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Effect of Austempering Temperature and Time on the Wear Characteristics of Austempered Ductile Iron(ADI)

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ABSTRACT - The present work was taken up to study the influence of austempering temperature and time on the wear characteristics in austempered ductile iron. Microstructure and wear behavior have been studied at austenitization temperature of 900°C and followed by austempering for 60 and 120 minutes at different temperatures, namely 235, 260, 285 and 310°C. Pin on disc test apparatus was used to determine the sliding wear characteristics of the ADI samples. The variation of wear loss with sliding distance, at different austempering temperatures were presented and discussed. It was found that increasing austempering temperature increased the Abrasion resistance of austempered ductile iron.

Keywords: austempered ductile iron, austenitization, austempering, abrasion resistance.

1. INTRODUCTION

Due to the attractive properties like good ductility at high strength, high fatigue strength, fracture toughness, along with good wear resistance, austempered ductile iron(ADI) is an interesting engineering material [1-4] and is related to its unique microstructure that consists of ferrite and high carbon austenite. Properties of ductile iron may be improved by subjecting it to austempering heat treatment process consisting of two stages namely austenitization [5,6] and austempering [6,7]. Wear is an important study in characterizing a material for a particular application [8,9]. It has been classified by different authors based on mechanism involved, interaction between the surfaces and medium used [6,10]. In the present study, investigation have been carried out on microstructure, wear properties of ADI at different austempering temperature and time [12].

2. EXPERIMENTAL WORK

The composition of ductile iron shown in table 1. Eight specimens size of 10mm thick and 15mm*10mm dimension cut from the given block for metallographic work.

Table 1 Chemical composition of ductile iron used in present work.

Element	C	Mn	Si	S	P	Ni	Cu	Cr	Ti	Mg
Wt%	3.332	0.275	3.325	0.017	0.026	0.263	0.713	0.012	0.013	0.027

Austenitization was done at 900°c for 120 minutes on all the samples in programmable heat treatment furnace. The samples were quickly transferred to the salt bath at 235°c, 260°c, 285°c, 310°c for the time period of 90 and 120minutes and then cooled in air at room temperature. The austempering temperature and time details are shown in table 2.

Optical microscopy was performed on all the polished and 5% etched natal solution. To test the wear resistance, pin on disk machine was used [11]. Abrasion test was calculated on 120 meshes alumina abrasive disk with a load of 40N, in accordance with ASTM standard. A standard time of 4 hours was selected the test on all the samples and sliding distance was calculated by using the formula.

Sliding distance (d) = Sliding velocity * time (t)

The test was used to calculate the wear loss after a gap of every 1 hour and compare wear loss of ADI with changing austempering temperature and time.

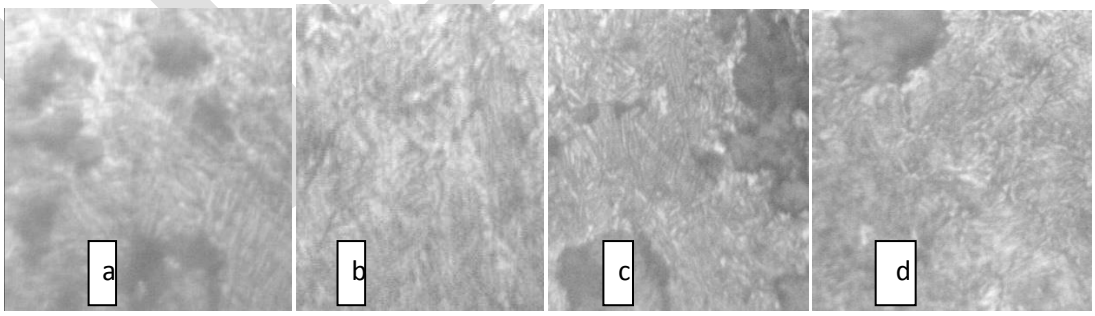
Table 2 List of austenitization and austempering temperature and time for all the samples.

Sample No.	Austenitization temperature (°C)	Austenitization time (minutes)	Austempering temperature (°C)	Austenitization time (minutes)
a	900	120	235	90
b	900	120	235	120
c	900	120	260	90
d	900	120	260	120
e	900	120	285	90
f	900	120	285	120
g	900	120	310	90
h	900	120	310	120

3. RESULTS AND DISCUSSION

Microstructural study

Fig 1 shows microstructure ADI samples through the magnification of 3000X under a microscope. Study of microstructure shows the formation of bainite and also shows the carburization of samples except in the sample e where a white patch is visible which lead to the decarburization of the particular sample. By studying all the samples it was seen that with the increase in austempering temperature size of bainite and martensite present in the ADI samples increases which leads to coarsening of the structure. Size of bainite needle remains approximately same for sample a, b and c but there is little increase in size for sample d and e and size increases drastically as we move to sample h with highest austempering temperature and time.



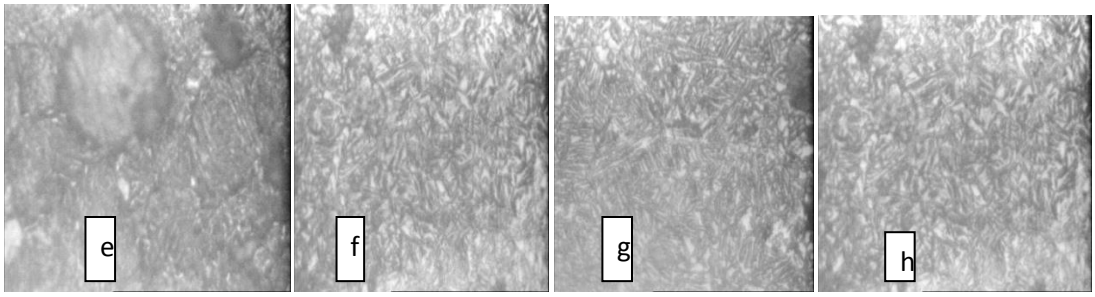
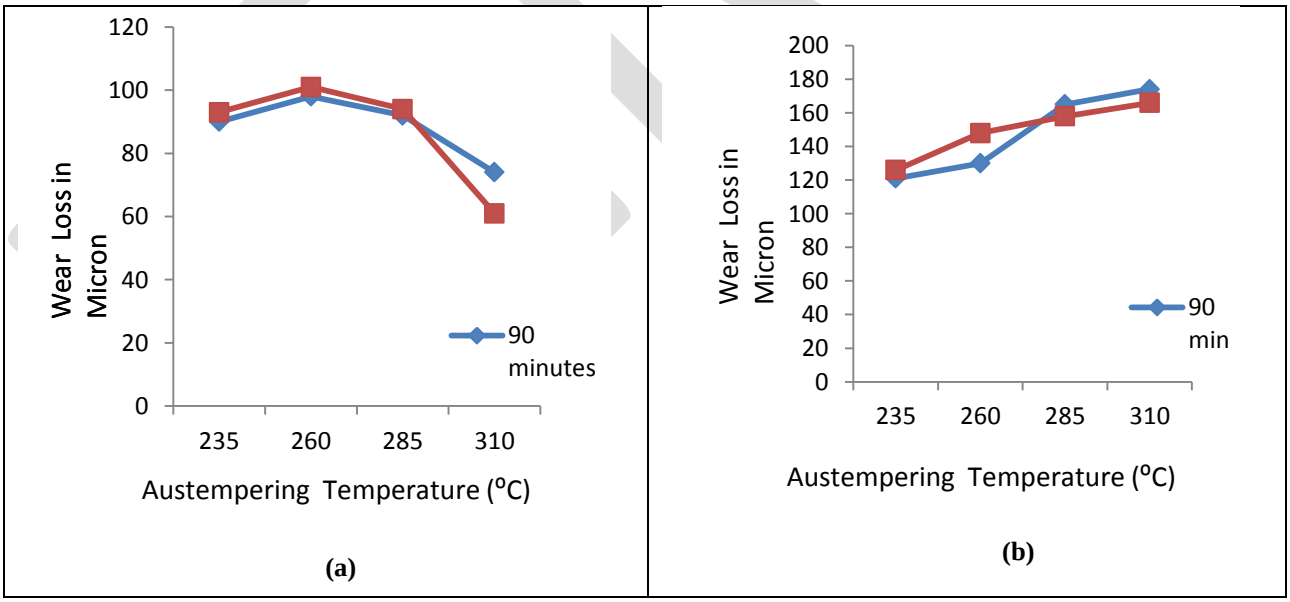


Fig 1 Microstructure of samples under optical microscope showing bainite formation. a(finer structure), b (finer structure), c (finer structure) and shows carburization, d (medium size needle), e(decarburized sample), f (medium needle), g (coarser structure), h (coarser structure).

Wear Analysis

Fig 2(a),(b),(C) and (d) shows wear loss of ADI samples at preselected temperatures and time. Wear loss is similar in first hour for both 90 and 120 minutes of heat treatment it increases as austempering temperature moves from 235°C to 260°C further with the increase of austempering temperature to 285°C wear loss decreases marginally and wear loss is more rapid when austempering temperature rises to 310°C. For wear between 1 to 2 hours wear loss is low for 235°C and 260°C of 90 minutes samples as compared to 120 minutes samples, but it remains same with further increase in temperature for both the time period. In the third and fourth hour of wear, wear loss is maintained for 235°C and 260◦C for both 90 and 120 minutes. with further increase in temperature to 285°C of 90 minutes sample wear loss is very drastic but marginally for 120 minutes sample and with rising of temperature to 310°C there is only little increase in wear for both the timings. As a result it was observed that wear loss increases with increasing the time period but it is rapid in starting and increases normally after some time. The abnormality in the sample e (285˚C,austempering temperature for 90 minutes) is because of fact that structure has undergone a drastic decarburization during austenitizing process. It is quite probable that during austenitization the sample must have remain outside the carburizing bed resulting in loss of carbon which contribute to decrease in wear resistance of this sample.



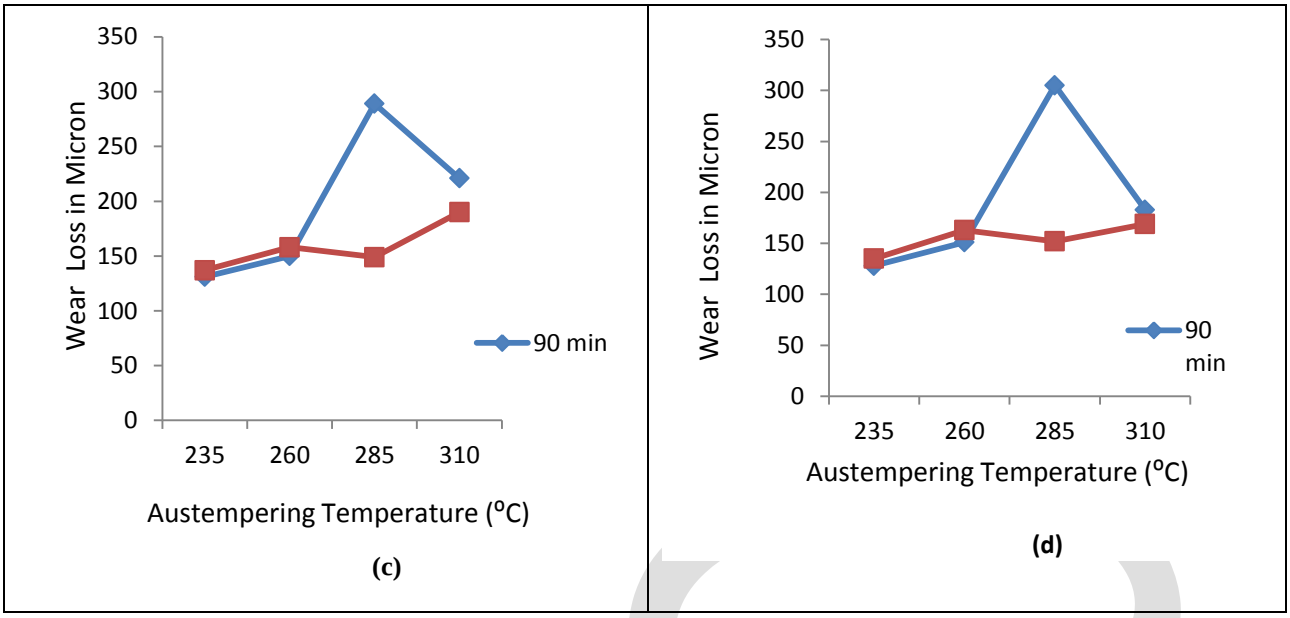


Fig 2 The wear loss changes with the change in austempering temperature and time. after (a) 1 hour (b) 2 hours (c) 3 hours (d) 4 hours

In fig.3(a) it was observed that with increasing sliding distance wear loss increases for all the samples but wear is more significant in 285°C and 310°C. With increasing the sliding distance from 15000m to 22000m sample austemepred at 285°C shows drastic wear loss as compared to the other austempering temperatures. After 22000m sliding distance wear becomes stable for all the samples except 285°C sample in which wear still increases. Fig 3(b) shows that wear starts an average of 87 microns except for 310°C sample which starts at 63 microns and goes to 156 microns as the sliding distance rises upto 15000m which is more than all other samples. With further increase in distance wear remained same upto 22000m of sliding distance except for sample austempered at 285°C for which wear comes down upto this point and again starts increasing beyond this as sliding distance rises upto 29000m. At that point wear for 310°C becomes stable and rises at same rate for all other samples which means wear for 260°C austempered sample is highest at this point. By comparing fig 3(a) and (b) it was observed that wear is less for sample austempered at lower temperature than the higher temperature.

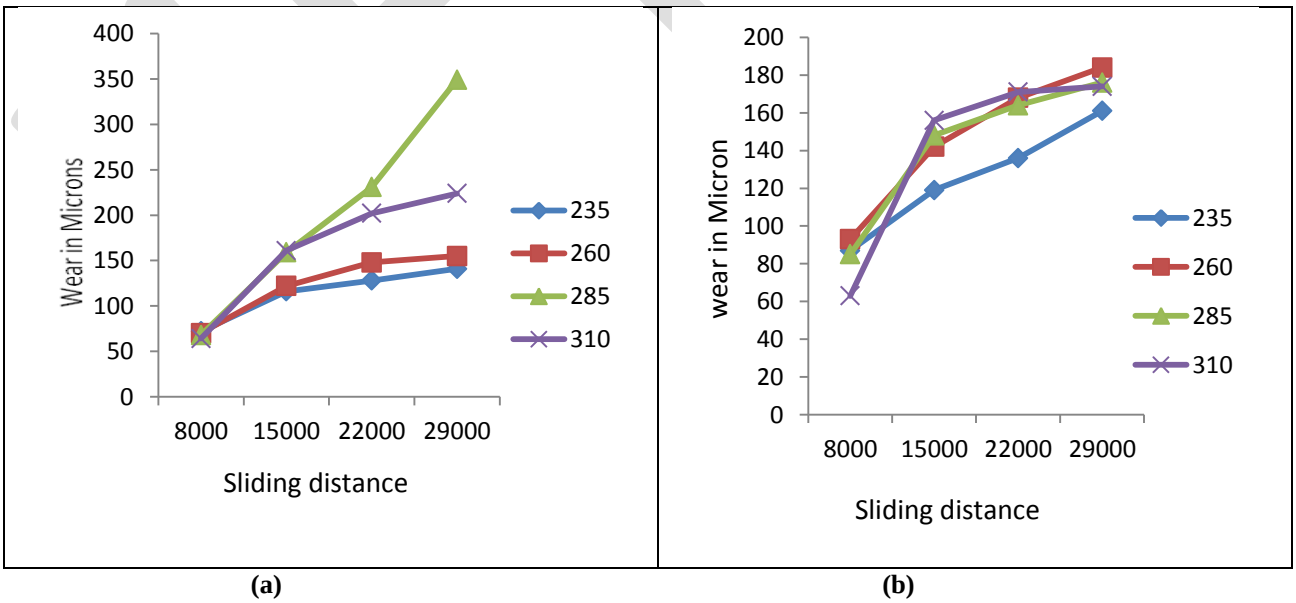


Fig 3 The amount of wear as sample covers more distance on the abrasive surface when austempering time is (a) 90 minutes (b) 120 minutes.

CONCLUSION

With the increase in austempering temperature and time microstructure of austempered ductile iron (ADI) becomes coarser. Abrasion resistance of austempered ductile iron (ADI) decreases with increase in austempering temperature and time. But the abrupt behavior shown by sample e in abrasion resistance is attributed to the decarburization that occurred during the austenitization process.

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