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Effect of Austenitization Temperature on Wear Behavior of Carbidic Austempered Ductile Iron (CADI)

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Abstract**—**Chromium bearing Austempered Ductile Iron (ADI) has been recently in the news for its improved wear performance over the ADI. The work presented below was taken up to study the effect of different austenitisation temperatures on the microstructure and wear performance of the Carbidic Austempered Ductile Iron (CADI). In this investigation Cr bearing ductile iron was subjected to austempering treatment to obtain an ausferritic microstructure. Two different austenitisation temperatures were selected whereas, the austempering temperature and time was kept unchanged. Microstructure and wear performance of this alloy, austenitized at two different temperatures was studied.

Keywords**—**Austempered Ductile Iron, Carbidic Austempered Ductile Iron.Austenitization temperature.

I. Introduction

AUSTEMPERED Ductile Iron (ADI) has long been recognized for its high tensile strength and has replaced forged steels in many applications. It is also well known for its ability to perform very well under different wear conditions such as rolling contact fatigue, adhesion and abrasion [1], [2]. Past literature study revealed that, metallurgists were trying to improve upon the wear resistance of the ADI by incorporating alloy carbides in the matrix of ADI and one of the outcomes of these efforts is the Carbidic Austempered Ductile Iron (CADI).

Austempering of ductile iron has widely been studied, but the same process when applied to 'Cr' bearing ductile iron, still it remains an unexplored area. Hence, the attempt has been made in the present work was to study the effect of austenitisation temperature on the microstructure and wear of these alloys.

II. Experimental Work

A. Composition

The chemical composition of the alloy studied is given in Table I.

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TABLE I
CHEMICAL COMPOSITION OF THE ALLOY

Element	*Wt%*
C	2.45
Si	1.8
Mn	0.88
S	0.014
P	0.03
Cr	2.42
Cu	0.55
Ni	0.52

B. Sample Preparation

The as cast samples in the form of cylindrical rods, 25mm in diameter and 300mm in length were subjected to an austempering treatment. Two temperatures 900^0C and 975^0C were selected for austenitisation. One set of samples was austenitized at 900^0C for 1 hour and then quenched in a molten salt bath maintained at 325^0C. Samples were taken out from the austempering bath after a holding of 2, 6 and 10 hours. Another set of samples was austenitized at 975^0C for 1 hour and was subjected to similar treatment as that of set 1. All samples were then air cooled to room temperature. The schematic representation of the austempering cycle is shown in Fig. 1.

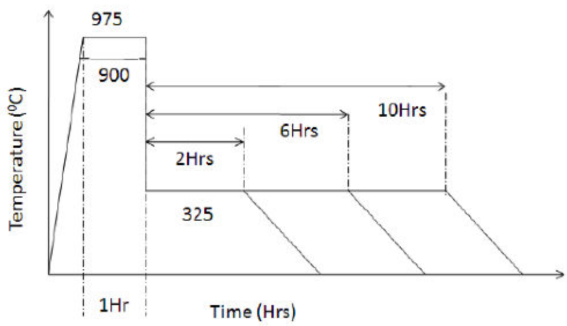

Fig. 1 Schematic representation of austempering treatment employed

All metallographic samples were obtained from the cross section of the austempered rods. The un-mounted samples were ground and fine polished thus avoiding artifacts due to oxidation. The samples were examined in un-etched condition, reveling graphite population characteristics on freshly polished samples. Essential information concerning the matrix structure was reveled after etching the sample with nital 2%.

C. Tests

Hardness measurements were made on the polished surface. The reported hardness values are the average of eight observations.

Wear tests were carried out on a Ducon make pin-on-disc type of machine. The speed of wear disc was kept constant at 400rpm; duration of test was 90min: wear track length was 10048m.

The pin dimensions were Ø10mm and 25mm height. Normal load on the pin was 2kg. 150 grade Silicon Carbide abrasive papers were used as counter face for the wear test. The wear was measured in term of weight loss. Wear rate was calculated as weight loss per unit area per unit time per unit load per unit of sliding distance.

III. Results and Discussions

A. Microstructure

The representative microstructure in the as cast condition is shown in Figs. 2(a), (b).

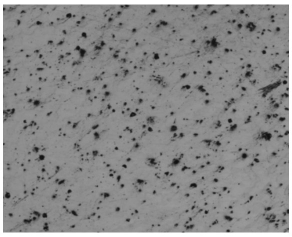

Fig. 2 (a) Un-etched condition 100X

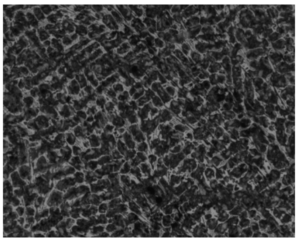

Fig. 2 (b) Etched with 2% Nital 100X

The as cast microstructure of the Cr- bearing DI in Fig. 2 (a) clearly shows the graphite in the nodular form uniformly distributed in an unetched condition while Fig. 2 (b) revealed the presence of chunky Cr-carbides (white areas) in a pearlitic matrix in the etched condition.

The representative microstructures obtained after austempering treatment are given in Fig. 3. It is clearly seen that the ausferritic microstructure is developed in both the heat treatments i.e. austenitization at 900^0C as well as 975^0C.

The structure obtained at 900^0C is very much fine as compared to that obtained at 975^0C. With increasing duration of holding at the austempering temperature, fine uniformly distributed carbides are visible in the matrix of samples austenitized at 900^0C. Such fine carbidesare not observed in samples austenitized at 975^0C.

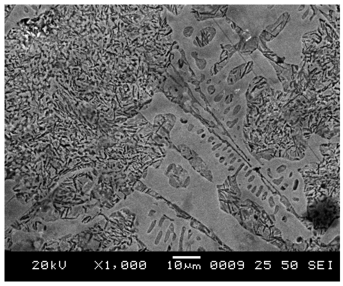

Fig. 3 (a) Microstructure of sample austenitized at 900^0C and austempered at 325^0C for 2 hours

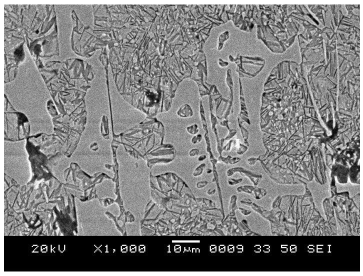

Fig. 3 (b) Microstructure of sample austenitized at 975^0C and austempered at 325^0C for 2 hours

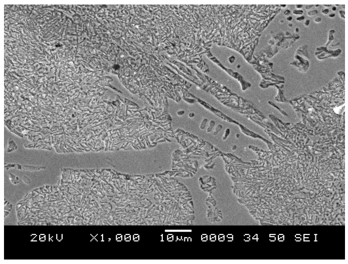

Fig. 3 (c) Microstructure of sample austenitized at 900^0C and austempered at 325^0C for 6 hours

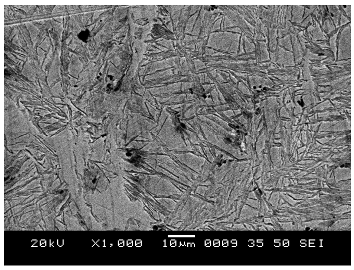

Fig. 3 (d) Microstructure of sample austenitized at 975^0C and austempered at 325^0C for 6 hours

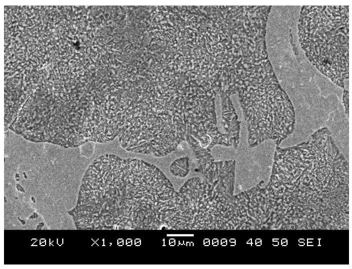

Fig. 3 (e) Microstructure of sample austenitized at 900^0C and austempered at 325^0C for 10 hours

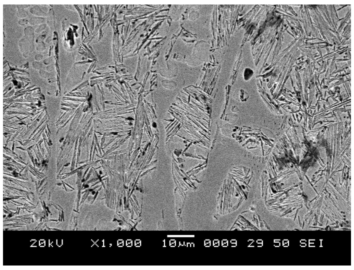

Fig. 3 (f) Microstructure of sample austenitized at 975^{0}C and austempered at 325^{0}C for 10 hours

B. Hardness & Wear

The hardness comparison of the samples austenitized at the two temperatures is given Fig. 4.

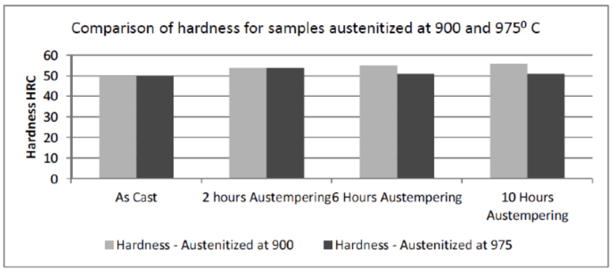

Fig. 4 Hardness comparison

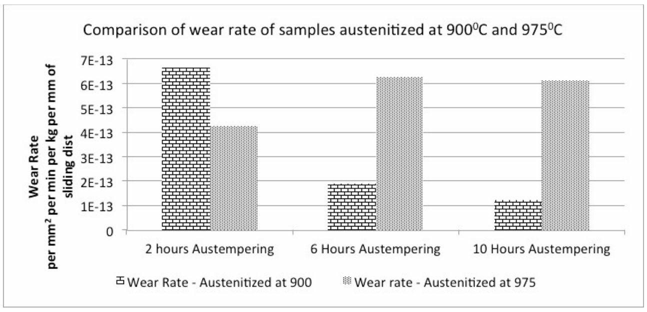

Fig. 5 Wear rate comparison

The bulk hardness observed after austempering in all samples is slightly higher than that seen in the as cast condition. It is also seen that the hardness in case of samples austenitized at 900^{0}C is slightly more than that in case of samples austenitized at 975^{0}C.The increase in hardness is attributed to the presence of fine ausferritic matrix observed in these samples.

Comparison of wear rate clearly shows that wear rate of samples austenitized at 900^{0}C is very less as compared to those austenitized at 975^{0}C. The low wear rate is attributed to the presence of finely dispersed carbides seen in these samples, which is illustrated in Fig. 5.

It is well known that the austempering temperature (T_A) and the austenitization temperature ($T\gamma$), both influence the microstructural characteristics of the ADI.

Tanaka et al. [3] have reported that the driving force for the austenite to transform into ferrite at the austempering temperature is more in case of ductile iron austenitized at lower temperature. With higher driving force available, more number of ferrite nuclei are formed at the selected austempering temperature. The observed fine microstructure in case of samples austenitized at 900^{0}C is thus in agreement with the findings of Tanaka.

Available literature [4]-[7] indicates that ductile iron austenitized at lower temperature will have iron carbides in the matrix along with the auseferrite.

Thus the ductile iron samples austenitized at 900^{0}C show evenly distributed carbides in the ausferritic matrix.

IV. Conclusion

Based on the observations it can be concluded that;

A. Austenitisation at 900^{0}C and subsequent austempering produces fine ausferritic microstructure with finely dispersed carbides in this matrix.
B. Lower austenitisation temperature decreases matrix carbon content of the parent austenite results in a more rapid transformation and a resulting finer scale product. Thus increase in transformation rate was attributed to an increased thermodynamic driving force for the reaction generating more ferrite nuclei and therefore a finer scale product.
C. The low wear rate is observed for DI austenitised at 900^{0}C indicating a better wear resistance in these samples

Acknowledgment

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