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Application of welding technology TIG to cast iron repair

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Abstract

Repair of cast iron elements realize in order to cut out a superficial casting defects. Defects decrease a usability of castings for constructional application and increase a manufacturing costs. The paper presents research results of use of TIG - Tungsten Inert Gas also known as GTA - Gas Tungsten Arc surfacing by welding on cold and half-hot to repair chromium cast iron EN-GJN-XCr15 with chromium content about 15% and nodular (with ferritic-pearlitic matrix) cast iron EN-GJS-500-7. The result of investigations show possibility of castings repair by put on defects a good quality padding welds, which have comparable or better properties than base material.

Key words: Surface Treatment, Casting Defects, TIG, Chromium Cast Iron, Nodular Cast Iron.

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÷11].

TIG or GTA surfacing by welding is an arc welding process that uses a nonconsumable tungsten electrode to produce the padding weld (fig.1).

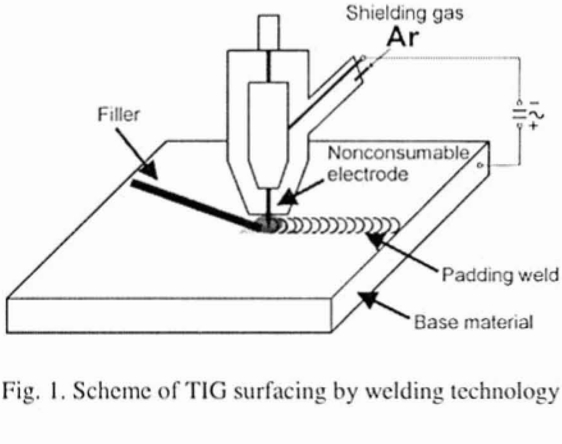

Fig. 1. Scheme of TIG surfacing by welding technology

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 or seldom helium. 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].

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 [7, 8, 11].

2. Range of studies

Repair of chromium cast iron EN-GJN-XCr15 and nodular cast iron EN-GJS-500-7 elements was realized with use of welder device CastoTIG 2002 AC/DC with current intensity 100A for surfacing by weldnig on cold and half-hot (preheating temperature 300°C). Filler in form of rod to surfacing by welding of chromium cast iron has the same chemical composition as base material. Whereas filler to surfacing by welding of nodular cast iron was chromium cast steel G90CrSi12-1 with chromium content about 13%. 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 600x. Surfaces of samples which were prepared for microstructure analysis were etched with use of $FeCl_3$ for chromium cast iron and cast steel padding weld and Nital for nodular cast iron.

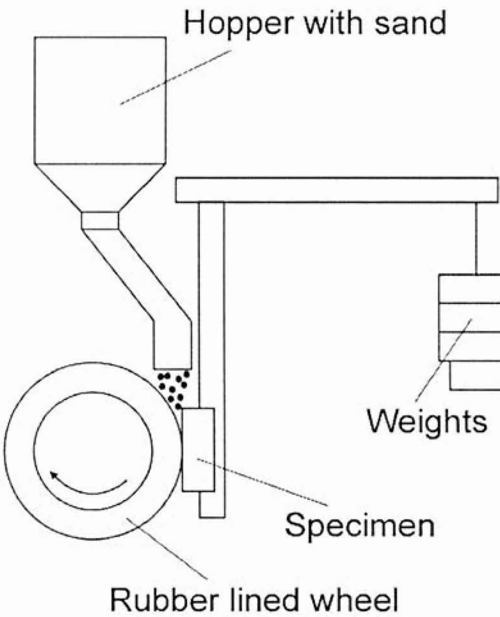

Fig. 2. Schematic diagram of test apparatus to wear resistance investigation [16]

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]:

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

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

3. Results and analysis

On figure 3 is presented fusion area after repair surfacing by welding of chromium cast iron EN-GJN-XCr15. 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.3).

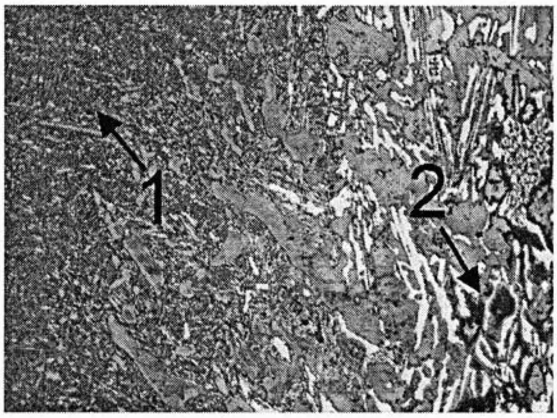

Fig. 3. Structure of fusion area in chromium cast iron – ferrite and carbide eutectic (ferrite + M_7C_3) – area 2, more fine-grained in padding weld – area 1, magnification: 200x, etching: $FeCl_3$

Investigated nodular cast iron has structure of nodular graphite in ferritic-pearlitic matrix (fig.4). While repair padding weld has fine-grained structure of cast steel G90CrSi12-1 (fig.5). On figure 6 is presented fusion area after repair surfacing by welding of nodular cast iron EN-GJS-500-7.

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.7 and 8). It result from large increase of HAZ hardness in sample after surfacing by welding on cold (fig.9 and 10). Wheras increase of hardness in HAZ result from creating of white cast iron structure in fusion area after fast cooling.

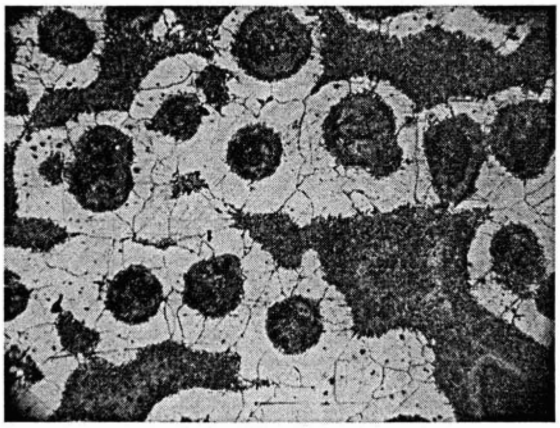

Fig. 4. Structure of nodular cast iron EN-GJS-500-7 – nodular graphite in ferritic-pearlitic matrix, magnification: 200x, etching: Nital

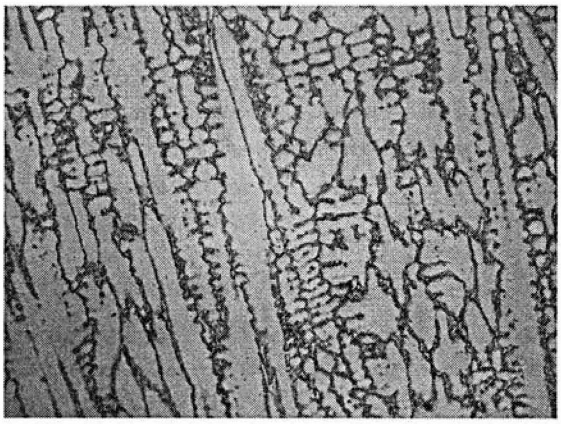

Fig. 5. Fine-grained dendritic structure of padding weld on nodular cast iron EN-GJS-500-7, magnification: 600x, etching: Nital

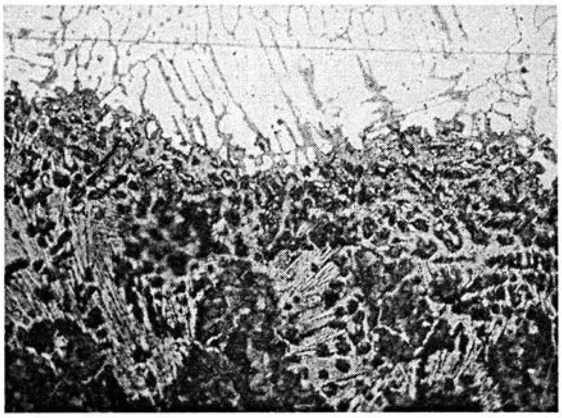

Fig. 6. Structure of fusion area in nodular cast iron EN-GJS-500-7 after surfacing by welding on cold – fine-grained structure in padding weld of cast steel G90CrSi12-1 and structure of white cast iron in fusion line, magnification: 400x, etching: Nital

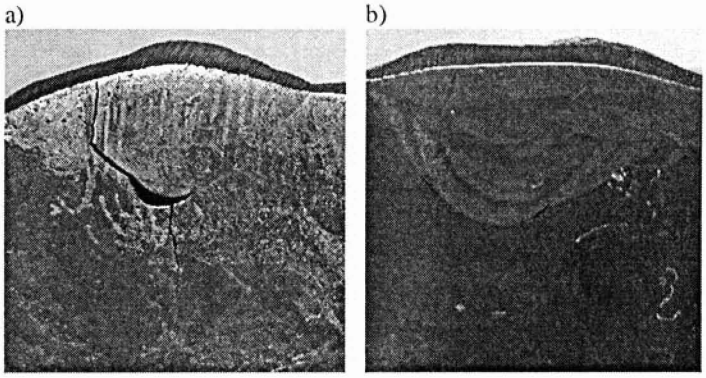

Fig. 7. Macrostructure of padding weld after surfacing by welding TIG of chromium cast iron EN-GJN-XCr15:
a - on cold (without preheating),
b – on hot-cold (preheating temperature 300°C)

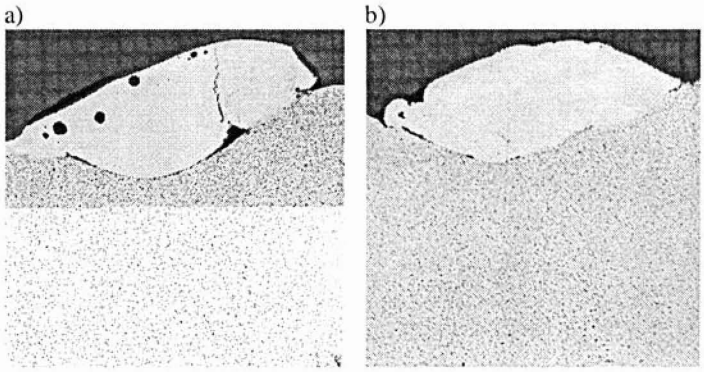

Fig. 8. Macrostructure of padding weld after surfacing by welding TIG of nodular cast iron EN-GJS-500-7:
a - on cold (without preheating),
b – on hot-cold (preheating temperature 300°C)

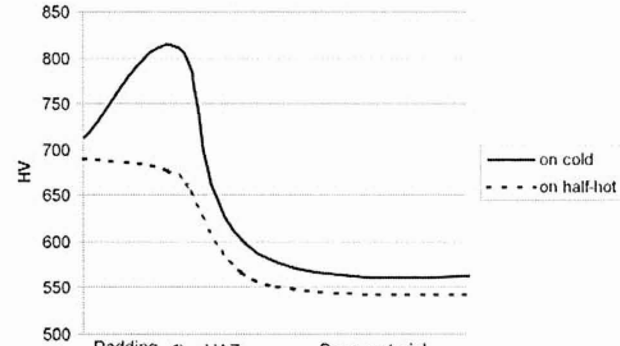

Fig. 9. Distribution of hardness on cross-section of chromium cast iron EN-GJN-XCr15 after surfacing by welding TIG

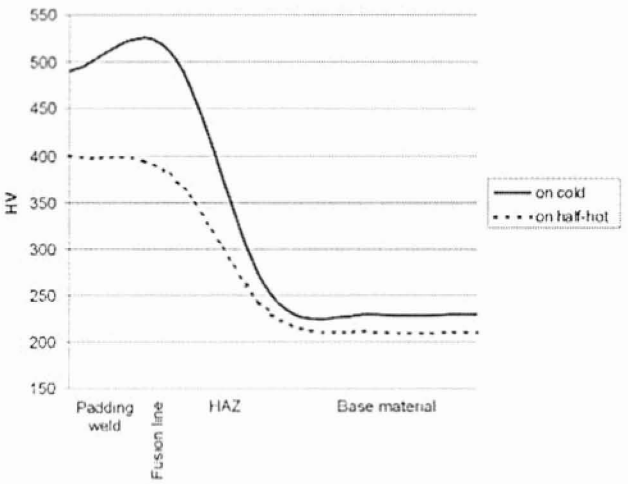

Fig. 10. Distribution of hardness on cross-section of nodular cast iron EN-GJS-500-7 after surfacing by welding TIG

Moreover, hardness and wear resistance (fig. 11) of padding weld in both cases is larger than in base material.

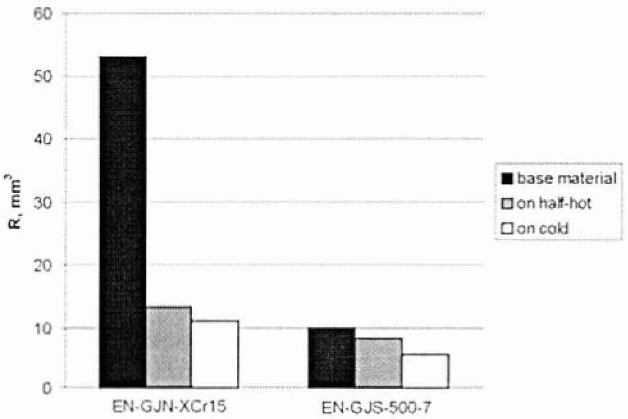

Fig. 11. Value of wear resistance of chromium and nodular cast iron after surfacing by welding TIG

4. Conclusion

Based on conducted studies following conclusions have been formulated:

1. Possibility have been shown of chromium cast iron EN-GJN-XCr15 and nodular cast iron EN-GJS-500-7 castings repair by put on defects a good quality padding welds with use TIG technology.
2. Padding weld on chromium cast iron and nodular cast iron after surfacing by welding with preheating (T = 300°C) has better quality than padding welds after surfacing by welding on cold.

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