Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

Effect of vanadium addition and cryogenic treatment on the development of carbidic austempered ductile iron

Subham, Parth Shukla and Indrajit Chakrabarty
Department of Metallurgical Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi-221005, India.
e-mail: ichakraborty.met@iitbhu.ac.in

The present study has been carried out with an objective to evaluate the effects of additions of vanadium to develop CADI structure. Further improvement in wear properties may be achieved with a cryogenic treatment. In view of this, the iron was subjected to cryogenic quenching in dry ice bath at -50^{0}C subsequent to austempering. The effects are characterized by optical and scanning electron microscopy, hardness and impact toughness measurement and the study of dry sliding wear behavior.

Keywords: *Carbidic austempered ductile iron, cryogenic treatment, impact toughness, dry sliding wear.*

1. Introduction

Hard carbides in a tough ausferritic matrix gives a superior quality wear resistant material which is known as carbidic austempered ductile iron (CADI). f CADI can be developed by alloying with Cr,Mo,V,B or Ti either singly or in combination so that approximately half of the carbon is bound as eutectic carbides [1,2]. Control over the microstructure is exercised in order to obtain the optimum balance between wear resistance and toughness. Deep cryogenic treatment at liquid nitrogen temperature has been reported to improve the wear properties of certain materials [3]. But use in ADI has been rather limited except a few [4,5]. Deep cryo-treatment has been found to cause a complete conversion of the retained austenite into martensite.The aim of the present paper is to study the effect of cryotreatment on the microstructure and mechanical properties of vanadium containing Carbidic Austempered Ductile Iron.

2. Experimental

The as-cast irons were subjected to austenitization at 900^{0}C for 1 h and subsequently austempered at 350^{0}C and 420^{0}C in a salt bath (KNO_3+ $NaNO_3$ in 1:1 ratio) for 15,30, and 45 minutes. Subsequently samples were either air cooled or quenched in dry ice in alcohol bath of temperature -50^{0}C for 6h.

Table 1 Chemical Compositions of the alloy irons.

Alloy Designation	%C	%Si	%V
Alloy 1	3.6	2.0	0.1
Alloy 2	3.5	2.2	0.3

3. Results and Discussions

The austempered structures of alloy 1 at 350^{0}C with varying austempering times followed by cryotreatment are shown in Fig.1. The structures show acicular ausferritic and considerable amount of retained austenite. With increase in austempering time acicularity is gradually decreasing and the retained austenite has increased with 30 min; further increase in causes increase in fine precipitate and decrease in retained austenite. On increasing austempering temperature from 350^{0}C to 420^{0}C, the morphology of ausferrite no longer remaining acicular in nature and fine secondary alloy carbides are precipitated in the matrix. When ferrite forms within the austenite during the austempered process of nodular or ductile cast iron, the carbon is rejected from these regions and goes into solution in the surrounding austenite. As more and more ferrite forms, the carbon content of austenite (γ_{HC}) increases. However, if sufficient austempering time is provided this γ_{HC} initiate rejection of alloy content and Ms temperature is raised. During subsequent cooling it will transform to martensite. Since the cryotreatment is shallow type the M_f is not reached and a considerable retained austenite is observed.

Although the amount of retained austenite differs, similar trend of transformation has been observed with and without cryo-treatment.

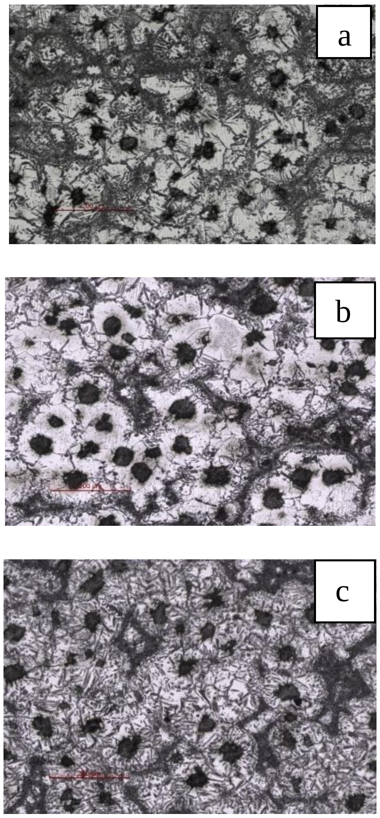

Fig. 1 Microstructures of austempered CADI at 350^{0}C for a)15, b)30 and c)45 minutes followed by cryotreatment.

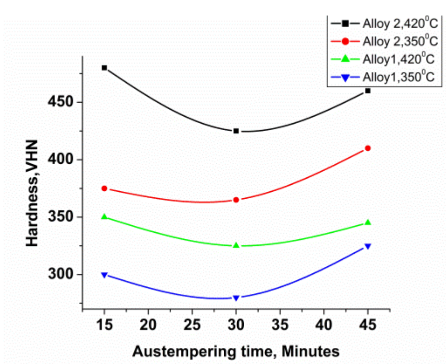

Fig. 2 Hardness vs. austempering time plot with cryotreatment.

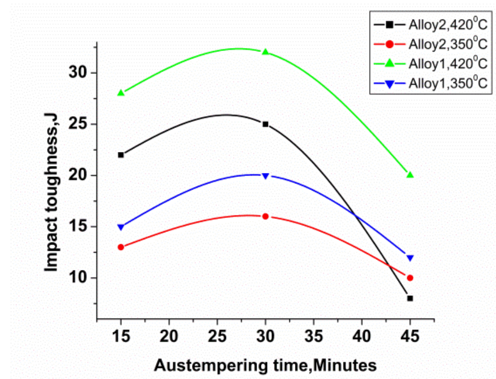

Fig. 3 Charpy impact toughness vs. Austempering time plot with cryotreatment.

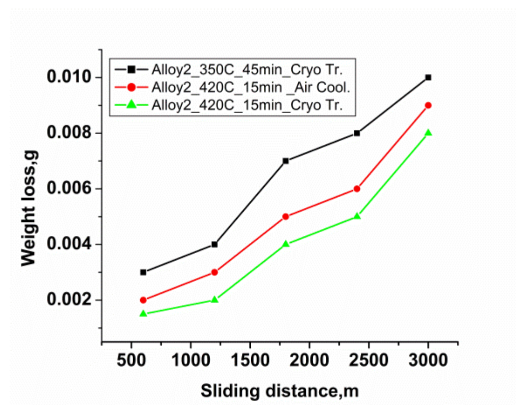

Fig. 4 Dry sliding wear loss vs. distance plot (velocity:1m/s; load:30N).

References

1. K.L. Hayrynen, K.R. Brandenberg: AFS Transactions,111 Paper No.03-088, (2003) 845-850.
2. S. Laino, J.A. Sikora and R.C. Dommarco: Wear 265 (2008) 1–7.
3. D.N. Collins, J. Dormer, Heat Treat.Met.24(1997) 71–74.
4. Susil Putatunda, C. Martis, R. Papp and F. Diekman, in: B.L.Ferguson, R. Jones, D.S. MacKenzie, D.Weires (Eds.), Proceedings of the 26th ASM Heat Treating Society Conference (2011) 44–49.
5. Saranya Panneerselvam, Codrick J. Martis, Susil K. Putatunda and James M. Boileau, Mater.Sci.Eng.A 626(2015)237–246.