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Microstructure and Effect of Heat Treatment on White Cast Iron B1 Alloy

Dhirendra Agarwal
FET Agra College
Agra

Dr. Ashok Kumar Bansal
S.G.V.Polytechnic College
Bharatpur

ABSTRACT:
The present study essentially comprised a detailed investigation of certain newly designed Fe –Mn –Cr white irons ,containing 10% Mn-6% Cr -3.0% C,10 % Mn -6% Cr -1.5% Cu-3% C and 10% Mn -5% Cr -3.0% C .The investigation was aimed at developing corrosion resistant white cast irons having corrosion resistance similar to expensive highly alloyed Ni-Resist irons. The study comprised assessing the heat treatment response of the experimental alloys with a view to establish interactions between structures and properties .Hardness measurements, optical and scanning metallographic, quantitative metallographic, electron probe micro analysis and differential thermal analysis were carried out to correlate structure, properties and corrosion rate.

INTRODUCTION:
Cast irons are basically binary alloys of iron and carbon having carbon exceeding its maximum solid solubility in austenite but less than the carbon content of iron carbide however like steel cast irons have varying quantities of silicon manganese phosphors and sulphur silicon plays an important role in controlling the properties of cast irons and for this reason the term cast iron is usually applied to a series of iron carbon and silicon alloys cast iron can be classified into various classes depending upon the form of carbon matrix micros structure and application A simple classification would be to categorize them into general purpose and special purpose cast irons the former as the name suggests are cast irons used for general engineering applications and include gray irons malleable irons nodular irons and compacted graphite irons special purpose cast irons include white and alloy cast irons which are mainly used for applications demanding enhanced abrasion corrosion or heat resistance in present study corrosion resistant cast irons are of our interest.
Multiphase microstructure is useful only when the presence of the third phase directly or indirectly helps in reducing the corrosion rate .Alloying elements adds to the corrosion resistance by forming a passive film ,changing the matrix phase ,developing favorable morphology or by changing the electro-chemical behavior of the phase present .

Experimental procedure:
ALLOY PREPERATION
Pig iron ferro-chrome ,ferro-manganese ,ferro-silicon, graphite powder ,electrolytic copper and mild steel scrap were used as raw materials for the preparations of the alloys A medium frequency induction furnace was used for the charge calculated .The molten alloy was cast into cylindrical rods of 25 mm diameter and rectangular strips of 10x20x100 mm size .X-ray fluorescence spectrometer was used for the chemical composition analyses .Chemical analysis is given in Table 1.1

Alloy	C	S	P	Si	Mn	Cr	Cu
B2	3.18	0.039	0.26	1.81	9.82	5.89	1.5

SPECIMEN PREPERATION

Cylindrical and rectangular samples of 8mm length were cut out from the cylindrical rods and rectangular strips respectively with the help of a cut-off wheal .Specimens so obtained were then subjected to grinding operation followed by emery paper polishing .

Round samples were used for hardness measurement, metallography and compression testing whereas rectangular samples were used for corrosion study by weight loss method .

HEAT TREATMENT

Heat treatment involves heating to 800,850,900,950 and 1000^0C ,holding these temperatures for 2,4,6,8, and 10 hours followed by air cooling .A muffle furnace with the accuracy of ± 5^0C was used for heat treating the samples .Temperature was measured by using a platinum –platinum/rhodium (Pt-Pt/Rh) thermocouple

METALLOGRAPHY

Optical metalographical examination was carried out on a Riechert –Jung MeF-3 microscope .Quantitative metallography was carried out on a LEITZ image analyzer at a magnification of 3000X Scanning electron microscopy was performed to see the nature of samples surfaces subjected to corrosion test .A Phillips 501 scanning electron microscope at an opening voltage of 15 KV was used .

RESULT:

Specimens of alloy is heat treated by air cooling from 800,900,950 and 1000^0C after holding for periods ranging from 2 to 10 hours with an interval of 2 hours .The alloys were subjected to these heat treatments to generate the different microstructures and to determine the effect of heat treatment on hardness of the as-cast alloys .Efforts were made to correlate the variation in the hardness values of generated microstructures to the compositions of the alloys and heat treatment schedules. Table 1.2 and Figures 5.1-5.8 show the effect of time and temperature on the hardness of these alloys .While the hardness values summarized in tables are the average values .Figure 5.1-5.3 show the effect of heat treatment time on the hardness of the three alloys B1,B2 and B3 respectively .Figure 5.4 depict the effect of heat treatment temperature (800,850,900,950 and 1000^0Crespectively) on the hardness of three alloys as influenced by soaking periods (2,4,6,8 and 10 hours respectively) .Figures 5.17-5.18 in the form of bar diagrams ,depict the effect of alloy composition on the hardness of the three alloys as affected by heat treatment temperature.

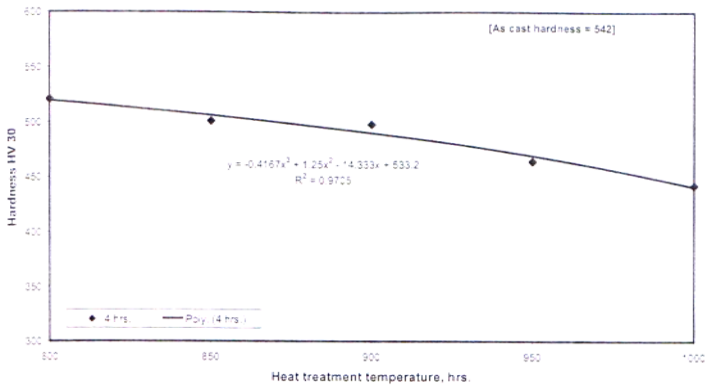

Figure 5.10 Effect of heat treatment temperature on hardness as influenced by h/t time (Alloy B2 - 4 hours)

Table 1.2: Effect of heat treatment on hardness Alloy B2
(At cast hardness =542 HV30)

S.No.	Temperature deg.C	Time, hrs				
		2	4	6	8	10
1	800	523	521	513	499	484
2	850	505	501	484	476	470
3	900	501	498	484	472	467
4	950	469	464	464	448	448
5	1000	442		402	383	366

Table 1.3. Effect of heat treatment on corrosion rate Alloy (As cast CR 23.588 mdd at 168 hrs. & 21.767 mdd at **720 hrs)**

Temperature, deg. C	2 hrs. SP		6 hrs. SP		10 hrs. SP	
	168 hrs.	720 hrs.	168 hrs.	720 hrs.	168 hrs.	720 hrs.
800	23.503	20.900	23.114	20.923	23.212	20.075
850	21.789	19.293	21.594	19.106	20.168	18.047
900	20.768	18.407	20.342	17.903	20.101	17.803
950	18.534	17.013	17.611	15.202	16.918	14.812
1000	16.052	14.334	16.019	13.792	15.823	13.372

DISCUSSIONS

Prior to analyzing the results, it is essential to understand the behavior of alloy under consideration. The microstructure of the alloy in the as-cast condition as well as in heat treated conditions should be explainable on the basis of the chemical composition and relative solubility of various alloying elements in the matrix phase/ and carbides. In addition to this, nature of alloying element will be responsible for the generated microstructures.

Carbon content of the alloy tends to combine with a relatively large concentration of alloying elements. As a result of it, more the carbon lesser is the amount of overall alloy content of the matrix and more is the amount of carbides. A matrix having lesser amount of alloying elements has a natural tendency to transform to martensite and on air cooling there are fair chances that martensite will be present in the microstructure along with austenite.

Graphitizing effect of silicon with the rise in temperature will generate discontinuous massive carbides with a tendency towards rounding off the edges. Austenite with increased stability can possibly precipitate carbides with increase in heat treating temperatures and soaking period. An increase of either heat treating temperature for soaking period or of a soaking period for a heat treating temperature will not only coarse the dispersed carbides but also may promote the dissolution of dispersed carbides and may/ may not transform to martensite. Austenite precipitates dispersed carbides and austenite plus dispersed carbides are obtained. The transformed austenite will contain lesser alloy contents. Massive carbides will get discontinuous and their volume fraction

will get reduced. Such a transformation will be accompanied by rejecting interstitial and substitution solute elements. Massive carbides will get converted to other types of carbides. Interstitial and substitution solute atoms available as a result of reduced volume fraction of massive carbides will go to austenite. This will give rise to formation of austenite having enhanced stability. Austenite having enhanced stability, on raising the heat treatment temperature or time, will precipitate dispersed carbides by lowering its stability. Dispersed carbides will increase with increase in temperature/time and finally will get coarsen. Another possibility also exists i.e. dispersed carbides may get dissolved into austenite at higher temperatures

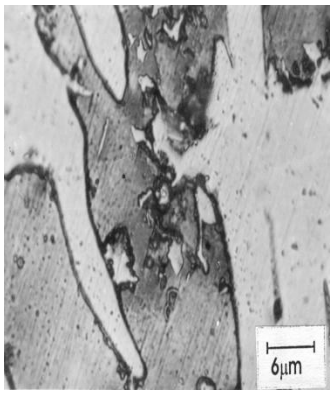

Figure 1

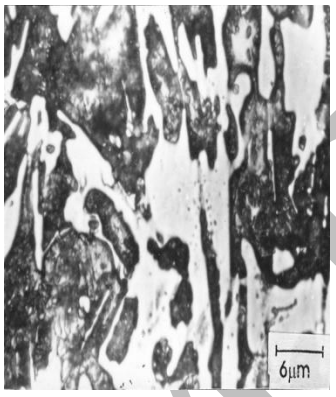

Figure 2

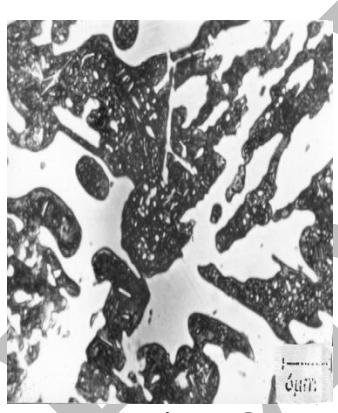

Figure 3

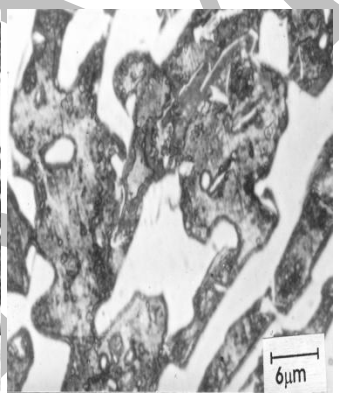

Figure 4

CONCLUSIONS:

On the basis of present study ,it can be concluded that :

1. White cast irons based on Fe-Mn-Cr systems can be successfully used as corrosion resistant cast irons.
2. Better corrosion resistance ,shown by the specimens heat treated from higher temperatures ,is due to austenitic matrix coupled with less volume fraction of massive carbides.
3. Microstructures comprising of spherical and needle like carbides in addition to martensite, austenite and massive carbides attained in the specimens heat treated from lower temperatures and undesirable .
4. Massive carbides have a tendency towards rounding off on heat treating from temperature higher than 900^0C .
5. 5.The volume fraction of massive carbides is lowest at 1000^0C ,10 hour heat treatment .Dispersed carbides coarsen with temperature and get dissolved at higher temperatures above 950-1000^0C .

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