Investigation of Heat Treatment on Mechanical Propertiesof Mild Steel

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Abstract

Aim of this research paper is to investigate the effect of heat treatment on mechanical propertiesof Mild Steel (ASTM A36). Heat treatment was carried out in a furnace at a temperature of 800^{o}C, after heating at such temperature quenching was carried out using brine solution. It was observed that on heating the mild steel resembles the properties of cast iron along with increase in boiling temperature.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 mild steel. To investigate the microstructure of the heat treated surface, grinding with the help of rough 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 Mild steel.

Keywords: boiling point, brittle, free from rust, alumina paste, emery paper.

1. INTRODUCTION

Mild Steel (ASTM A36) is suitable for welding process, grinding process, punching process, taping process, drilling process, and machining process[1].Mild Steel is also known as low carbon steel having carbon percentage ranging from 0.250% to 0.290% and iron percentage 98.0% shown in table 1. Mild Steel (ASTM A36) is available in Rectangular bar form, square bar form, Circular rod form and steel shapes such as channels, angles, H-beams and I beams[2-3].Mild Steel (ASTM A36) is used in bolted, riveted or welded constructions of bridges, buildings and oil rigs. Hardening is the process in which steel is heated to a temperature above the critical point, held at this temperature and quenched in water, oil, molten salt baths, brine. This process induces the property of hardness in the material. The chemical composition of the Mild steel is given in Table-1.

Table 1.Chemical Composition

Mild Steel (ASTM A36)		
Sr. No.	Element	Content
1.	Iron, Fe	98.0%
2.	Manganese, Mn	1.03%
3.	Carbon, C	0.250% – 0.290%
4.	Silicon, Si	0.280%
5.	Copper, Cu	0.20%
6.	Sulfur, S	0.050%
7.	Phosphorus, P	0.040%

1.1 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.

2. THEORY

Mild Steel is also known as low carbon steel. Mild Steel (ASTM A36) is suitable for welding process, grinding process, punching process, taping process, drilling process, and machining process. Mild Steel (ASTM A36) is available in Rectangular bar form, square bar form, Circular rod form and steel shapes such as channels, angles, H-beams and I beams[2-4] .Density of Mild Steel (ASTM A36) is 7.85 g/cm^3.Mach inability rate of Mild Steel (ASTM A36) is estimated to be 72%.Average surface cutting feed of Mild Steel (ASTM A36) is 120 ft. /min.Mild Steel (ASTM A36) is easy to weld any kind of welding method. Mild Steel (ASTM A36) is used in bolted, riveted or welded constructions of bridges, buildings and oil rigs.Mild Steel (ASTM A36) is used in forming tanks, bins, bearing plates, fixtures, rings, templates, jigs, sprockets, cams, gears, ornamental instruments. Mild Steel (ASTM A36) is used for various parts obtained in flame cutting.

2.2 Methodology

First of all circular rod of Mild Steel (ASTM A36) was taken. Then jobs from the Mild Steel (ASTM A36) according to requirement were made. To investigate the impact on mechanical properties of Mild steel specimen various properties such as length, diameters etc. were measured. Various mechanical properties such as tensile strength is obtained by using Universal Testing machine. It is calculated by using a relationship (load / cross sectional area). Similarly yield strength of Mild Steel (ASTM A36) was obtained by using the relationship between formula (yield load / cross sectional area). Various mechanical properties bulk modulus, shear modulus and poisson ratio of Mild Steel (ASTM A36) was computed by the formula (bulk stress / bulk strain).Then shear modulus of Mild Steel (ASTM A36) was calculated by the formula (shear stress / shear strain). Then Poisson's ratio of Mild Steel (ASTM A36) was calculated by the formula (lateral strain / axial strain).Then elongation percentage of Mild Steel (ASTM A36) was calculated by universal testing machine. Then hardness of Mild Steel (ASTM A36) was calculated by Rockwell hardness testing machine. Then impact of Mild Steel (ASTM A36) was calculated by impact testing machine. Then torsion of Mild Steel (ASTM A36) was calculated by torsion testing machine. Then Mild Steel (ASTM A36) was grinded on 120, 220, 320, 400 & 600 grit rough emery papers. Then Mild Steel (ASTM A36) was grinded on 1/0, 2/0, 3/0 & 4/0 grit fine emery papers. Then Mild Steel (ASTM A36) 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.

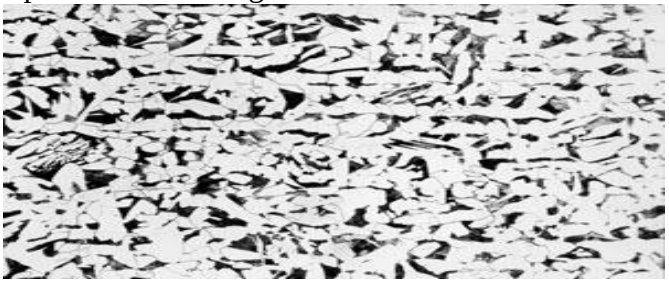

Fig-1. Before heat treatment microscopic view

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 800 degree Celsius for heating.Then after heating jobs were allowed to cool in brine (brine = 90% water + 10% salt).After cooling, hardening heat treatment process were completed. After heat treatment same process for finding properties were repeated.Now tensile strength of heat treated Mild Steel (ASTM A36) was calculated by the formula (loads / cross sectional area).Now yield strength of heat treated Mild Steel (ASTM A36) was calculated by the formula (yield load / cross sectional area). Now modulus of elasticity of heat treated Mild Steel (ASTM A36) was calculated by the formula (tensile stress / tensile strain). Now bulk modulus of heat treated Mild Steel (ASTM A36) was calculated by the formula (bulk stress / bulk strain).Now shear modulus of heat treated Mild Steel (ASTM A36) was calculated by the formula (shear stress / shear strain).Now Poisson's ratio of heat treated Mild Steel (ASTM A36) was calculated by the formula (lateral strain / axial strain).Now elongation percentage of heat treated Mild Steel (ASTM A36) was calculated by universal testing machine.Now hardness of heat treated Mild Steel (ASTM A36) was calculated by Rockwell hardness testing machine.Now impact of heat treated Mild Steel (ASTM A36) was calculated by impact testing machine.Now torsion of heat treated Mild Steel (ASTM A36) was calculated by torsion testing machine.Now Mild Steel (ASTM A36) was grinded on 120, 220, 320, 400 & 600 grit rough emery papers.Now heat treated Mild Steel (ASTM A36) was grinded on 1/0, 2/0, 3/0 & 4/0 grit fine emery papers.Nowheat treated Mild Steel (ASTM A36) 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.

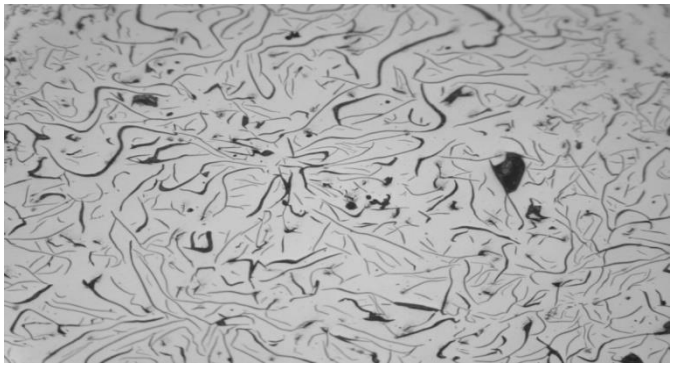

Fig-2.After heat treatment microscopic view

2.3 Equations

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

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

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

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

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

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

2.3 Result & Discussion

Table 2. Value of mechanical properties before heat treatment

Sr. No.	MECHANICAL PROPERTY	VALUE
1.	Tensile Strength	450 MPA
2.	Yield Strength	250 MPA
3.	Modulus of Elasticity	210 GPA
4.	Bulk Modulus	140 GPA
5.	Shear Modulus	79.3 GPA
6.	Poisson's Ratio	0.266
7.	Elongation Percentage	23 %
8.	Hardness	63 HRC

Table 3. Value of mechanical properties before heat treatment

Sr. No.	MECHANICAL PROPERTY	VALUE
1.	Tensile Strength	325 MPA
2.	Yield Strength	200 MPA
3.	Modulus of Elasticity	190 GPA
4.	Bulk Modulus	98 GPA
5.	Shear Modulus	39 GPA
6.	Poisson's Ratio	0.260
7.	Elongation Percentage	14 %
8.	Hardness	67 HRC

Table 2 and 3 shows the value of mechanical properties which were analyzed for the investigating the effect of heat treatment on mild steel. It was revealed that there is significant reduction in the various mechanical properties of the mild steel suchas tensile strength which decreases from 450 MPa to 325 MPa, yield strength 250MPa to 200MPa, young modulus of elstaicity 210 GPa to 190 GPa. It was further revealed that significant reduction in the properties of mild steel was attributed with decrease in ductility and increase in brittleness which causes higher hardnesss. Various equations which are used for measuring the mechanical properties are given in the paper. Before heat treatment bulk modulus of Mild Steel (ASTM A36) was 140 GPA and after heat treatment bulk modulus strength of Mild Steel (ASTM A36) is 98 GPA given in table 2 & table 3 and by the eqn. (4). Before heat treatment shear modulus of Mild Steel.
(ASTM A36) was 79.3 GPA and after heat treatment shear modulus of Mild Steel (ASTM A36)is 39 GPA given in table 2 & table 3 and by the eqn. (5). Before heat treatment Poisson's ratio of Mild Steel (ASTM A36) was 0.266 and after heat treatment Poisson's ratio of Mild Steel (ASTM A36) is 0.260 given in table 2 & table 3 and by the eqn. (6). Before heat treatment elongation percentage of Mild Steel (ASTM A36) was 23% and after heat treatment elongation percentage of Mild Steel (ASTM A36) is 14 % given in table 2 & table

3. Before heat treatment hardness of Mild Steel (ASTM A36) was 63 HRC and after heat treatment hardness of Mild Steel (ASTM A36) is 40 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 thick as shown in fig.1 but after heat treatment grain boundaries become thinner as in fig.2 and this show the structure resembling to cast iron.

3 CONCLUSIONS

It was revealed that the heat treatment affects the mechanical properties of Mild Steel (ASTM A36). It was depicted from the study that hardness was induced in the mild steel on heating. Ductility of the mild steel was appreciably decreased when heated in the furnace. After hardening mechanical property of Mild Steel (ASTM A36) becomes brittle. It was further revealed that hardness can be induced in the mild steel so that it can be further used for wear and tear purpose.After hardening Mild Steel (ASTM A36) was free from rust. After heat treatment their microscopic view had been changed as shown in fig. 1 & fig. 2. Before heat treatment grain boundaries were thick as shown in fig.1 but after heat treatment grain boundaries become thinner as in fig.2 and this show the structure resembling to cast iron.

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