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Investigation of Performance Reduction in Grate Bar Parts with HH Heat Resistance Steel

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Abstract—*Casting heat resistance steels of Fe-Cr-Ni have a high oxidation and delaminating resistance, with strength stability in operating temperature and structural stability considering carbide deposition and they have special importance in many industries. HH casting steel is a wide group of these steels, as they use in many industries such as cement plants, petrochemical and mining industries. In casting steels, higher carbon content than wrought, increases possibility of carbide deposition particularly between grain boundaries and this causes decreasing of mechanical properties and corrosion resistance in this kind of steels. Therefore using methods to change the carbide distribution and decreasing carbide contents to achieve suitable casting structure with high mechanical properties is desirable. In this paper, grate bar segments of iron mines were studied. Three kinds of these steels were investigated as HH steel, HH steel with titanium and HI steel. The microstructure and corrosion resistance of these steel were studied and results were discussed.*

Keywords*: HH steels, HI steels, Heat treatment, corrosion resistance.*

1. INTRODUCTION

Now a days, steels are utilizing within various and widespread situation including high temperature and corrosion environment under dynamical and statistical condition, in which it can be point out to airplane engine exhaust gates, furnace media, oil cracking unit and gas turbines. High temperature applicant steels containing 3 main properties as: 1- resistance to oxidation and scaling, 2- constancy preservation within working temperature and 3- structural stability considering carbides precipitation and sigma phase being spherical [1]. Heat resistance steel of casting type (Fe-Cr-Ni) has properly aforesaid specification and is in high importance within different industries. Heat Resistant steel are containing of different amount of Chromium and nickel. These Steels are many similar to stainless steels unless their carbon content which provide more consistency in high temperature [2]. These casting steel could be of stable austenite, Ferrite or martensite type depending their chromium and nickel content. Therefore their chromium and nickel content would be selected so to bring high consistency in high temperature along with oxidation and corrosion resistance properties [3-4]. Delicate carbide distribution or inter metallic compositions within an austenite matrix considerably enhance the strength in high temperature. For this reason, casting heat resistant steels containing more carbon in relation with stainless steel which containing same chromium and nickel content. Casting Steel HH type establish wide group of heat resistant steel which has most significant application within cement and petrochemical industries [5]. Within casting steel group, containing high carbon content in related to wrought steel, possibility of eutectic carbides precipitation particularly in grain boundary will be increased and reduce mechanical and corrosion resistance property within these steels. Totally a carbide network in grain boundaries is undesired in heat resistant steel. Carbide network in grain boundaries mostly occurred in high carbon content steel or those that are in cooling process from high temperature slowly, in which surplus carbon in austenite will be precipitate (rather than distributed particle). In this way, proportionally to these networks integration brittleness will be appeared. Therefore carbide network, provide proper path for invade of some melting salt in determined atmospheres. Therefore, it would be suggested to some extent of salt bath application which neglecting of resistance in high temperature (which resulting of high amount of carbon content), enhance intra granular corrosion resistance through carbon content optimizing [6]. Hence, implementation of method to make change in carbide distribution and its content reduction and achieve proper casting structure among desired mechanical properties, as an important issue is less noted by others. But considering its importance present research has been focused on verification of these methods and their effective factors.

2. MATERIALS AND METHODS

Grate bar part which extracted from iron mine has been illustrated in figure 1, the samples produced through investment casting method in which its ceramic shell mold has been presented in figure 2. Molten steel has been prepared in 100 kg capacity induction furnace and their chemical composition which obtained through analyzing by quantometer instrument (Spectrolab) has been presented in table 1. Following to said operation, slag sweeping has been performed then molten material pouring into mold has been done in temperature of 1510˚C while mold vacuum was done.

Fig. 1: Grate bar main particle

Fig. 2: Grate bar samples ceramic shell

Table 1: Samples chemical composition (wt%)

Samples	C	Si	Mn	P	S	Cr	Ni	Mo	Ti
HH1	0.4	1.18	0.95	0.022	0.024	24.5	12.1	0.14	-
HH2	0.39	1.75	0.82	0.022	0.023	24.7	12.5	0.14	0.4
HI	0.28	1.55	0.74	0.022	0.013	27	14.2	0.16	-

Heat Treatment on as cast samples has been performed on electrical furnace on temperature 1150˚C in 10 hours, with rate of 100˚C/hr, then all samples quenched in cold water.

To investigation of micro structures, metallographic samples according to standard no. ASTM E3-01 have been prepared and polished under standard condition and etched by 2% Nital solution and resulting structure verified by optical microscope. All as cast heat treated samples, examined by hardness testing procedure. Hardness Testing has been performed by Brinel Equipment, according to ASTM E384-05. To verification of corrosion resistance, mass loss method was utilized.

3. RESULT AND DISCUSSION

Microscopic structures of as cast and heat treated samples have been illustrated in figure 3. As it figured out within as cast samples, carbides have been accumulated on grain boundary and their surroundings, and there were some area without carbides in matrix. Whereas within heat treated samples, there were scattered carbides on the surface and prevented to accumulation of grain boundaries.

Results from hardness testing examination have been illustrated in table 2. Hardness of all as cast samples have been increased after one month passed and treated samples have been reduced.

Weight of samples before and after one month operation has been illustrated in table 3. A littler weight reduction is observed while operation which is not significant.

To receive proper results, the samples would be holding more time in furnace and in operation condition, which will conclude appropriate corrosion results. Considering above mentioned result HI heat treated steel imposing desired structure to utilize as grate bar Parts.

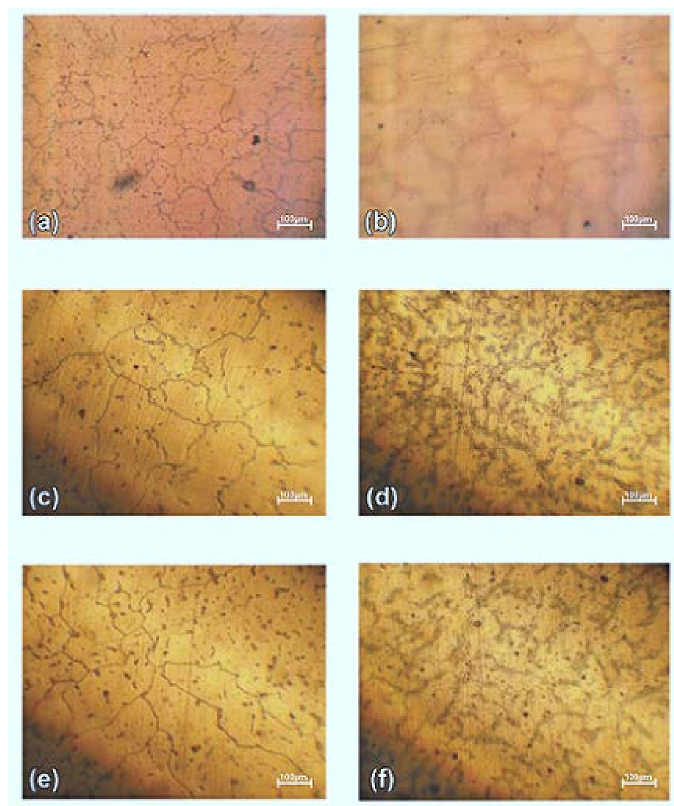

Fig. 3: Microstructure of specimens: (a) and (b) as cast and heat treated HH1, (c) and (d) as cast and heat treated HH2, (e) and (f) as cast and heat treated HI

Table 2: Hardness result of as cast and heat treated samples

specimens	Hardness(HB)	Hardness(HB) (after 1 month operation)
HH1(as cast)	200	215
HH1(Heat treated)	260	238
HH2(as cast)	175	210
HH2(Heat treated)	209	190
HI(as cast)	170	230
HI(Heat treated)	230	200

Table 3: Sample weight before and after operation

specimens	Weight(Kg)	Weight(Kg) (after 1 month operation)
HH1(as cast)	4.26	4.26
HH1(Heat treated)	4.19	4.18
HH2(as cast)	4.18	4.17
HH2(Heat treated)	4.11	4.11
HI(as cast)	4.29	4.28
HI(Heat treated)	4.14	4.14

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