover metallographic examinations were made with use of light microscopy Nikon EPIPHOT-TME with magnification from 50x to 600x. Surfaces of samples which were prepared for microstructure analysis were etched with use of [9]: Mi19Fe on composition: 3g ferrous chloride, 10cm³ hydrochloric acid and 90cm³ ethyl alcohol.

Whereas X-ray examinations were made using RTG XPertPro Panalytical diffractometer with Co anode. X-ray tube was supplied with voltage of $U=25kV$. Diffraction examinations were performed within the range of angles 2θ from 35° to 115°. The measurement step was 0,05° in length while the pulse counting time was 5s. On the basis of International Center for Diffraction Data ICDD was made identification of phases.

3. Results and analysis

On figures 1÷3 are presented view of cross-section of cast steel 200-450 castings with composite surface layer and with padding welds on Ni matrix, Ni and Co matrix with wolfram carbides WC and on the basis on Fe-Cr-C alloy. On the basis of metallographic examinations it was affirmed, that satisfactory quality of joint between layers and cast steel was obtained.

On figures 4÷8 are presented results of metallographic microscopic examinations. Investigated cast carbon steel 200-450 has pearlite and ferrite in configuration of Widmanstätten in structure (fig.4). Whereas composite surface layer on the basis of Fe-Cr-C alloy, which was put directly in founding process has structure with chromium carbides in alloy ferrite matrix (fig. 5).

The padding weld, which was put with use of TIG surfacing by welding technology with filler in form of flux-cored wire with powder on Ni matrix of sort Eutroly 16223, has fine-grained structure of chromium carbides in solid solution γ matrix (fig.6). Likewise fine-grained structure of chromium carbides in solid solution γ matrix, which was created in conditions of rapid crystallization, has padding weld on Ni and Co matrix from powder of sort Eutalloy 10611. Additionally in structure of this padding weld is present reinforced phase in form of wolfram carbides WC, which are primary constituents of powder Eutalloy 10611 (fig.7).

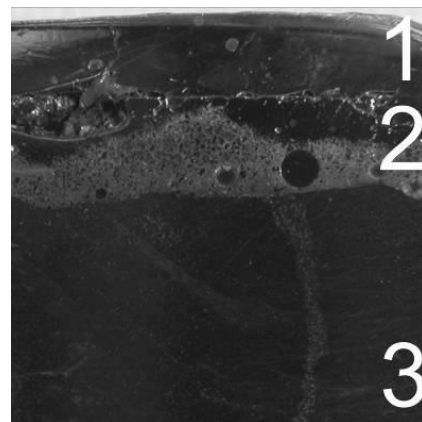


Fig. 1. View of cross-section of cast steel 200-450 castings (3) with composite surface layer (2) and padding weld on Ni matrix (1)

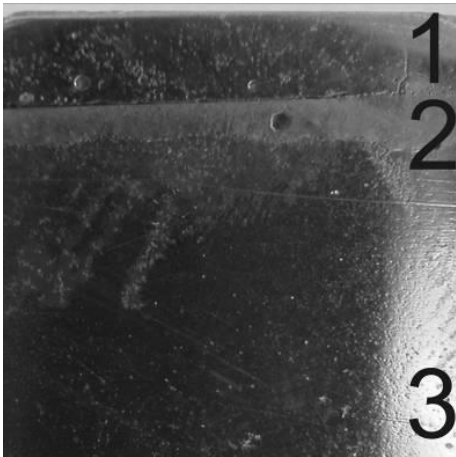


Fig. 2. View of cross-section of cast steel 200-450 castings (3) with composite surface layer (2) and padding weld on Ni and Co matrix with wolfram carbides WC (1)

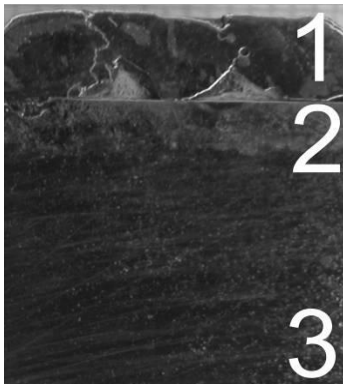


Fig. 3. View of cross-section of cast steel 200-450 castings (3) with composite surface layer (2) and padding weld on the basis on Fe-Cr-C alloy (1)

Whereas the padding weld, which was put with use of TIG surfacing by welding technology with filler in form of flux-cored wire with granulated product of Fe-Cr-C alloy has the same chemical composition with alloy, which was used for making of composite surface layer and in consequence of this has the same structure i.e. chromium carbides in alloy ferrite matrix but with larger degree of its refinement than in composite surface layer which was put directly in founding process of cast carbon steel (fig.8).

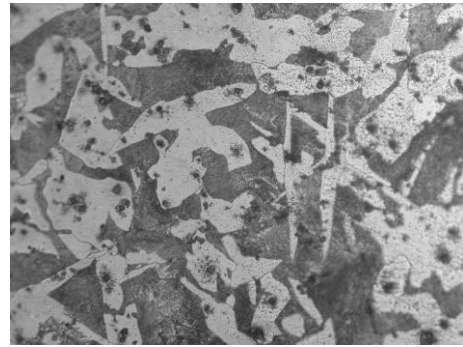


Fig. 4. Microstructure of cast carbon steel 200-450 – pearlite and ferrite – etching Mi19Fe, magnification 400x

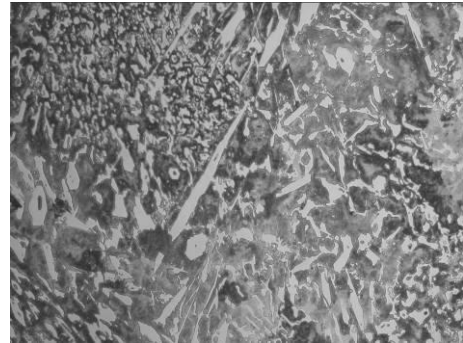


Fig. 5. Microstructure of composite surface layer – chromium carbides in alloy ferrite matrix – etching Mi19Fe, magnification 400x

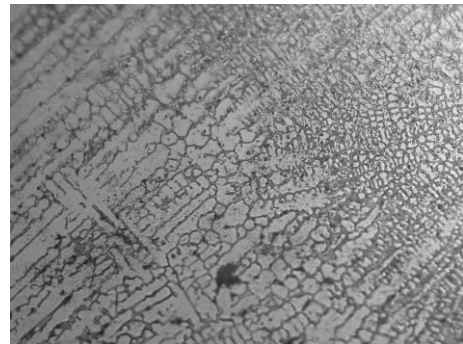


Fig. 6. Microstructure of padding weld on Ni matrix – chromium carbides in solid solution γ matrix – etching Mi19Fe, magnification 400x

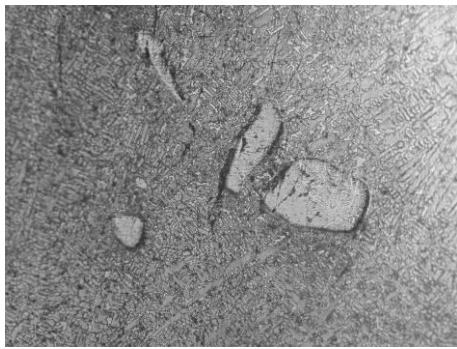


Fig. 7. Microstructure of padding weld on Ni and Co matrix with WC carbides – chromium carbides and primary reinforced phase in form of wolfram carbides in solid solution γ matrix – etching Mi19Fe, magnification 200x

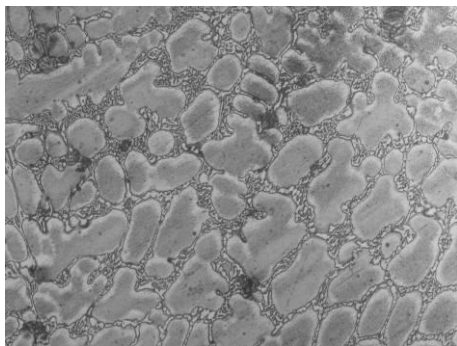


Fig. 8. Microstructure of padding weld on the basis on Fe-Cr-C alloy – chromium carbides alloy ferrite matrix – etching Mi19Fe, magnification 400x

On the basis of conducted X-ray examinations was affirmed that in structure of padding weld, which was put with use of TIG surfacing by welding technology with filler in form of flux-cored wire with powder on Ni matrix of sort Eutroly 16223, are present chromium carbides Cr_7C_3 in solid solution γ matrix (fig.9).

Whereas in structure of padding weld on Ni and Co matrix - powder of sort Eutalloy 10611, are present chromium carbides Cr_7C_3 in solid solution γ matrix. Additionally in structure of this padding weld were identified reflections of crystal planes of primary reinforced phase in form of wolfram carbides WC (fig.10).

Structure of the padding weld, which was put with use of filler in form of flux-cored wire with granulated product of Fe-Cr-C alloy, creates the same constituents than in composite surface layer i.e. chromium carbides Cr_7C_3 in ferrite matrix, which calls alloy in consideration of large content of chromium (fig.11).

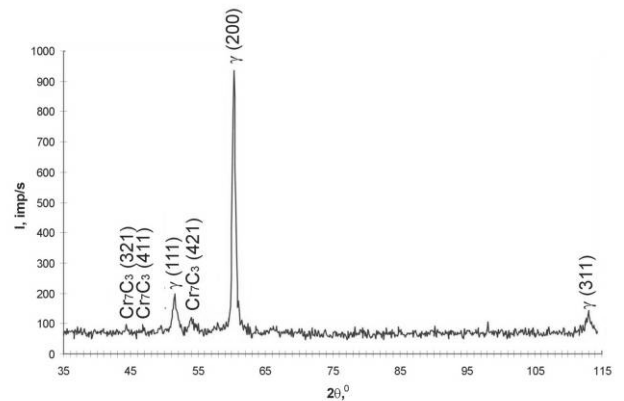


Fig. 9. X-ray diffraction of padding weld on Ni matrix

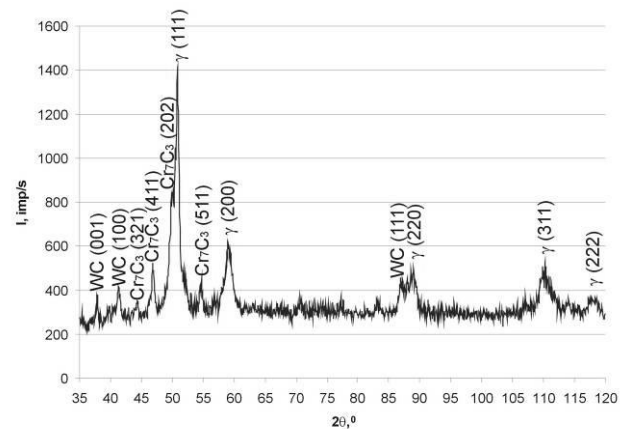


Fig. 10. X-ray diffraction of padding weld on Ni and Co matrix with wolfram carbides WC

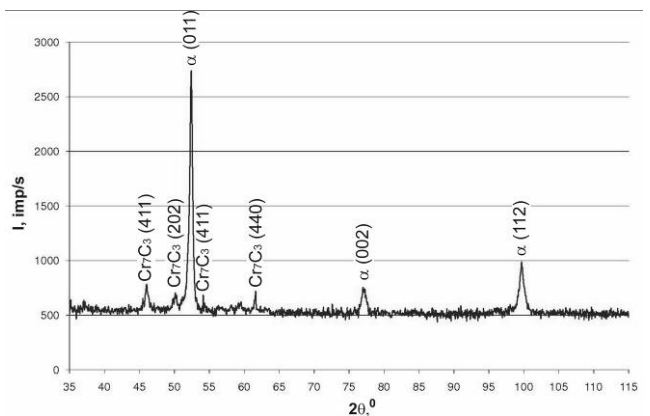


Fig. 11. X-ray diffraction of padding weld on the basis on Fe-Cr-C alloy

Moreover, on the basis of conducted studies was affirmed that surfacing by welding TIG of cast carbon steel castings with composite surface layer with use of filler in form of flux-cored wire on Ni and Co matrix with wolfram carbides WC, guarantees

obtainment of hardness gradient in direction from cast steel core (180 HV) through composite surface layer (520 HV) to surface of padding weld (620 HV) (fig.12). In smaller degree accepted criterion of hardness gradient in direction from core to surface was achieved for cast carbon steel with composite surface layer and with padding weld on basis of Fe-Cr-C alloy (570 HV).

Whereas surfacing by welding TIG of cast carbon steel castings with composite surface layer with use of filler in form of flux-cored wire on Ni matrix (310 HV), does not guarantee obtainment of increase of hardness in accepted direction.

Results of hardness measurements was confirmed by results of abrasive wear resistance of type metal-mineral researches. The least mass decrement Δm guarantees surface layer of test-casting in form of padding weld on Ni and Co matrix with wolfram carbides WC (fig.13). Moreover, generally every of applied in studies variants of surface hardening influences on increase of hardness in comparison with as-cast condition of cast carbon steel 200-450.

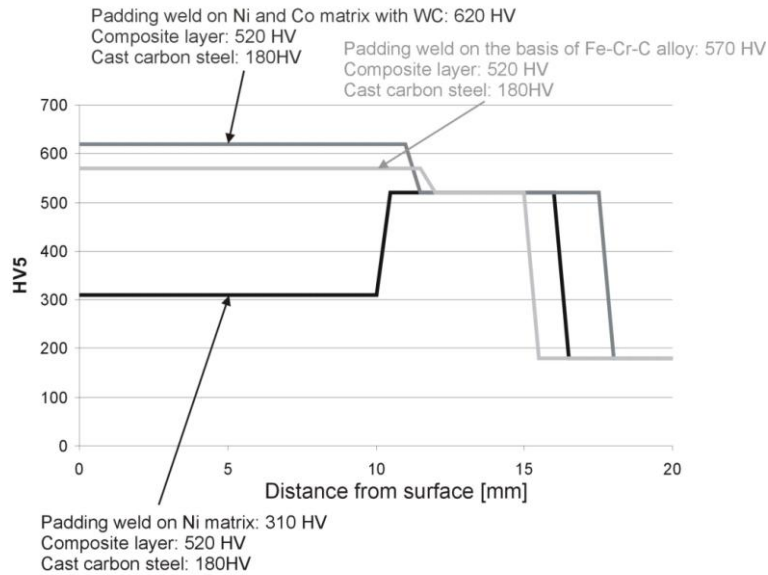


Fig. 12. Distribution of hardness on cross-section of cast carbon steel 200-450 with composite surface layer and with padding welds, which was put with use of TIG surfacing by welding technology

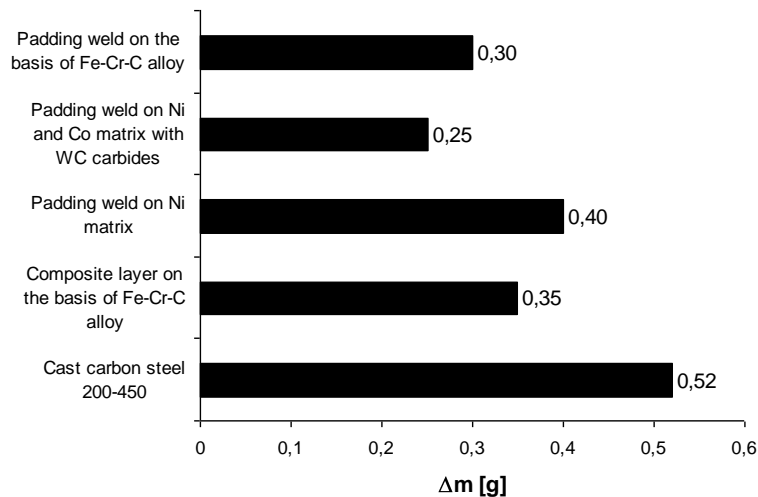


Fig. 13. Graphic interpretation of results of abrasive wear resistance of type metal-mineral, Δm - mass loss of test-casting

4. Summary

Connection of casting with welding technologies widen a possibility of industrial application of composite surface layer, which was put directly in founding process with use of preparation of mould cavity method.

Allows on increase of their thickness, which is limited in case of thin-walled castings by thermal conditions in time of pouring of mould. Moreover, creates conditions to increase and so high usable properties of composite layer. Confirms also the possibility of repair and regeneration of machine elements with composite surface layer on the basis of Fe-Cr-C alloy.

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