CHARACTERIZATION OF ADI THROUGH FRACTOGRAPHIC ANALYSIS

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Abstract
Two different grades of nodular Cast iron one with Copper and another without Copper were austempered at 300°C for different lengths of time (30 minutes, 60 minutes, 90 minutes & 120 minutes). The mechanical properties like Yield strength (0.2 % offset) U.T.S. and ductility (in terms of % of elongation) were determined and at the same time the fractured surfaces of all the specimens were analyzed with the help of the Scanning Electron Microscope (S.E.M.).

Key Words: **Austempering, Nodular Iron, Strength, Ductility, Fractography.**

INTRODUCTION

Which material offers the design engineer the best combination of low cost, design flexibility, good machinability, high strength to weight ratio & good toughness; wear resistance and fatigue strength? Perhaps the answer will be Austempered Ductile Iron (ADI) [1,2]. ADI offers this superior Combination of properties because it can be cast like any other member of the Ductile Iron family, thus offering all the production advantages of a conventional Ductile Iron Casting. Subsequently it is subjected to the austempering process to produce mechanical properties which are superior to Conventional Ductile Iron [31.

Compared to the conventional grades of Ductile Iron, ADI delivers twice the strength for a given level of elongation. In addition ADI offers exceptional wear resistance and fatigue strength [4,5]. Ductile Iron has commercially replaced as cast and forged steels in the lower strength region now ADI is following its applications in the higher strength regions [6].

Due to its a vast area of applications, extensive works are being carried out now-a-days to study the characteristics this material. Characterization of ADI is of great importance as a result of the great utility of the material. Fractographic Analysis is one of the very important methods of Characterization [7]. In the present work efforts have been made to correlate the mechanical properties of two different grades of ADI with fractographs.

EXPERIMENTAL TECHNIQUES

Two different grades of S.G.Iron (whose composition has been shown in Table-I) were austempered in a salt bath containing a mixture of KNO_3, & $NaNO_3$, (1:1 ratio). It was done at temperatures of 300°C, for 0.5 hrs, 1 hr, 1.5 hrs & 2 hrs. The specimens were then subjected to tensile testing in INSTRON-1195 Machine. The Ultimate Tensile Strength (U.T.S.), 0.2% offset Yield Strength (Y.S.) & % of elongation were measured. The fractured specimen were then studied with the help of the Scanning Electron Microscope (S.E.M.) to determine the nature of fracture.

Table-I (Composition)

Grade of S.G.	% C	% Si	% MN	% MG	% NI	% Cu
Grade – I	3.45	2.3	0.3	0.04	0.03	0.4
Grade - II	3.6	2.1	0.3	0.04	0.03	-

RESULTS & DISCUSSION

The results of tensile test have been shown in Table - 2 & 3 and the fractographs have been shown in Figs. [3&4]. Figs. [1&2J give the graphical representation of the effect of austempering time on the strength property of ADI.

Table – 2 (Tensile Test Data for the ADI with Copper)

Austempering Time (Hrs)	U.T.S. (MPa)	Y.S. (MPa) 0.2 % offset	% Elongation
0.5	872.5	154	21
1.0	967	170	13.51
1.5	745	163.9	17.45
2.0	715	147.7	10.05

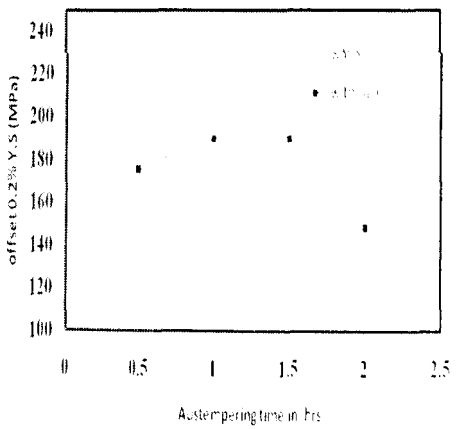


FIG 1. Effect of Austempering time on U.T.S.

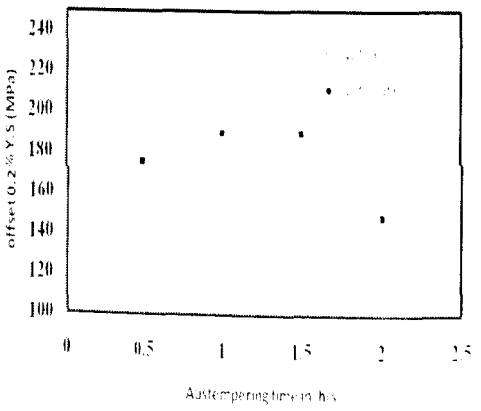
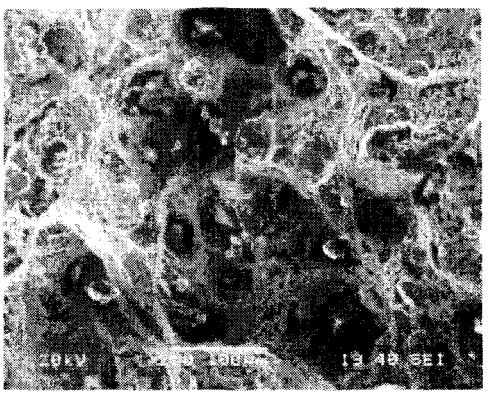
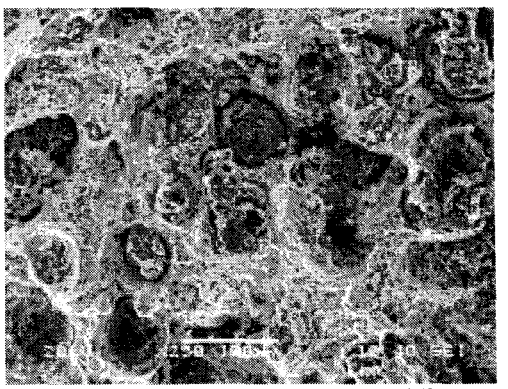


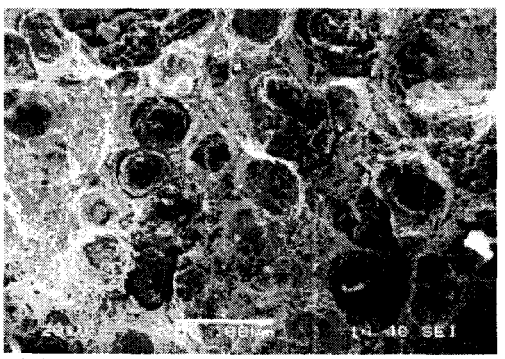
FIG 2. Effect of Austempering time on Y S.



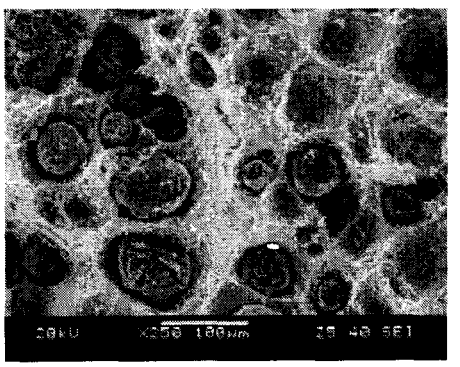


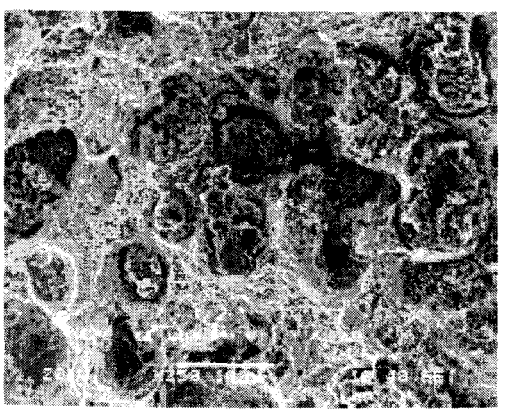
(q) Austempered (1.5Hrs) (s) Austempered (2 Hrs)

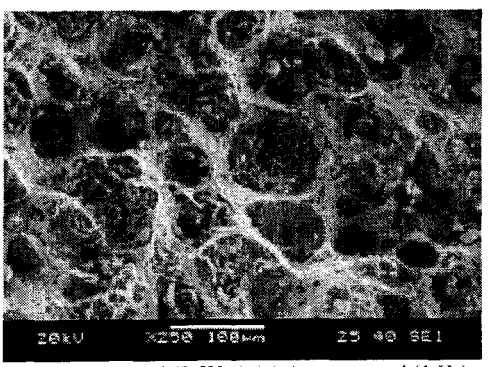
Fig 3. Fracture Surface of specimens (With Cu) after tensile testing.



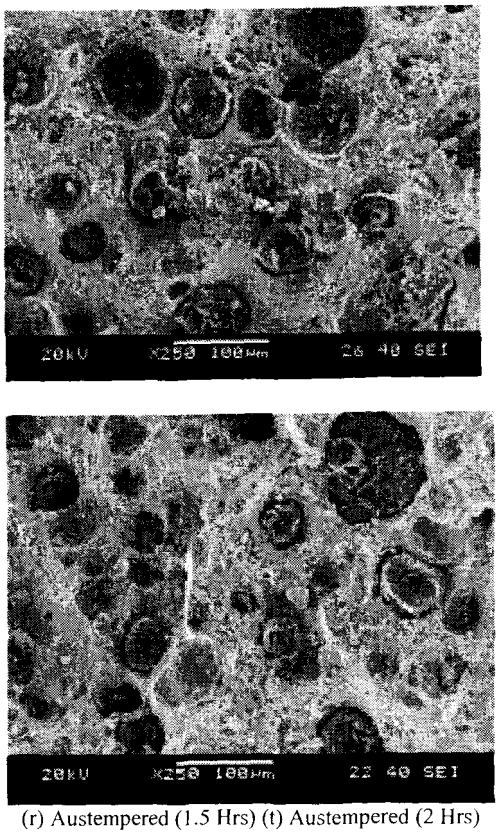
(m)Austempered (0.5Hrs) (o) Austempered (1 Hr







(n)Austempered (0.5Hrs) (p) Austempered (1 Hr)



(r) Austempered (1.5 Hrs) (t) Austempered (2 Hrs)

Fig 4. Fracture Surface of specimens (Without Cu) after tensile testing.

Table – 3 (Tensile Test Data for ADI without Copper)

Austempering Time (Hrs)	U.T.S. (MPa)	Y.S. (MPa) 0.2 % offset	% Elongation
0.5	850	175	33
1.0	942	190	15
1.5	730	190	22
2.0	685	158	19

From the results it is clear that initially there is an increase in strength (both the U.T.S. and the Y.S.) due to austempering but when the austempering time exceeds 1 hr the strength begins to decrease. The effect of austempering is more pronounced on the U.T.S. than on the offset Yield Strength. This behaviour has been found on both the grades of the S.G. Iron (with and without Copper). The effect of austempering time on ductility (which is measured in terms of % of elongation) is not so conclusive. The presence of Cu increases strength and reduces ductility.

Now if we analyses the fractographs *of* the different austempered samples, it can be found that the samples austempered for shorter duration (upto 1 hr) exhibit mixed mode of fracture while the proportion of ductile dimples increases as the time of austempering is increased above 1 hr. The effect of Copper is. however, insignificant on the mode of fracture.

So from the experimental observations it may be concluded that there is a distinct relationship between the mechanical properties and the mode of fracture. In other words it may be stated that the fractographic analysis can serve as a tool for the Characterization of the AD! (Austempered Ductile Iron).

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