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Enrichment of surface of low-alloyed cast iron with use of austenite layer

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Abstract

In paper is presented method of obtainment of bimetallic casting for lining of quenching car to coke production. In range of studies were made bimetallic casting of cast iron with chromium-nickel steel plates for their different thickness, researches of joint quality with use of ultrasonic method, metallographic examinations of microstructure and researches of selected usable properties.

Keywords: Bimetallic; Cast iron, Steel, Austenite

1. Introduction

Complex working condition of lining of quenching car (thermal shock, corrosive influence of water, abrasive wear) cause their working cycle relatively short, which does not cross one year (fig.1). At present the material on lining plates is low-alloyed cast iron (chromic, chromic-cupric) or nodular cast iron. Lengthening of life in range of early tests was possibility by application of plate of austenitic chromium-nickel cast steel. Austenite in structure assures better corrosion resistance in elevated temperature, small changes in time of heating and cooling. Moreover strengthened austenite has larger abrasive wear resistance than ferrite or pearlite [1÷3].

However for economic reasons i.e. price of nickel, direction of this solution is unprofitable. New type of solution for quenching cars in coking plant can be bimetallic castings [4, 5] in which only directly endangered on abrasive wear and corrosion surface layer is made from highly alloyed steel plate or cast steel. Residual parts of lining plates are made from cheap grey cast iron or cast carbon steel.

2. Range of studies

Studies were made on test-castings of cuboid shape and dimensions 125 x 105 x 40mm.

In sand mould were placed plates of thickness 1,5 and 5mm from X10CrNi18-8 steel with activate covering on their surface (fig.2). Mould was poured low-alloyed cast iron EN-GJL-XCr1 from temperature 1450^{o}C. In result of this was made bimetallic casting (fig.3).

Nondestructive ultrasonic research of joint quality in bimetallic casting was realized with use of defectoscope DIO 562 STARMANS ELEKTRONICS.

Moreover metallographic macro- and microscopic examinations were made with use of light microscopy Nikon EPIPHOT-TME with magnification from 100x to 400x. Surfaces of samples which were prepared for microstructure analysis were etched with use of [6]: Mi19Fe on composition: 3g ferrous chloride, 10cm^3 hydrochloric acid and 90cm^3 ethyl alcohol.

a)

b)

Fig. 1. View of quenching car with lining in form of cast iron plates in time of following stages of work: a) dropping of heated coke and b) its quenching [7]

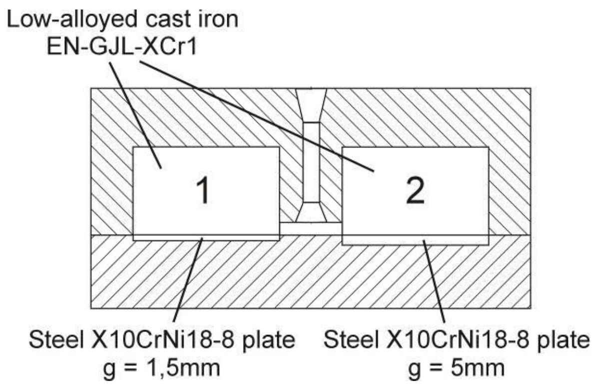

Fig. 2. Section of sand mould ready to pour liquid metal and obtain a test bimetallic casting

Structure examinations were widened by X-ray examinations, which were made using RTG XPertPro Panalytical diffractometer with Co anode. Diffraction examinations were performed within the range of angles 2θ from 35° to 125°. The measurement step was 0,05° in lenght while the pulse counting time was 5s. On the basis of International Center for Diffraction Date ICDD was made identification of phases. This researches concern samples, which were cut from bimetallic casting with use chromium-nickel steel plate to enriched the surface, after one cycle exploitation in conditions of abrasive action of type metal-mineral. The aim of this researches was checking a possibility of abrasive wear resistance increase in result of induce by plastic strain austenite in martensite transformation (γ→α').

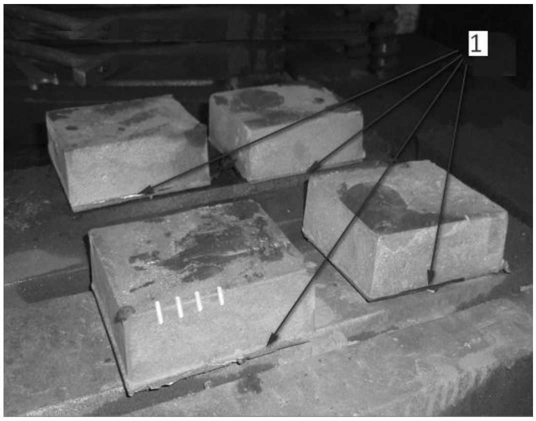

Fig. 3. View of cast iron test-castings with enriched surface by austenitic steel plate – 1

In range of usable properties researches were made hardness, which was measured on ultrasound MIC2 Krautrkramer-Branson 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 in which measure of wear is loss in mass of sample Δm.

3. Results of studies

On the basis of conducted nondestructive ultrasonic researches was affirmed that on complete surface of test bimetallic casting (apply a head from steel plate side) bottom echo was larger than transition zone echo, what shows on good quality of diffusion joint between cast iron and steel plate.

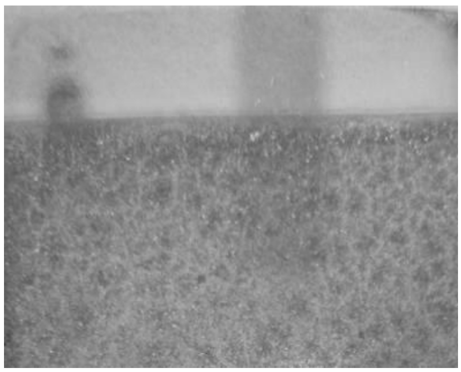

Fig. 4. View of cross-section of bimetallic low-alloyed cast iron casting with enriched surface by austenitic steel plate about thickness 5mm

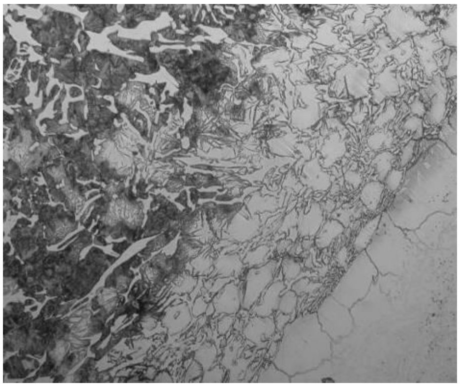

Fig. 5. Microstructure of bimetallic casting from low-alloyed cast iron EN-GJL-XCr1 with enriched surface by austenitic steel plate X10CrNi18-8 about thickness 1,5mm. In direction from surface is visible following: austenite, chromium carbides, chilled cast iron – etching Mi19Fe, magnification 400x

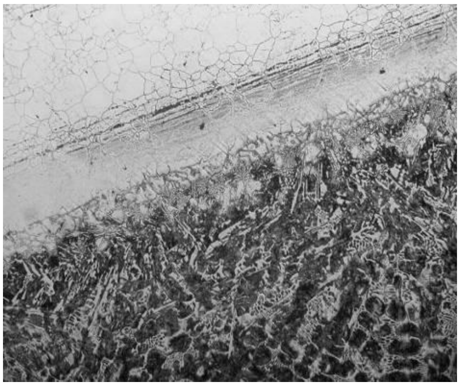

Fig. 6. Microstructure of bimetallic casting from low-alloyed cast iron EN-GJL-XCr1 with enriched surface by austenitic steel plate X10CrNi18-8 about thickness 5mm. In direction from surface is visible following: austenite, impoverished austenite in chromium, chromium carbides, chilled cast iron – etching Mi19Fe, magnification 100x

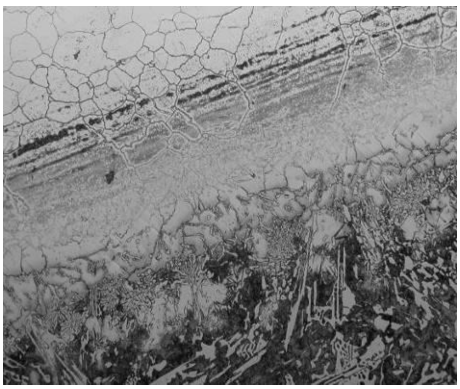

Fig. 7. Microstructure from fig.6 – etching Mi19Fe, magnification 400x

These results were confirmed by presented on figure 4 example of cross-section of test bimetallic casting. Moreover was affirmed that in case of application of thinner plates i.e. about thickness 1,5mm in result of larger temperature gradient and stresses is present their deformation. In result of this part of liquid cast iron pours the plate from above, what additionally causes its dissolution. This phenomenon does not concern steel plate about thickness 5mm.

On figures 5÷7 are presented results of metallographic microscopic examinations. On the basis of this studies was affirmed that in result of carbon diffusion in direction from cast iron EN-GJL-XCr1 to steel plate X10CrNi18-8 and chromium in opposite direction is present diversified structure in joint area of both materials.

In direction from plate to cast iron are following zones: austenite, impoverished austenite in Cr, carbides mainly of Cr, chilled cast iron and far suitable for cast iron i.e. flake graphite in pearlite matrix. Testifying proof about Cr diffusion in direction from plate to cast iron are etching effects (pinholing), which are clearly present in external areas of austenitic plate (fig.6 and 7).

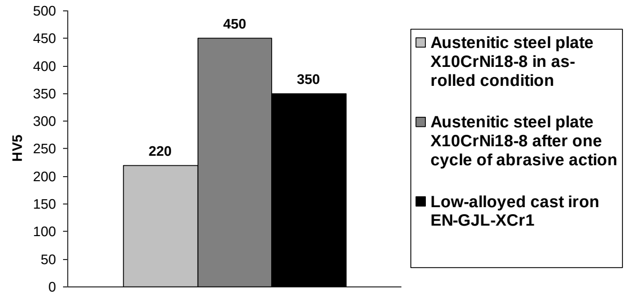

Fig. 8. Graphic interpretation of results of hardness measurements

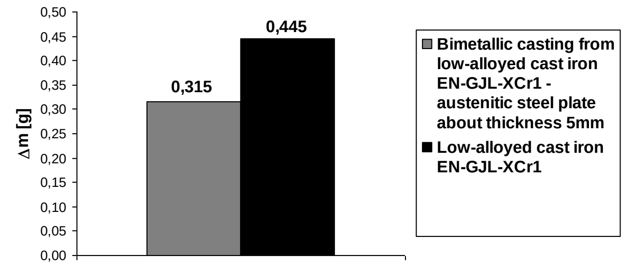

Fig. 9. Graphic interpretation of results of abrasive wear resistance of type metal-mineral, Δm - mass loss of test-casting

Researches of hardness was made for bimetallic casting with austenitic steel plate about thickness 5mm before and after one cycle exploitation in conditions of abrasive action of type metal-mineral. On the basis of this studies was affirmed that is present in this type of casting increase of surface hardness in result of induce by plastic strain austenite in martensite transformation ($\gamma \rightarrow \alpha'$), what is important for exploitation properties. Moreover obtained hardness and abrasive wear resistance of type metal-mineral for bimetallic casting with austenite surface, which strengthens in time of exploitation are larger than for applied so far on lining of quenching car low-alloyed cast iron (fig.8 and 9).

X-ray examinations confirms presence of martensite $Fe_{\alpha'}$, which guarantees increase in hardness and abrasive wear resistance of surface layer structure of enriched bimetallic casting by austenitic Fe_{γ} steel plate (fig.10)

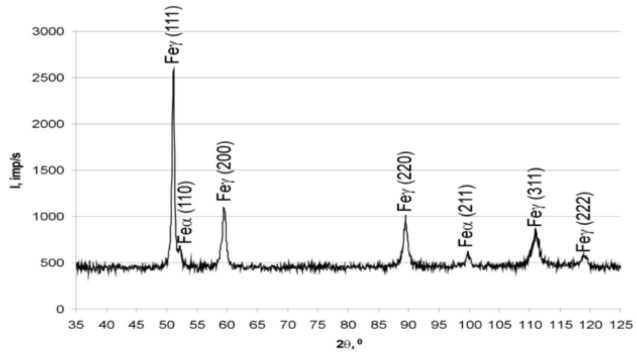

Fig. 10. X-ray diffraction of bimetallic casting with enriched surface by austenitic steel plate after one cycle exploitation in conditions of abrasive action of type metal-mineral

4. Summary

In range of studies authors develop a technology of bimetallic casting steel plate – low-alloyed cast iron for lining of quenching car with very good quality of joint between these both materials. Obtained permanent joint has diffusion character on which decides carbon diffusion in direction from cast iron to steel plate and chromium in opposite direction.

Moreover it was affirmed that application of thinner plates i.e. about thickness 1,5mm causes their deformation in time of pouring, what disqualify this casting for industrial application. Considerably best results was obtained with use thickness of plate 5mm in which austenite has larger heat resistance and hardness after hardening by plastic strain than low-alloyed cast iron.

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