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Development Of Effect Austempered Ductile Iron And Property Evaluation With Addition Of Aluminium

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Abstract

*Many engineering applications in the present scenario are utilizing ferrous metals and its alloys, because of its better properties compared to its any other alloys or metals. Few metals like Titanium, Niobium, Vanadium etc exhibits better properties than ferrous metals even at higher temperatures, but cost of application is too high. Ductile iron is the ferrous metal which is used in railways, machine tools, machine members etc. This material has properties of both steel and cast iron. But the researchers found difficulties in using the ductile iron in place of steels due to lack of formability. The main objective of this work to increase the tensile strength and ductility with the addition of Al (commercially pure 99.97%) to the ductile iron which is followed by austempering. By considering the differences in melting point between the ductile iron [>**1400 ºC**] and Al [**660ºC**] alloying may become difficult. The effort has been made to overcome the difficulties encountered during alloying by taking cost in to consideration. It is achieved by varying the composition of Al into ductile iron matrix and austempering is carried out on prepared specimen and effect of variation in austempering time and temperature on the tensile behaviour of the ADI specimen is discussed.*

Keywords: *ADI, Austempering, Ferrous metals, Melting point.*

1. INTRODUCTION

Cast iron and steel are the ferrous materials, which are used extensively in many structural and industrial applications. Some of the applications need both the properties of CI and Steel. For steels that ductile iron is subjected to special heat treatment process called Austempering, which results in development of ADI [1]. ADI is nearly twice as strong as pearlitic ductile iron and also it has high elongation and toughness. This combination provides a material with superior wear resistance and fatigue strength to conventional ductile iron, cast and forged aluminum and many cast and forged. The mechanical properties of ductile iron and ADI are primarily determined by the metal matrix. The matrix in conventional ductile iron is a controlled mixture of pearlite and ferrite. The properties of ADI are due to its unique matrix of acicular ferrite and carbon stabilized austenite; called ausferrite.

Austempered ductile iron (ADI) is a ductile iron that has undergone a special isothermal heat treatment called austempering. Unlike conventional “as-cast” irons, its properties are achieved by specific heat treatment. Therefore, the only prerequisite for good ADI is a good quality ductile iron. Austempering process modifies the microstructure of the basic cast iron to obtain a bainitic matrix. Austempering treatment enables reaching mechanical characteristics comparable with those of certain steels [2].

2. EXPERIMENTAL PROCEDURE:

Material Selection: Cold rolled Coil (CRC) scrap is used as the raw material for the preparation ductile iron. Carbon is added in the form of burnt coconut shell. Magnesium and silicon is added in the form of Ferro silicon magnesium and Ferro silicon.

Melting: Melting was done in a induction furnace of capacity of 250kg and 130 kW power.. After melting the melt was transferred into the ladle for alloying purpose. After alloying the melt was poured into the prepared mould.

Mould Preparation: Standard Y block were prepared using green sand mould. There are 3 main reasons for the use of the Y blocks in case of standard tensile test bars that are used for ductile iron castings. These reasons are,
\To prevent the formation of casting defects like shrinkage.

i. To take the slag from upper part of the casting.
ii. To enable the full spherodization and complete formation of pearilitic microstructure.

(a) (b)

Figure.1. (a) pattern used preparing the mold, (b) mold prepared using the pattern

Specimen preparation: The prepared melt was poured in to sand mouldafter solidification Y block taken out and proper machining operations were carried out to prepared standard test bar.

Figure.2. Front and left views of the Y block prepared from DI

2.1. Heat Treatment

The prepared specimen was subjected to austempering process. Before austempering the specimen was subjected to austenization in a resistance furnace. Program was done in the furnace in such a way that to maintain 900°C where the specimen is kept for 1hour. Then the specimen is transferred to the oven where the quenching media was maintained at 300°C in a cylindrical tube. The oven chamber was enclosed and specimen kept for 1hour and it is allowed for cooling slowly to room temperature. The quenching media selected for austempering was engine oil (Servo Max 4T grade). Figure.3 shows the heat treatment cycle used in this experiment.

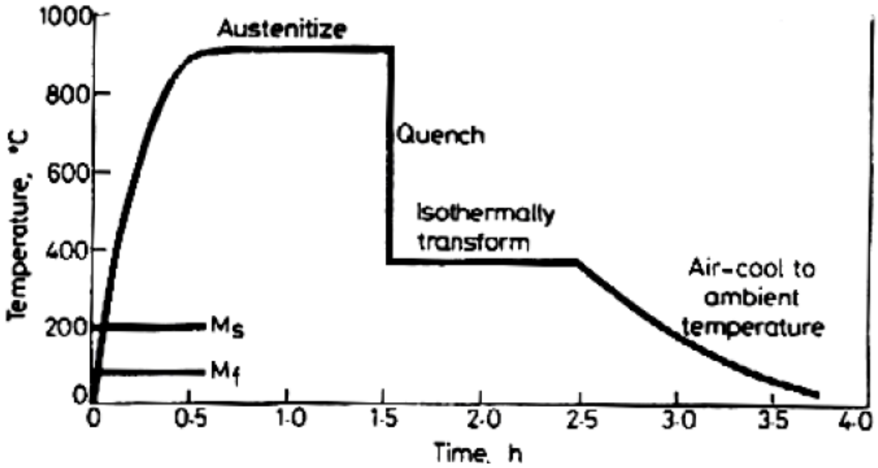

Figure.3. Typical Heat Treatment cycle

3. EFFECT OF ALLOYING ELEMENTS ON DUCTILE IRON

Experimentation has done by varying the composition of Cu and Al separately in the ductile iron matrix. The effect of these alloying additions on the tensile property of the ductile iron was studied before and after the heat treatment.

3.1. Effect of Aluminum on the Tensile Strength of Ductile Iron

To find out effect of Aluminum, four samples were made with 0.0 wt. %, 0.5 wt %, 1.0 wt. % and 2.0 wt. %. The tensile samples were machined from the castings. The results are tabulated in table 1

Table 1: Effect of Aluminum on Tensile Strength of Ductile Iron

Aluminum	ULTIMATE TENSILE STRENGTH (N/mm^2)			
	0 wt%	0.5 wt%	1.0 wt%	2.0 wt%
Without heat treatment	561.5	616.7	499.0	498.17
With heat treatment	1009.4	1324.6	1047.65	789.7

The tensile strength of ductile iron samples was 561.5 N/mm^2 without any addition of Aluminum to the heat. When Aluminum addition of 0.5 wt % was made in the ductile iron, the tensile strength increased to 696.1 N/mm^2. With the Aluminum addition of 1.0 wt %, the tensile strength decreased to 499 N/mm^2. When the Aluminum addition was further increased to 2.0 wt %, the tensile strength again decreased to 498.17 N/mm^2. Table 4.2 shows the variation in the tensile property as the change in Al composition. From the result obtained it clearly said that 0.5% is optimal value for the addition of Al to DI, above that composition there will be decrease in the tensile strength of DI before the heat treatment.
After the heat treatment, tensile strength of ductile iron samples was 1009.4 N/mm^2 without any addition of Aluminum into the melt. With the Aluminum addition of 0.5 wt % in the ductile iron the tensile strength increased to 1324.6 N/mm^2. When the Aluminum addition was increased to 1.0 wt %, the tensile strength was decreased to 1047.65 N/mm^2. When the Aluminum addition was further increased to 2.0 wt %, the tensile strength again decreased to789.7 N/mm^2. From the result obtained it clearly said that 0.5% is optimal value for the addition of Al to DI, above that composition there will be decrease in the tensile strength of DI after the heat treatment.

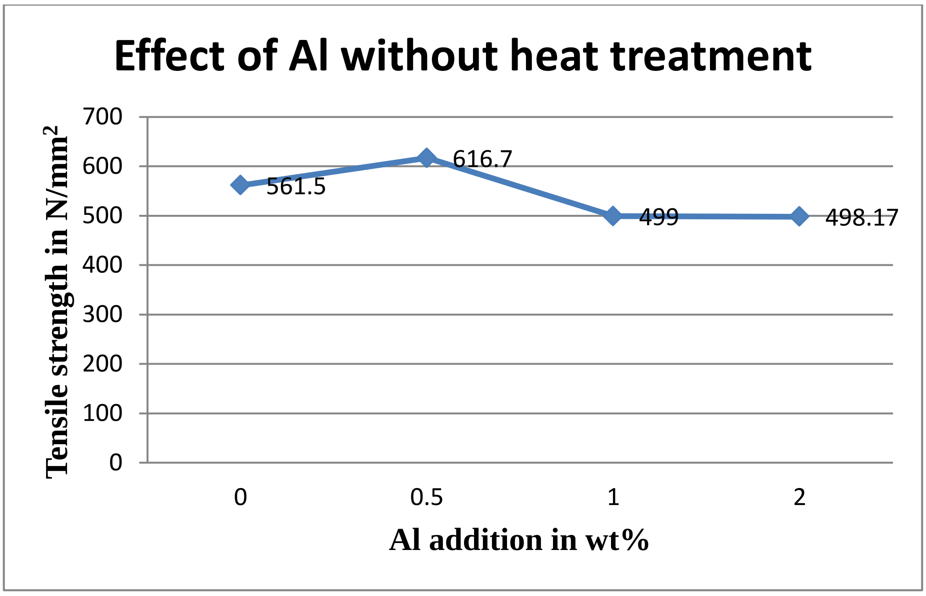

Figure 4. Effect of Aluminum on tensile strength without any heat treatment

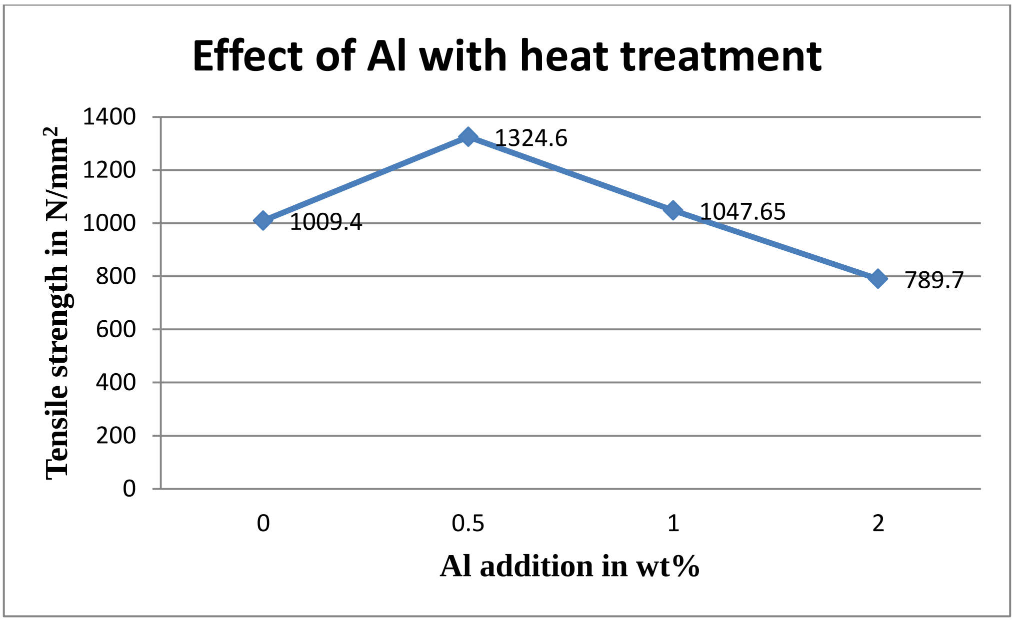

Figure 5. Effect of Aluminum on tensile strength with heat treatment

3.2. Effect of Aluminum on the Hardness of Ductile Iron:

To find out effect of Aluminum, four samples were made with 0.0 wt. %, 0.5 wt %, 1.0 wt. % and 2.0 wt. %. The Hardness samples were machined from the castings. The results are tabulated in table 4.4.

Table 2. Effect of Aluminum on Hardness of Ductile Iron

Aluminum	Brinell Hardness Number (BHN)			
	0 wt%	0.5 wt%	1.0 wt%	2.0 wt%
Without heat treatment	184	211	207	239
With heat treatment	371	451	451	345

From the table 2 it is shows that the Hardness increased with increasing the Aluminum addition. The Hardness of ductile iron samples was 184 BHNwithout any addition of Aluminum to the heat. When Aluminum addition of 0.5 wt % was made in the ductile iron, the Hardness increased to 211 BHN. With the Aluminum addition of 71.0 wt %, the Hardness decreased to 207 BHN. When the Aluminum addition was further increased to 2.0 wt %, again Hardness increased to 239 BHN. Above table shows the variation in Hardness with increase of Aluminum content without any heat treatment.
After the heat treatment the Hardness of ductile iron samples was 371 BHNwithout any addition of Aluminum to the melt. With the Aluminum addition of 0.5 wt % and 1% in the ductile iron the Hardness increased to 451 BHN. When the Aluminum addition was further increased to 2.0 wt %, the Hardness was decreased to 345 BHN.

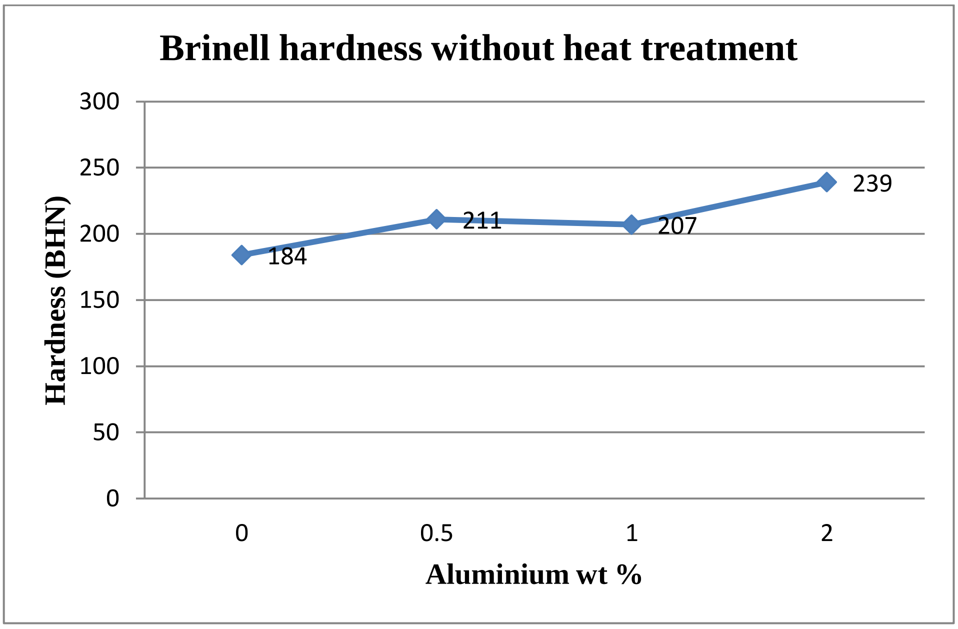

Figure.6. Effect of Aluminum on Hardness without any heat treatment

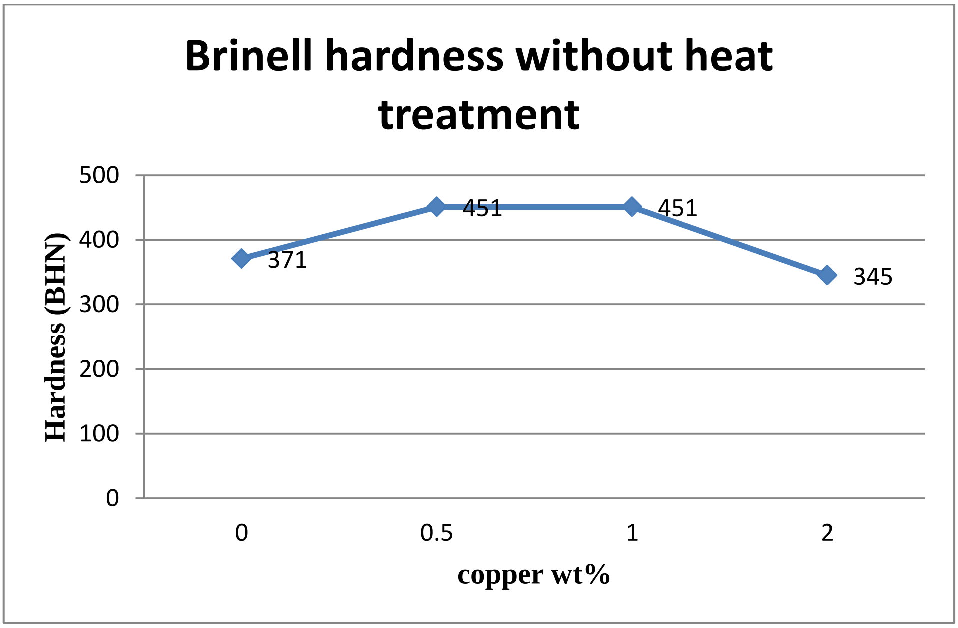

Figure. 7. Effect of Aluminum on Hardness with heat treatment

4. CONCLUSION:

ADI is the important material in aspect of many industrial applications. But present investigations made to prepare ADI shown that considerable increase in tensile strength and hardness.

The problem arises during the alloying of aluminium in the ductile iron matrix as there considerable difference in melting point of ductile iron and aluminium.

Due to this, obtaining ADI with required hardness and ductility is very difficult consistently. Some experiments shows that the amount of hardness and ductility can be varied by using different austenization and austempering time, temperature and also composition of alloying elements etc.

But it found difficult in producing large scales to near net shapes. ADI can be regarded as best replacement for steel and cast iron.

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