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# Properties shaping and repair of selected types of cast iron

**J. Szajnar [a], M. Stawarz [a], P. Wróbel[a], T. Wróbel[a], ***
[a] Zakład Odlewnictwa, Politechnika Śląska, ul. Towarowa 7, 44-100 Gliwice, Polska
*Kontakt korespondencyjny: e-mail: tomasz.wrobel@polsl.pl

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## Abstract
The paper presents research results of twofold use of TIG - Tungsten Inert Gas also known as GTA - Gas Tungsten Arc. First is surfacing by welding on cold and hot-cold to repair chromium cast iron with chromium content about 15%. Second is remelting with electric arc of selected gray (with pearlitic matrix) and ductile (with ferritic-pearlitic matrix) cast iron. Repair of cast iron elements was realized in order to cut out a casting defects. Defects decrease a usability of castings for constructional application and increase a manufacturing costs. Application of surface heat treatment guarantees mechanical properties i.e. hardness and wear resistance improvement. The result of investigations show possibility of castings repair by put on defects a good quality padding welds, which have comparable properties with base material. Use of electric arc surface heat treatment resulted in increase of hardness and wear resistance, which was measured on the basis of ASTM G 65 - 00 standard.

**Key words:** heat treatment, casting defects, TIG, cast iron, chromium.

## 1. Introduction

Wear resistance is very important for elements of machines and devices such as: digger teeth, jaw of crusher, which are subject to ridging, grinding and erossion. Basic materials which has high wear resistance is chromium cast iron. High wear resistance in this materials result from dispersion of $Cr_7C_3$ carbides and from fine-grained, homogeneous structure of this alloy [1÷4].

Gray cast iron is an very versatile material and relatively inexpensive, used in thousands of industrial products. Gray cast iron with flake and nodular graphite belong to the most popular alloys in this group.  However, mechanical properties of ductile cast iron are better than gray cast iron with flake graphite [1, 5, 6].

The weldability of cast iron is difficult in particulary on cold – without preheating. For fusion welding, preheating of the casting is absolutely essential. But surfacing by welding on cold to repair cast iron is possible. Repair of cast iron elements realized in order to cut out a casting defects, which decrease a usability of cast to constructional application and increase a manufacturing costs. Often, for this aim is used welding technology for example TIG - Tungsten Inert Gas also known as GTA - Gas Tungsten Arc [7÷10].

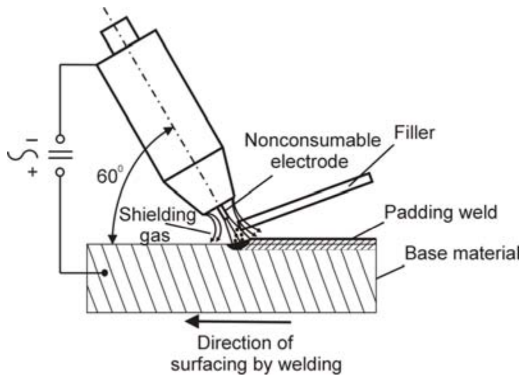


Fig.1. Scheme of TIG surfacing by welding technology

Table. 1
Chemical composition of the investigated cast iron

| Mass contents in % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| C | Mn | Si | Cr | Cu | Ni | Mo | Mg | S | P |
| EN-GJN-XCr15 | | | | | | | | | |
| 3,1 | 0,5 | 0,8 | 15 | - | 0,4 | 0,3 | - | 0,03 | 0,03 |
| EN-GJL-300 | | | | | | | | | |
| 3,54 | 0,54 | 2,02 | 0,06 | 0,34 | - | - | - | 0,02 | 0,064 |
| EN-GJS-500-7 | | | | | | | | | |
| 3,6 | 0,29 | 2,3 | 0,02 | 0,03 | - | - | 0,05 | 0,015 | 0,045 |

Moreover, application of welding technology in particular TIG to surface heat treatment guarantee mechanical properties i.e. hardness and wear resistance improvement in gray cast iron.

TIG surfacing is an arc welding process that uses a nonconsumable tungsten electrode to produce the padding weld (fig.1). The welding arc is created between a tungsten electrode, and the weld pool. The weld area is protected from atmospheric contamination by a shielding gas - usually an inert gas such as argon. Filler in form of rod, wire, shaped wire or powder is used. A constant-current welding power supply produces energy which is conducted across the arc through a column of highly ionized gas and metal vapors known as a plasma [11÷15].

## 2. Range of studies

Chemical composition of the investigated cast iron are presented on table 1. Repair of chromium cast iron elements was realized with use of welder device CastoTIG 2002 AC/DC with current intensity 100A for surfacing by weldnig on cold and hot-cold (preheating temperature 300°C). Filler to surfacing by welding has the same chemical composition as base material. Surface heat treatment was realized with use of the same device with current intensity 20, 40 and 60A. Rate of flow of shielding gas – argon was 5l/min. Nonconsumable electrode (W + 2%$ThO_2$) ϕ 3,2mm was used.

Metallografic examinations of the material structure were made on Nikon light microscope with magnification from 50x to 400x. Surfaces of samples which were prepared for microstructure analysis were etched with use of $FeCl_3$ for chromium cast iron and Nital for gray cast iron. Hardness examinations were made on ultrasound MIC2 hardness tester with load 49N. Microhardness examinations were made on microhardness tester D32 – VEB Carl Zeiss Jena with load 0,3924N. Wear resistance investigations were measured on the basis of ASTM G 65 - 00 standard (fig.2). Value of wear resistance is described by volume loss [16]:

$$R = \frac{\Delta m}{\rho} \cdot 1000 \quad (1)$$

where:
R – volume loss, $mm^3$,
Δm – mass loss, g
ρ - density, $g/cm^3$.

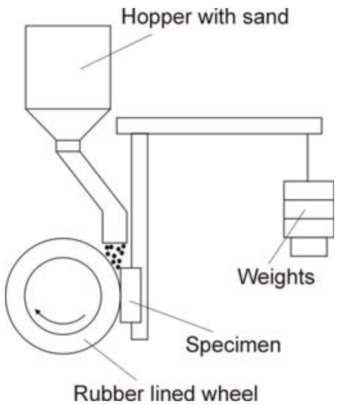


Fig.2. Schematic diagram of test apparatus to wear resistance investigation [16]

## 3. Results and analysis

Investigated chromium cast iron has structure of ferrite and carbide eutectic (ferrite + $M_7C_3$) (fig.3). The same structure but fine-grained has put padding weld in places of casting defects (fig.4). Fusion area is presented on fig. 5. While, padding weld after surfacing by welding with preheating has larger quality (without cracks in HAZ (heat affected zone) and lack of weld penetration) than padding welds after surfacing by welding on cold (fig.6 and 7). It result from large increase of HAZ hardness in sample after surfacing by welding on cold (fig.8). Moreover, hardness of padding weld in both cases is larger than in base material.

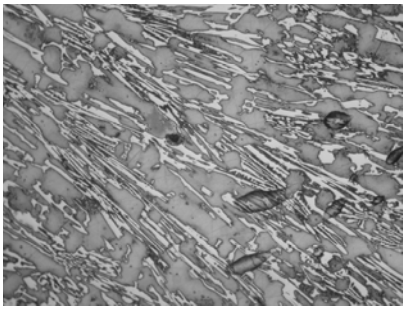

Fig. 3. Structure of chromium cast iron – ferrite and carbide eutectic (ferrite + $M_7C_3$), 200x

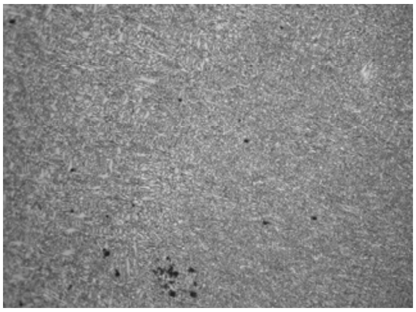

Fig. 4. Fine-grained structure of chromium cast iron padding weld – ferrite and carbide eutectic (ferrite + $M_7C_3$), 200x

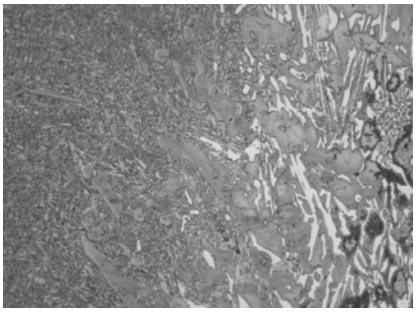

Fig. 5. Structure of fusion area, 200x

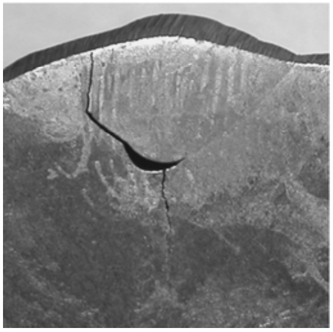

Fig. 6. Macrostructure of padding weld after surfacing by welding TIG without preheating

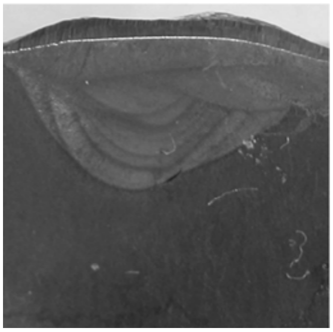

Fig.7. Macrostructure of padding weld after surfacing by welding TIG with preheating T = 300°C

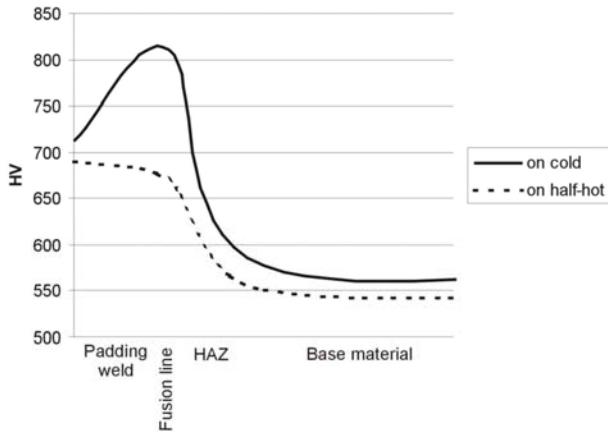


Fig. 8. Distribution of hardness on cross-section of chromium cast iron after surfacing by welding TIG

Application of TIG technology to surface heat treatment of EN-GJL-300 and EN-GJS-500-7 cast iron result in increase of hardness and wear resistance on castings surface (tab.2). Increase of these propeties result from creating of white cast iron structure on surface after fast cooling (fig. 9÷11). Value of harness and wear resistance after electric arc surface heat treatment with current intensity 60A is large than after remelting with 40 and 20A.

Table 2.
Result of hardness and wear resistance measurements

| Cast iron | Current intensity, A | Zone* | HV | R**, mm³ |
|---|---|---|---|---|
| EN-GJL-300 | 20 | I | 607 | 3,89 |
| | | II | 396 | |
| | | III | 278 | |
| | 40 | I | 1015 | 1,45 |
| | | II | 580 | |
| | | III | 300 | |
| | 60 | I | 1173 | 0,27 |
| | | II | 557 | |
| | | III | 290 | |
| EN-GJS-500-7 | 20 | I | 380 | 6,38 |
| | | II | 289 | |
| | | III | 216 | |
| | 40 | I | 747 | 4,44 |
| | | II | 301 | |
| | | III | 222 | |
| | 60 | I | 956 | 1,38 |
| | | II | 345 | |
| | | III | 245 | |

* - I – surface, II – HAZ, III – base material;
** - R = 10,93 mm³ for EN-GJL-300
R = 16,78 mm³ for EN-GJS-500-7

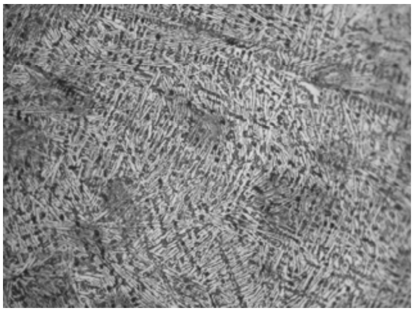

Fig. 9. White cast iron structur in fusion area, 200x

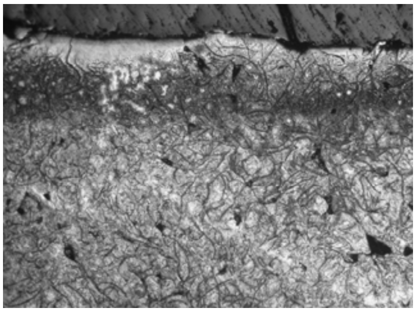

Fig. 10. Structure of EN-GJL-300 cast iron after electric arc surface heat treatment – hardening structure in HAZ, 50x

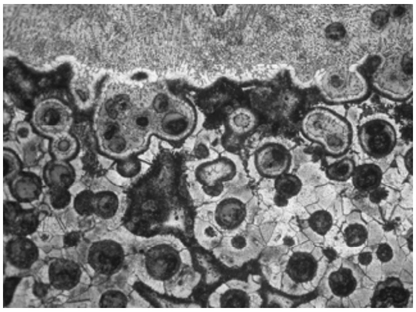

Fig. 11. Structure of fusion line in EN-GJS-500-7 cast iron after electric arc surface heat treatment, 100x

# 4. Conclusion

Based on conducted studies following conclusions have been formulated:

1. Possibility have been shown of chromium cast iron castings repair by put on defects a good quality padding welds with use TIG technology.
2. Padding weld on chromium cast iron after surfacing by welding with preheating (T = 300°C) has better quality than padding welds after surfacing by welding on cold.
3. Application of TIG technology to surface heat treatment of small area of EN-GJL-300 and EN-GJS-500-7 cast iron result in increase of hardness and wear resistance on castings surface.

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