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Experimental Study on the Impact of Heat Treatment on Low Carbon Steel

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ABSTRACT

Heat treatment of steels is one of the most important factors in engineering metallurgy because it improves various physical and mechanical properties that are useful in a variety of structural applications. Heat treatment is essentially a set of operations involving the heating and cooling of a metal or alloy in solid state in order to achieve the desired microstructures by refining the grain growth. Low carbon steel is readily available and inexpensive, and it possesses all of the material properties required for a wide range of applications. The purpose of heat treatment on low carbon steel is to increase ductility, toughness, strength, hardness, and tensile strength, as well as to relieve internal stress in the material. The experiment of hardness and ultimate tensile strength is carried out in order to gain an understanding of heat-treated low carbon steel, which has numerous applications in industrial and scientific fields.

Keywords*: Low carbon steel, Heat treatment process.*

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I. INTRODUCTION

Low carbon steel has carbon content of 0.15% to 0.45%. Low carbon steel is the most common form of steel as it's provides material properties that are acceptable for many applications. It is neither externally brittle nor ductile due to its lower carbon content. It has lower tensile strength and malleable. Steel with low carbon steel has properties similar to iron. As the carbon content increases, the metal becomes harder and stronger but less ductile and more difficult to weld.

The process heat treatment is carried out first by heating the metal and then cooling it in water, oil and brine water. The purpose of heat treatment is to soften the metal, to change the grain size, to modify the structure of the material and relive the stress set up in the material. The various heat treatment process are annealing, normalizing, hardening, austempering, mar tempering, tempering and surface hardening.

Case hardening is the process of hardening the surface of metal, often low carbon steel by infusing elements into the metal surface forming a hard, wear resistance skin but preserving a tough and ductile applied to gears, ball bearings, railway wheelsVarious vehicles are appearing in the current generation with new technology for implementing human comfort and other accessories. An intelligent braking system would satisfy the technological ways of stock extension to propagate the shorter philosophy and proceed differently. This entire system is installed on a stainless-steel chassis and is utilized to automatically operate the braking system.The most important heat treatments and their purposes are:

Stress relieving - a low-temperature treatment, to reduce or relieve Internal stresses remaining after casting

Annealing - to improve ductility and toughness, to reduce hardness and to remove carbides

Normalizing - to improve strength with some ductility Hardening and tempering - to increase hardness or to give improved Strength and higher proof stress ratio.

Austempering - to yield bainitic structures of high strength, with significant ductility and good wear resistance.

Surface hardening - by induction, flame, or laser to produce a local wear resistant hard surface.

II. LITERATURE REVIEW

Basakandchakroborty(2017)developedCr-Mn-Cuwhitecastironforapplicationinmining, farm machinery; etc requiring erosive and corrosive we resistance properties. They found that the addition of Cu improves the corrosionresistance of Cr-Mn iron and hence reduced the rate of corrosive wear of high copper

,chromium and manganese cast iron.

Kuma and Gupta(2019) studied the abrasive wear behavior of mild, mediumcarbon, leaf and high carbon, low Cr. Steel by means of a dry stand rubberwheelabrasion apparatus. They found that the heat treated high carbon low Cr. Steel andmild steel carburized by their own technique to be the best abrasion resistancematerials. The abrasive wear resistance values of the two materials w ear found to be very much comparable with each other.

They also studied the abrasive wear of carburized mild steel. They investigatedthe influence of carburization conditions (e.g., temperature, time, properties ofcarbonaceous material etc.) on the abrasive wear loss. During the study, Kumar developed a cheaper method of carburizing producing better wear resistance.

III. SCOPE OF THE PROJECT

Metal heat treatment refers to a process of altering the physical and chemical properties of metals through different operations such as heating, holding, and cooling of metal in the solid state in order to obtain a particular desirable metallurgical properties. Rising demand from end-use industries is a key factor driving the demand for metal heat treatment process and services. Manufacturing industries are integrating these processes with their existing production lines in order to enhance the overall efficiency of final production. The automotive industry is a major end-user of metal heat treatment services and equipment. The metal heat treatment process is employed to achieve metal surface hardening, improve cutting properties of tool steels, obtain fine grain size, increase ductility and softness, and improve electrical and magnetic properties.

Metal Heat Treatment Market – Competitive Landscape
Blue water Thermal Solutions

Founded in 1996, Blue water Thermal Solutions presently is based in Greenville, South Carolina, U.S. It has manufacturing facilities in Texas, Michigan, Illinois, Indiana, and Pennsylvania; U.S., and Canada. The company operates a network of steel heat treatment and brazing plants. Blue water Thermal Solutions is a leading player in the field of commercial thermal solutions. It provides thermal processing and metal joining services; and processes components that comply with stringent engineering specifications. The company caters to various manufacturing industries based in North America including aerospace, automotive, construction, energy, heavy equipment, agriculture equipment, and medical.

Bohler Uddeholm

Incorporated in 1991, Bohler Uddeholm is based in Vienna, Austria. The company specializes in the production of tool steel and special forgings. The company has production sites in Austria, Turkey, China, Germany, Brazil, Belgium, Sweden, U.S., and Mexico. As of 2008, Bohler Uddeholm was a wholly owned subsidiary of vestal pine. The company caters to diverse sectors including automotive, aerospace & power generation. It also offers high performance metals, tool steel and high speed steel, long products, tubes & pipings, additive manufacturing, and precision strips.

American Metal Treating Inc.

Established in 1976, American Metal Treating Inc. is presently based in High Point, North Carolina, U.S. The company serve as a metallurgical processing supplier of high-quality, high-value products. It specializes in full range of commercial heat treater and heat treatment of all types of gears.

IV. METHODOLOGY

The experimental procedure for the project work can be listed as:

1) Specimen preparation
2) Heat treatment
3) Harden measurement
4) Mechanical property study
5) Microstructure study

4.1. SPECIMEN PREPARATION*:*

The first and foremost job for the experiment is the specimen preparation. The specimen size should be compatible to the machine specifications:

We got the sample from mild steel sale shop .The sample that we got was low carbon steel. It is one of the American standard specifications of the low carbon steel having the pearlitic matrix (up to70%) with relatively less amount of ferrite (30-40%). And so it has low carbon with moderate ductility.

4.2. HEATTREATMENT

Low Carbon Steel are primarily heat treated to create matrix microstructures and associated mechanical properties not readily obtained in the as-cast condition. As-cast matrix microstructures usually consist of ferrite or pearlite or combinations of both, depending on cast section size and/or alloy composition. The principle objective of the project is to carry out the heat treatment of Low carbon steel and then to compare the mechanical properties. The rear various types of heat treatment processes we had adopted.

4.2.1. ANNEALING

a) The specimen wash heated to a temperature of 900 deg Celsius

b) At 900 deg Celsius the specimen was held for 2hour

c) Then the furnace was switched off so that the specimen temperature will decrease with the same rate as that of the furnace.

Now the specimen is allowed to cool in the ordinary environment. i.e. the specimen is air cooled to room temperature.

d) The process of air cooling of specimen heated above Ac1 is called normalizing

4.2.2. QUENCHING:

This experiment was performed to harden the low carbon steel. The process involved putting the red hot steel directly in to a liquid medium.

Then continue the steps what we have done before in Annealing.

4.2.3. TEMPERING:

This is the one of the important experiment carried out with the objective of the experiment being to induce some amount of softness in the material by heating to a moderate temperature range.

a) First the ‘4’specimen we reheated to 900 deg Celsius for 2hourS and then quenched in the oil bath maintained at room temp.

b) Among the 4specimen 2were heated to 250 deg Celsius. But for different time period of 1hour ,1and half hour and 2 hour respectively.

c) Now 3 more specimens were heated to 450 deg Celsius and for the time period of 1hour ,1and a half hour and 2hour respectively.

After the specimens got heated to a particular temperature for a particular time period, they were air cooled. The heat treatment of tempering at different temp for different time periods develops variety of properties within them.

4.2.4. AUSTEMPERING:

This is the most important experiment carried out for the project work. The objective was to develop all round property in the material.

a) A salt bath was prepared by taking 50% NaN03 and 50 % KnO3 salt mixture. The objective behind using NaNO3 and KNO3 is though the individual melting points are high the mixture of them in the bath with 1:1 properties from an eutectic mixture this eutectic reaction brings down the melting point of the mixture to 290deg Celsius. The salt remains in the liquid state in the temp range of 290-550 deg Celsius where as the salt bath needed for the experiment should be at molten state at 350 deg Celsius

b) After the specimen getting properly homogenized it was taken out of the

Furnace and put in another furnace where the container with the salt mixture was kept at 350 deg Celsius.

At that temp of 350 degree the specimen was held for 2 hrs In this time the austenite gets converted to binate. The objective behind choosing the temperature of 350 deg Celsius is that at this temperature will give upper binate which has fine grains so that the properties developed in the materials are excellent.

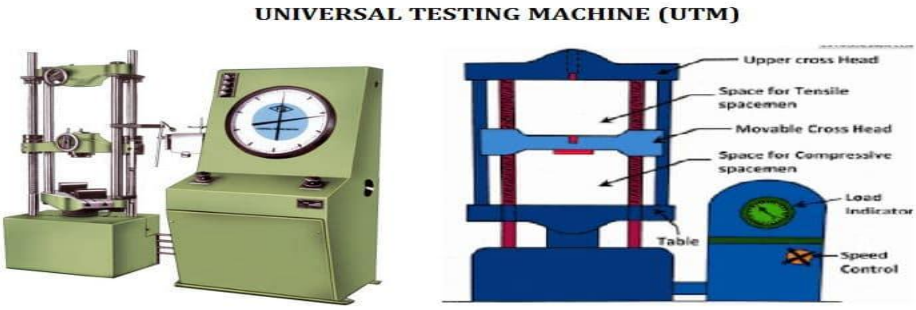
4.3. STUDY OF MECHANICAL PROPERTIES:

As the objective of the project is to compare the mechanical properties of various heat treated low carbon steel specimen. With the help of universal testing machine and specimen gauge.

4.3.1. HARDNESS TESTING:

The heat treated specimens hardness were measured in Rockwell hardness testing machine.

1. First the brale indenter was inserted in the machine the load is adjusted to100 kilograms.
2. The minor load is applied on specimen (10 kilo grams)
3. Now the major load of 100 kilograms is applied on the specimen with a penetration of 0.002 mm.



4.3.2. ULTIMATE TENSILE STRENGTH TESTING:

As the objective of the project now the specimen subjected Universal testing machine to get percentage of elongation.

1) First measure the specimen which is used in UTM.
2) Then fix the fixed jaw based on specimen dimensions.
3) Then apply the maximum load of 150 kilo Newton's.
4) The corresponding Load vs. Displacement diagrams were plotted by using the software. From the data obtained the % elongation, yield strength and ultimate tensile strength were calculated by using the following formulae:-

Percentage of elongation =(change in gauge length of specimen/initial gauge length of the specimen.) *100 .Yield strength = load at 0.2% offset yield/ initial cross section area Ultimate tensile strength = maximum load/initial cross section area

V. RESULTS

5.1. Results :

5.1.1. TABULATION FOR HARDNESS TESTING:

Table.1

SPECIMENSPECIFICATION	TIME	HARDNESS
Quenched from 900 and tempered at 250 degree Celsius	1hour	43
	1½ hour	37
	2hour	32
Quenched from 900 and tempered At 450degree Celsius	1hour	39
	1½ hour	33
	2hour	27
Quenched from 900 and tempered at 650 degree Celsius	1hour	32
	1 ½ Hour	29
	2hour	23
Tempered 350degree celsius	1hour	28
	2hour	27
As Received		21

Table.2

Specimen Specification	Time(inhours)	Hardness
Quenchedfrom900andtempered at250degreecelsius	1hour	39
Quenchedfrom900andtempered At450degreecelsius	1hour	32
Quenchedfrom900andtempered at650degreecelsius	1hour	33

Hardness vs. tempering temperature for constant tempering timeof1hour

Table.3

Specimen Specification	Time(inhours)	Hardness
Quenchedfrom900andtempered at250degreecelsius	1½ hour	37
Quenchedfrom900andtempered At450degreecelsius	1½ hour	31
Quenchedfrom900andtempered at650degreecelsius	1½ hour	29

Hardness vs. tempering temperature for constant tempering timeof1½ hour

Table.4

Specimen Specification	Time(inhours)	Hardness
Quenchedfrom900andtempered at250degreecelsius	2hour	33
Quenchedfrom900andtempered At450degreecelsius	2hour	29
Quenchedfrom900andtempered at650degreecelsius	2hour	23

Hardness vs. tempering temperature for constant tempering timeof2hour

5.1.2. TABULATION FOR ULTIMATE TENSILE STRENGTH TESTING:

Table.5

Specimen Specification	Time	UTS(in mpa	YieldStrength(in Mpa)	Elongation%
Quenched from 900 tempered at 250 deg cel	1	539	328	9.534
Quenched from 900 tempered at 450 deg cel	1	487	289	14.236
Quenched from 900 tempered At 650degree	1	307	224	19.426

Tensile properties for different tempering temperature for 1 hour tempering time

Table.6

Specimen Specification	Time	UTS(in mpa	YieldStrength(in Mpa)	Elongation%
Quenched from 900 tempered at 250 deg cel	1 ½	523	301	11.239
Quenched from 900 tempered at 450 deg cel	1 ½	303	254	16.325

Quenched from 900 tempered at 650 deg cel	1 ½	447	227	22.836

Tensile properties for different tempering temperature for 1 ½ anhourtempering time.

Table.7

Specimen Specification	Time	UTS(in mpa	YieldStrength(in Mpa)	Elongation%
Quenched from 900 tempered at 250 deg cel	1 ½	397	257.5	20.621
Quenched from 900 tempered at 450 deg cel	1 ½	352	214.3	24.624
Quenched from 900 tempered at 650 deg cel	1 ½	232	187	25.625

Tensile properties for different tempering temperature for 2 hour tempering time

VI. CONCLUSION

After getting various results by performing various operations we concluded that the mechanical properties vary depending upon the various heat treatment processes. It is seen that annealing causes a tremendous increase in percentage of elongation(Ductility). Finally we can clearly seen that after performing all heat treatment process and UTS, Yield strength, percentage elongation .

After completion of these processes we got that hardness will obtaine by austempering only.

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