Investigation of Heat treatment Effect on Cast Iron Microstructure Behaviour

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Abstract

Aim of this research paper is to investigate the effect of heat treatment on micro structural behavior of Cast Iron (ASTM A48). For investigating the effect heat treatment was carried out in stages. In first stage material is heated in a furnace at a temperature of 850^{o}C, followed by quenching inside the furnace. Further in second stage material was heated at a temperature of 900^{o}C, followed by quenching with the help of cooled still air. It was observed that on heating, cast iron resembles the properties of mild steel along with increase in melting temperature. It reduces the cost to be bear for making mild steel .Various mechanical properties such as. Tensile strength, yield strength, modulus of elasticity, bulk modulus, shear modulus, Poisson's ratio, elongation percentage & hardness are analyzed to investigate the effect of heat treatment on the cast iron. To analyze the microstructure of the heat-treated surface, grinding with the help of rough emery paper & fine emery paper and by using alumina paste on double disk polishing machine was carried out. It was revealed that heat treatment produces significant effect on properties of cast iron.

Keywords: Heat treatment, mechanical properties, microstructure.

1. INTRODUCTION

Cast Iron (ASTM A48) is generally used for making casts of any kind, from components of various machines to intricate shapes, such as cast-iron furniture or gates. It is slightly destructive upon drilling, produces powder and does not bend or dent because it is very hard, but it breaks easily[1].Cast Iron (ASTM A48) is grey cast iron having carbon percentage ranging from 2.5% to 3.4% and iron percentage from 92.28% to 95.04% shown in table 1. Cast Iron (ASTM A48) is cheaper than steel, and it has a low melting point with an ability to mold into any form or shape because it does not shrink when it gets cold[2-5]. Cast Iron (ASTM A48) is used for construction materials and is also used to make structures for buildings. Cast Iron (ASTM A48) has been used to make pipelines and guttering in the past. It is still used for making manhole covers, cylinder blocks in the engines of cars, and for very heavy and expensive cooking utensils, besides its other uses as a construction material.

Annealing involves treating steel or iron up to a high temperature, and then cooling it very slowly to room temperature, so that the resulting microstructure will possess high ductility and toughness, but low hardness[3]. Annealing is performed by heating a component to the appropriate temperature, soaking it at that temperature, and then shutting off the furnace while the piece is in it.

Normalizing involves heating steel or iron, and then keeping it at that temperature for a period, and then cooling it in air[4]. Normalizing is performed on structures and structural components that will be subjected to machining, because it improves the Machinability

Materials. CAST IRON (ASTM A48)

Table 1. Chemical Composition

Cast Iron (ASTM A48)		
Sr. No.	Element	Content
1.	Iron, Fe	92.28% - 95.04%
2.	Carbon, C	2.5% – 3.4%
3.	Silicon, Si	1.8% - 2.5%
4.	Manganese, Mn	0.5% - 0.8%
5.	Phosphorus, P	0.1% - 0.9%
6.	Sulfur, S	0.06% - 0.12%

2. APPARATUS

Universal testing machine**,** Rockwell hardness testing machine**,** Impact testing machine**,** Torsion testing machine, Double disk polishing machine**,** Metallurgical microscope**,** Furnace**,** Brine**,** Rough emery paper (120, 220, 320, 400 & 600 grit)**,** Fine emery paper (1/0, 2/0, 3/0 & 4/0 grit)**,** Alumina paste I grade, II grade & III grade.

3. THEORY

Cast Iron (ASTM A48) is grey cast iron having carbon percentage ranging from 2.5% to 3.4%. Cast Iron (ASTM A48) is cheaper than steel, and it has a low melting point with an ability to mold into any form or shape because it does not shrink when it gets cold.Cast Iron (ASTM A48) is sufficient enough to making casts of any kind, from components of various machines to intricate shapes, such as cast-iron furniture or gates. It is slightly destructive upon drilling, produces powder, and does not bend or dent because it is very hard, but it breaks easily.Density of Cast Iron(ASTM A48) is 7.2 g/cm^3.Cast Iron (ASTM A48) is used for construction materials, and is also used to make structures for buildings. Cast Iron (ASTM A48) has been used to make pipelines and guttering in the past. It is still used for making manhole covers, cylinder blocks in the engines of cars, and for very heavy and expensive cooking utensils, besides its other uses as a construction material.

4. METHODOLOGY

First, circular rod of cast iron(ASTM A48) was taken. Then jobs from the cast iron(ASTM A48) according to requirement were made. Then each dimension of all the jobs like length, diameters etc. were taken. Then tensile strength of cast iron(ASTM A48) was calculated by the formula (load / cross sectional area).Then yield strength of cast iron(ASTM A48) was calculated by the formula (yield load / cross sectional area). Then modulus of elasticity of cast iron(ASTM A48) was calculated by the formula (tensile stress / tensile strain). Then bulk modulus of cast iron(ASTM A48) was calculated by the formula (bulk stress / bulk strain). Then shear modulus of cast iron(ASTM A48) was calculated by the formula (shear stress / shear strain). Then

Poisson's ratio of cast iron(ASTM A48) was calculated by the formula (lateral strain / axial strain).Then elongation percentage of cast iron(ASTM A48) was calculated by universal testing machine. Then hardness of cast iron(ASTM A48) was calculated by Rockwell hardness testing machine. Then impact of cast iron (ASTM A48) was calculated by impact testing machine. Then torsion of cast iron(ASTM A48) was calculated by torsion testing machine. Then cast iron(ASTM A48) was grinded on 120, 220, 320, 400 & 600 grit rough emery papers. Then cast iron(ASTM A48) was grinded on 1/0, 2/0, 3/0 & 4/0 grit fine emery papers. Then cast iron(ASTM A48) was polished on double disk polishing machine by using alumina paste I grade, II grade & III grade. Then microscopic view was taken by using metallurgical microscope as shown in Fig. 1.

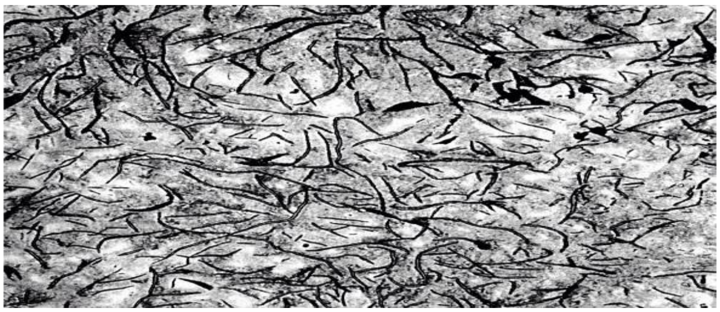

Fig.1. Before heat treatment microscopic view

After these same specifications of job were made as it was made before for initial testing.After this all the jobs were kept in furnace at 850 degrees Celsius for heating.Then after heating jobs could cool with in the furnace. After cooling with in the furnace againall the jobs were kept in furnace at 900 degrees Celsius for heating.Then after heating jobs could cool in the cooled still air.After cooling, hardening heat treatment process were completed. After heattreatment, same process for finding properties were repeated.Now tensile strength of heat treated cast iron(ASTM A48) was calculated by the formula (loads / cross sectional area).Now yield strength of heat treated cast iron(ASTM A48) was calculated by the formula (yield load / cross sectional area). Now modulus of elasticity of heat treated cast iron(ASTM A48) was calculated by the formula (tensile stress / tensile strain). Now bulk modulus of heat treated cast iron(ASTM A48) was calculated by the formula (bulk stress / bulk strain).Now shear modulus of heat treated cast iron(ASTM A48) was calculated by the formula (shear stress / shear strain).Now Poisson's ratio of heat treated cast iron(ASTM A48) was calculated by the formula (lateral strain / axial strain).Now elongation percentage of heat treated cast iron(ASTM A48) was calculated by universal testing machine. Now hardness of heat treated cast iron(ASTM A48) was calculated by Rockwell hardness testing machine. Now impact of heat treated cast iron(ASTM A48) was calculated by impact testing machine. Now torsion of heat treated cast iron(ASTM A48) was calculated by torsion testing machine. Now cast iron(ASTM A48) was grinded on 120, 220, 320, 400 & 600 grit rough emery papers. Now heat-treatedcast iron(ASTM A48) was grinded on 1/0, 2/0, 3/0 & 4/0 grit fine emery papers. Nowheat-treatedcast iron(ASTM A48) was polished on double disk surface polishing machine by using alumina paste I grade, II grade & III grade.Now again microscopic view was taken by using metallurgical microscope as shown in Fig. 2.

Fig.2.After heat treatment, microscopic view

Equations.

$$Tensile.Strength = \frac{Load}{Cross - sectional.Area} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

$$Yield.Strength = \frac{Yield.Load}{Cross - Sectional.Area} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

$$Modulus.Of.Elasticity = \frac{Tensile.Stress}{Tensile.Strain} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

$$Bulk.Modulus = \frac{Bulk.Stress}{Bulk.Strain} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

$$Shear.Modulus = \frac{Shear.Stress}{Shear.Strain} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(5)$$

$$Poisson's.Ratio = \frac{Lateral.Strain}{Axial.Strain} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

5. RESULT & DISCUSSION

Table 2 and 3 shows the value of mechanical properties which were analyzed for the investigating the effect of heat treatment on cast iron. It was revealed that there is significant increase in the various mechanical properties of the cast iron such as tensile strength which increases from 300 MPa to 425 MPa, yield strength 220MPa to 270MPa, young modulus of elstaicity 145 GPa to 215 GPa.

Table 2. Value of mechanical properties before heat treatment

S. No.	MECHANICAL PROPERTY	VALUE
1.	Tensile Strength	300 MPA
2.	Yield Strength	220 MPA
3.	Modulus of Elasticity	145 GPA
4.	Bulk Modulus	102 GPA
5.	Shear Modulus	40 GPA
6.	Poisson’s Ratio	0.261
7.	Elongation Percentage	15 %
8.	Hardness	69 HRC

Table 3. Value of mechanical properties after heat treatment

S. No.	MECHANICAL PROPERTY	VALUE
1.	Tensile Strength	425 MPA
2.	Yield Strength	270 MPA
3.	Modulus of Elasticity	215 GPA
4.	Bulk Modulus	145 GPA
5.	Shear Modulus	81 GPA
6.	Poisson's Ratio	0.269
7.	Elongation Percentage	23 %
8.	Hardness	64 HRC

It was further revealed that significant increase in the properties of cast iron was attributed with increase in ductility and decrease in brittleness which causes lesser hardness. Various equations which are used for measuring the mechanical properties are given in the paper. Before heat treatment bulk modulus of cast iron(ASTM A48) was 102 GPa and after heat treatment bulk modulus strength of cast iron(ASTM A48) is 145 GPA given in table 2 & table 3 and by the eqn. (4). Before heat treatment shear modulus of cast iron (ASTM A48) was 40 GPA and after heat treatment shear modulus of cast iron(ASTM A48) is 81 GPa given in table 2 & table 3 and by the eqn. (5). Before heat treatment Poisson's ratio of cast iron(ASTM A48) was 0.261 and after heat treatment Poisson's ratio of cast iron(ASTM A48) is 0.269 given in table 2 & table 3 and by the eqn. (6). Before heat treatment elongation percentage of cast iron (ASTM A48) was 15% and after heat treatment elongation percentage of cast iron(ASTM A48) is 23 % given in table 2 & table 3. Before heat treatment hardness of cast iron(ASTM A48) was 69 HRC and after heat treatment hardness of cast iron(ASTM A48) is 64 HRC given in table 2 & table 3 and. Even after heat treatment their microscopic view had been changed as shown in fig. 1 & fig. 2. Before heat treatment grain boundaries were thin as shown in fig.1 but after heat treatment grain boundaries become thicker as in fig.2 and this show the structure resembling to mild steel.

6. CONCLUSION

It was revealed that the heat treatment affects the mechanical properties of cast iron (ASTM A48). It was depicted from the study that hardness was reduced in the cast iron on heating. Ductility of the cast iron was appreciably increased when heated in the furnace. After annealing and normalizing, mechanical property of cast iron (ASTM A48) becomes ductile. It was further revealed that hardness can be reduced in the cast iron so that it cannot be further used for wear and tear purpose. After annealing and normalizing; cast iron (ASTM A48) was free from rust. Even this process also reduces the cost of mild steel or we can say by this process material with the properties of mild steel will be available at cheaper cost. After heat treatment, their microscopic view had been changed as shown in fig. 1 & fig. 2. Before heat treatment grain boundaries were thin as shown in fig.1 but after heat treatment grain boundaries become thicker as in fig.2 and this show the structure resembling to mild steel.

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