Repair welding of cast iron coated electrodes

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Abstract. Welding cast iron is a complex production procedure. Repair welding was used to repair damaged or poorly made castings. This is due to a tendency to cracking of the material during welding as well as after it. Welding cast iron can be carried out on hot or on cold. Hot welding requires high heat material and the use of welding material in the form of cast iron. In the case of cold welding, it is possible to use different materials. Mostly used filler metals are nickel and copper based. The work shows the course of research concerning repairmen of ductile iron with arc welding method. For the reparation process four types of ESAB company coated electrodes dedicated for cast iron were used with diameter 3.2 and 4 mm: ES 18-8-6B (4mm) , EB 150 (4mm), OK NiCl, EŻM. In the cast iron examined during the testing grooves were made using plasma methods, in order to simulate the removed casting flaws. Then the welding process with coated electrodes was executed. The process utilized low welding current row of 100A, so there would only be a small amount of heat delivered to the heat affected zone (HAZ). Short stitches were made, after welding it was hammered, in order to remove stresses. After the repair welding the part of studies commenced which purpose was finding surface defects using visual testing (VT) and penetration testing (PT). In the second part, a series of macro and microscopic studies were executed witch the purpose of disclosuring the structure. Then the hardness tests for welds cross sections were performed. An important aspect of welding cast iron is the colour of the padding weld after welding, more precisely the difference between the base material and padding weld, the use of different materials extra gives the extra ability to select the best variant. The research of four types of coated electrode was executed , based on the demands the best option in terms of aesthetic, strength and hardness.

1. Introduction

Most of the castings have external or internal defects and whether it pays to fix them depends on their subsequent use. In the case of small elements, serial production or very responsible parts the castings should not be repaired mainly from economical point of view. When the cost of production is high or preparation time of the mould is long. It is usually decided to repair the discontinuity. In the casting process there is a certain allowance for possible, acceptable defects and the defects that need to be removed or may not be encountered.

Therefore, it is important to achieve very similar colour overlay to the base material. The achievement of appropriate strength properties and hardness is also a vital issue. The repair of castings can be made in different ways from typical foundry methods were material is refilled (casting-on), welding with coated electrodes GMA, TIG. Repair can be performed using mechanical strapping material (metalock method) or by using the insoles, which are intended to replace the material with defects [1-9].

Surface treatment is very broadly defined department techniques one of primary is welding. Shielded metal arc welding is often used for repairs on the cold, apply all sorts of binders from the low carbon steel by nickel alloys, copper. This method has a high versatility, can I use when we have small defects in the material or the big disadvantages. Selection of welding parameters, respectively, you can enter a small amount of warm which is recommended for welding of cast iron, since it is sensitive to processes where we provide heat with subsequent cooling [1-14].

2. Experimental Details

The article shows the process of research repair welding of ferritic-perlitic ductile iron GJS 350-22, utilizing the method of coated electrode (the chemical composition of cast iron was shown table 1 and the microstructure on the figure. 1) in samples taken with the use of plasma-arc gouging method. Table 2 describes the parameters of the plasma gouging. The grove was made in order to simulate the removed casting defects, Half of the gouging was mechanically grinded in order to remove the layer after gouging. Then the welding process took place in accordance to EN 1011-8. Material was not preheated. Electrodes selected for this studies were EB150 4mm, EŻM 3, 2 mm OK NiCl 3.2 mm, ES 18-8-6B 4mm (typical composition and properties in tables 3 and 4). In order to introduce a small amount of heat low current parameters were used. During the welding one stich was made. Each overlay weld was hammered in order to prevent cracking. The welding parameters were presented in table 5.

After MMA welding made visual and penetration testings in order to designate the defects on the surface which was evaluated by accordance to PN-EN 13018 and ISO 9934. Then metallographic specimen was made to demonstrate the impact of different types electrode and gouging surface preparation of the heat affected zone (HAZ) and overlay weld properties. Hardness HV 1 was measurement along one line across down padding of the weld in accordance to ISO 6507. Figure 2 shows a scheme of measurements. At the end of the subjective assessment method was carried out to compare the appearance of the weld in obtained terms. This is an important aspect of repairmen of castings.

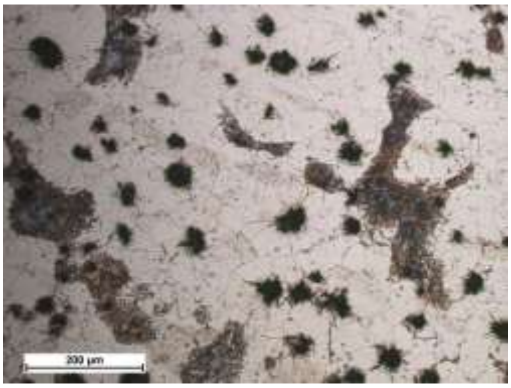

Figure 1. Microstructure of examined ductile iron.

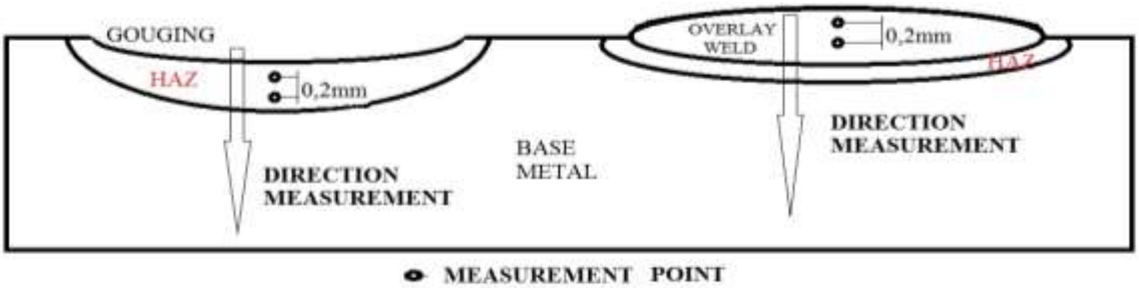

Figure 2. Scheme of measurements points.

Table 1. Chemical composition of base metal, mass %.

Chemical composition, [%]													
Sample	C	Mn	Si	P	S	Cr	Ni	Mo	V	Cu	Ti	Al	Mg
GJS 350-22	3.37	0.47	2.63	0.04	0.001	0.13	0.04	0.02	0.01	0.07	0.03	0.01	0.04

Table 2. Parameters of plasma-arc gouging.

Parameters					
Sample	Current [A]	Plasma gas	Numbers of grove	Inclination of the plasma torch [°]	Nozzle diameter [mm]
B1	60	Air	1	30	1.6

Table. 3 Chemical composition of filer metal.

Chemical composition, [%]							
Type of electrodes	C	Si	Mn	Fe	Ni	Cu	Cr
NiCl	0.9	0.6	0.6	3.5	>92	-	-
EŻM	<0.7	0.1	0.9	3.0	rest	32	
ES 18-8-6B	0.11	0.5	6	rest	8.5	-	18.5
EB 150	0.08	0.4	1.1	rest	-	-	-

Table 4. Properties of filers metal.

Properties of filer metal				
Type of electrode	Rm [MPa]	A_5 [%]	KV[J]/∘C -40	Hardness
NiCl	300			130-170 HB
EŻM	300-350	15		140-160 HB
ES 18-8-6b	605	35	85	190 HV *
EB 150	500-640	>20	>47	

*after squeeze 400HV.

Table 5. Welding parameters.

Sample	Type of electrode	Current [A]	Polarity	Surface preparation
A2	NiCl	100	+	Grinding
A3				No grinding
B2	EŻM	100	+	Grinding
B3				No grinding
C2	ES 18-8-6B	100	+	Grinding
C3				No grinding
D2	EB 150	130	+	Grinding
D3				No grinding

3. Results and discussion

After plasma-arc gouging occurrence of hardening zone can be noticed. It was revealed in cutting line as martensitic structure, part of the graphite began to dissolve, some of metal is malted in the process and crystalized as ledeburite (figure 3). Hardness in the cutting line reaches up to 650HV and the HAZ is present in the material on about 0.5 mm (scheme of measurement figure 2). Visual testing and penetration testing did not reveal the cracks in the plasma grooves.

Figure 3. Microstructure of cutting HAZ.

Figure 5. View of penetration testing.

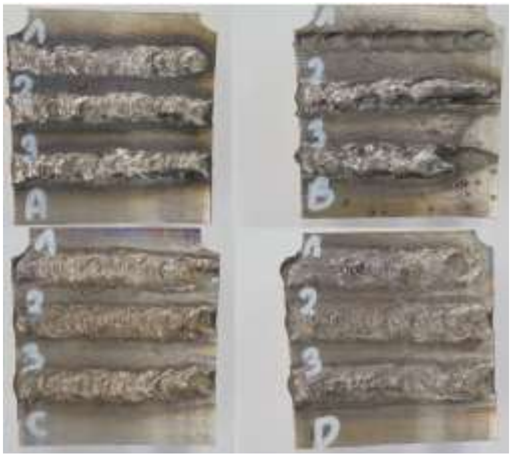

Figure 4. Padding weld after welding.

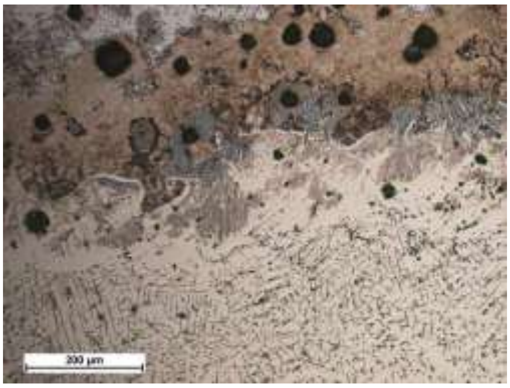

Figure 6. Microstructure of fusion line NiCl padding weld.

After the execution of the welding process with coated electrodes visual testings were carried out (figure 4 shows padding weld). Welding with electrodes EŻM, NiCl, ES 18-8-6B resulted in non-complete fulfilment of the grove, the remaining welds were laid correctly. The biggest problem was, however, in the case of electrodes EŻM. In the case of penetration testing cracks on the padding weld were encountered while utilizing EŻM electrodes as well as several indications in the padding weld while using EB 150 electrodes. The indication of the crater was only in the case of electrodes EB 150. Figure 5 show results of penetration testing.

Macroscopic and microscopic studies revealed a very narrow HAZ, in every case hard spot in the area of the weld (fusion line) was noticed. Fusion line is show on figure 6. The largest part of hard spot was evident in the case of electrodes EB150, in each case also a martensitic structure was disclosed in the HAZ. The deposit made in the groove without grinding had wider area of hard spot As a result of microstructure examination the presence of austenitic structures was reviled for welding electrodes EŻM, NiCl, ES 18-8-6B, in the case of electrodes ES18-8-6 visible are large dendrites were noticed (figure 7). Welding electrodes EB 150 resulted in obtaining a martensitic structures with very large dendrites (figure 8). In the case of welds performed with EŻM slag inclusions were observed in the vicinity of the fusion line (figure 9).

Figure 7. View of dendrites in padding weld ES 18-8-6B.

Figure 8. View of microstructure of EB 150 overlay weld.

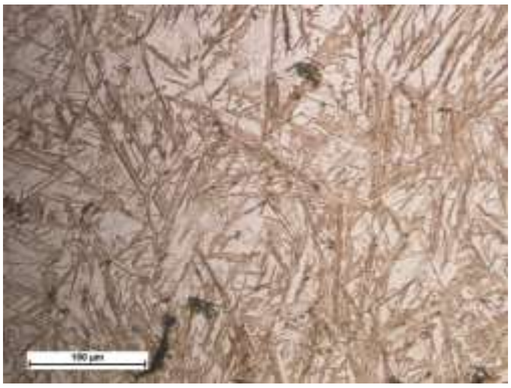

Figure 9. Slag inclusion in padding weld.

The results of research hardness examination (figure 10) did not show visible changes between padding weld when laying the grooves in the ground and with no ground. Achieved hardness of the welds varied at different levels, so in the case of welds electrodes EŻM and NiCl obtained hardness was about 200HV which gives large possibilities when it comes to post-processing mechanism. Overlay weld of electrodes ES 18-8-6 increased hardness to approximately 350HV. Although on the surface appeared area with hardness of up to 500HV. With the deposit weld metal electrodes EB 150 best they had the greatest hardness was achieved of up to 750HV, resulting in inability to further machining. Such hardness results from the high carburizing of the welds. In any case hardness values of hard spot it 600-800HV (figure 11), martensitic zone in HAZ reaches about 600 HV. Due to the fact that the material of the structure was ferritic-perlitic and because of the heterogeneity of castings hardness of the base metal ranged at around 160 to 200HV.

Comparison of colours of the padding weld and base metal the best colour was obtained for electrodes EB 150 and ES 18-8-6B, in the other you can see a lighter shade of the deposit. Figure 12 show differences of deposit colour.

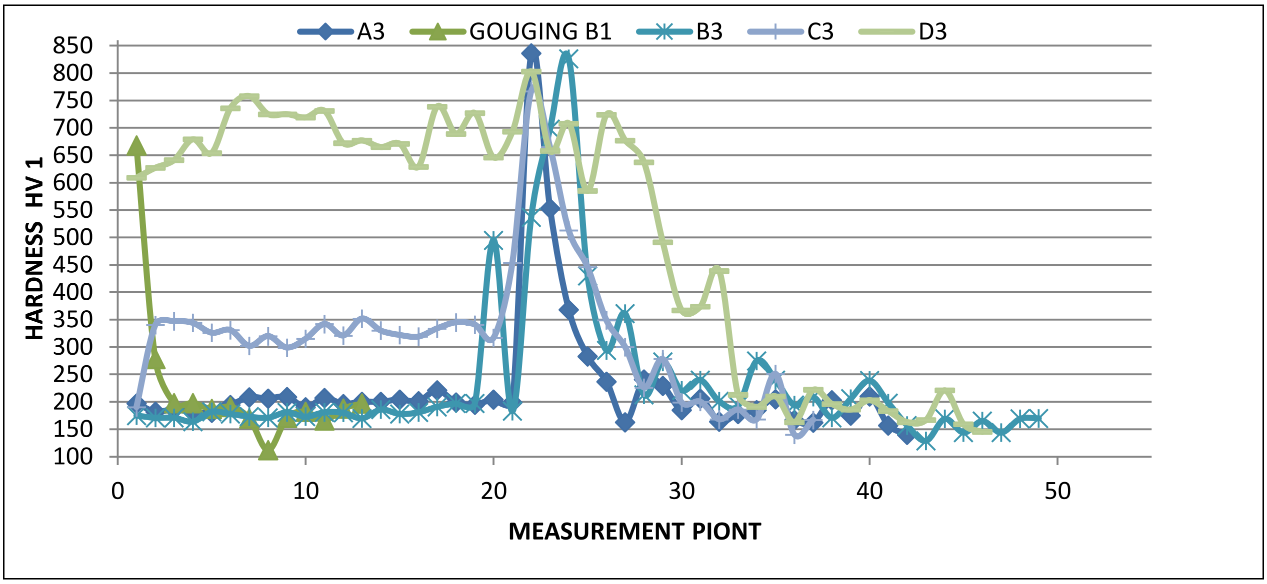

Figure 10. Hardness distribution in gouging and grinding groove.

Figure 11. Hard spot in padding weld. Measured point 707 HV 0.5.

Figure 12. View of padding weld colour.

4. Conclusion

After the studies it can be concluded that the way used to prepare the surface before welding does not significantly affect the structure and hardness of repaired area. Only slight increase of hard spot was disclosed. The deposits obtained after the trial were acceptable only in 3 cases, unfortunately, the case utilizing electrodes EŻM did not achieve full penetration, slag inclusions occurred and did not fill the face. In this case there were numerous cracks on the face. Only electrodes EB 150 did not pass the testings with a high mark because of too high hardness. The best electrodes in this study were electrodes NiCl and ES 18-8-6B. For ES 18-8-6B electrodes both the lower price and better colour of the weld might be an important factor for determining it as the best electrode in this test, however

NiCl electrodes demonstrated the lowest hardness which should translate to the highest impact strength, so the choice depends on the demands.

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5. References

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