HEAT TREATMENT OF LOW CARBON STEEL

Bablu Kumar Yadav[1], Akshat Singh Jhala[2]

[1]M.Tech. Student, Department of Mechanical Engineering, Pacific Academy Of Higher Education And Research University, Udaipur, Rajasthan, India
[2]Assistant Professor, Department of Mechanical Engineering, Pacific Academy Of Higher Education And Research University, Udaipur, Rajasthan, India

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Abstract:-In engineering metallurgy, warmness remedy of steels is one of the most vital elements as it complements numerous bodily and mechanical homes which can be taken into consideration available in severa structural applications. Heat remedy is essentially the mixture of operations involving the heating and cooling of a metal or alloy in stable kingdom for obtaining required microstructures by using refining the grain size and a aggregate of homes.

The high object of this investigation is to illustrate the effect of heat treatment on low carbon metallic (AISI 1020) to reveal its mechanical (hardness) and microstructural (microstructures) homes. For this motive, cylindrical shaped AISI 1020 steel specimens have been used. The samples had been polished the use of a specimen sharpening device and heated in a warmness remedy furnace at about 950°C for almost 2 hours and then cooled via different quenching media (Water, Air, Ash). After warmness remedy (Hardening, Normalizing, Full Annealing) the Brinell hardness number (B.H.N) turned into decided using a Universal checking out machine (U.T.M) and the microstructures had been tested using a metallurgical microscope. It was discovered that, because of hardening the resultant structure turned into a splendid saturated solid answer of carbon trapped in a body targeted tetragonal shape known as martencite which extended the hardness quantity of the metallic specimens significantly making an intense harder metallic. Moreover, full annealing furnished lower hardness fee due to the presence of ferrite structure and normalizing provided slight hardness value and ductility because of sluggish cooling.

Low carbon steel is without difficulty to be had and reasonably-priced having all material houses that are acceptable for many programs. Heat remedy on low carbon metallic is to improve ductility, to enhance durability, electricity, hardness and tensile strength and to relive inner strain advanced in the cloth. Here basically the experiment of harness and ultimate tensile power is executed to get concept approximately warmness dealt with low carbon metallic, which has good sized makes use of in all industrial and medical fields.

1. INTRODUCTION

As we recognise there may be a bit bit of steel in every person lifestyles. Steel has many sensible applications in each elements of existence. Steel with favorable homes are the great among the goods. The metallic is being divided as low carbon metal, excessive carbon metal, medium carbon metallic, excessive carbon steel on the idea of carbon content.

Low carbon metallic has carbon content of zero.15% to 0.45%.

Low carbon steel is the most common form of metallic because it's presents cloth residences which can be ideal for plenty packages. It is neither externally brittle nor ductile due to its decrease carbon content material. It has decrease tensile power and malleable. Steel with low carbon metallic has residences much like iron. As the carbon content material increases, the steel will become tougher and stronger however less ductile and greater difficult to weld.

The method warmth treatment is finished first through heating the steel after which cooling it in water, oil and brine water. The reason of warmth treatment is to soften the steel, to alternate the grain size, to regulate the structure of the cloth and relive the strain set up within the cloth. The numerous warmth treatment method are annealing, normalizing, hardening, austempering, mar tempering, tempering and surface hardening.

Case hardening is the procedure of hardening the surface of metal, regularly low carbon metallic through infusing factors into the metallic surface forming a hard, put on resistance skin however preserving a difficult and ductile carried out to gears, ball bearings, railway wheels.

As my venture involved it is essentially deal with carburizing that's a case hardening system. It is a process of including carbon to surface. These are accomplished with the aid of exposing the element to carbon wealthy ecosystem at the extended temperature (near melting factor) and permit diffusion to transfer the carbon atoms into the steel. This diffusion paintings at the principle of differential concentration.

But it isn't always clean to undergo all of the carburizing procedure like gas carburizing, vacuum carburizing, plasma carburizing and salt bath carburizing.

So we go through % carburizing that can easily performed in experimental setup. In this process the part that is to be carburized is located in a metal box, in order that it's miles completely surrounded via granules of charcoal which is activated by barium carbonate. The carburizing manner does no longer harden the steel it most effective increases the carbon content to a few pre determined depth under the surface to a sufficient degree to permit next quench hardening.

The most critical heat treatments and their purposes are:

1. **Stress relieving -** a low-temperature treatment, to lessen or relieve Internal stresses closing after casting
2. **Annealing -** to improve ductility and sturdiness, to lessen hardness and to cast off carbides
3. **Normalizing -** to enhance electricity with a few ductility Hardening and tempering - to increase hardness or to give stepped forward Strength and higher evidence strain ratio.
4. **Austempering -** to yield bainitic systems of excessive electricity, with significant ductility and appropriate wear resistance.
5. **Surface hardening -** through induction, flame, or laser to supply a neighborhood put on resistant tough floor.

Proper warmness treatment of steels is one of the maximum important elements in determining how they may perform in carrier. Engineering substances, generally metallic, are warmness dealt with below controlled series of heating and cooling to regulate their physical and mechanical properties to fulfill favored engineering applications.

Heat treatment operation is a means of controlled heating and cooling of substances with a purpose to effect modifications in their mechanical homes. Heat remedy is likewise used to boom the energy of substances via changing a few sure manufacturability goals in particular after the materials would possibly have undergo principal stresses like forging and welding. It changed into however known that mechanical residences of metallic had been strongly linked to their microstructure acquired after warmness remedies which might be achieved to gain proper hardened and tensile strength with sufficient ductility.

Microscopic exam (microanalysis) is the take a look at of the based materials underneath a microscope at large magnification. The shape found is referred to as microstructure. A particular even though only qualitative dating exists among the structure of a metallic discovered in an optical microscope and certain homes of that steel. In many instances microanalysis indicates that the versions in alloy residences are due to variations in chemical composition and situations of remedy.

1.1 OBJECTIVES

1) To increase strength, hardness and wear resistance.

2) To increase ductility and softness.

3) To increase toughness.

4) To obtain fine grain size.

5) To remove internal stresses induced by differential deformation by cold working, non-uniform cooling from high temperature during casting and welding.

6) To improve machinability.

7) To improve cutting properties of tool steels.

8) To improve surface properties .

9) To improve electrical properties .

10) To improve magnetic properties .

1.2 CLASSIFICATION OF STEELS

It is impossible to decide the right range of steel compositions and different variations that presently exist, despite the fact that the total range probably exceeds one thousand; consequently, any inflexible type is impossible. However, steels are arbitrarily divided into 5 corporations, which has proved usually pleasant to the metalworking network.

These five lessons are:

- Carbon steels
- Alloy steels (now and again known as low-alloy steels)
- Stainless steels

• Tools steels

• Special-cause steels

The first 4 of those companies are properly described with the aid of designation structures developed through the Society of Automotive Engineers (SAE) and the American Iron and Steel Institute (AISI). Each general class is subdivided into severa groups, with each grade indentified. The 5th organization accommodates numerous hundred unique compositions; most of them are proprietary.Many of those unique steels are much like specific steels within the first 4 businesses however vary sufficiently to be marked as separate compositions. For example, the SAE-AISI designation machine lists nearly 60 stainless steels in four one-of-a-kind wellknown subdivisions. In addition to those steels (typically called "general grades"), there are nicely over a hundred different compositions that are nonstandard. Each metal become evolved for a specific application.

1.3 WHY STEEL IS SO IMPORTANT

It could be unjust to nation that any person metal is greater crucial than any other with out defining parameters of attention. For example, with out aluminum and titanium alloys, cutting-edge airplanes and space vechicles could not were advanced. Steel, however, is by means of a long way the most extensively used alloy and for a very good cause. Among layman, the motive for metal's dominance is commonly taken into consideration to be the abundance of iron ore (iron is the major ingredient in all steels) and/or the convenience by which it is able to be refined from ore. Neither of these is always correct; iron is by no means the maximum plentiful detail, and it isn't the easiest steel to produce from ore. Copper, for instance, exists as almost pure metallic in sure components of the sector.

Steel is such an vital material due to its top notch flexibility in metallic operating and heat treating to provide a huge form of mechanical, physical, and chemical properties.

2. LITERATURE REVIEW

Basak and chakroborty (1983) advanced Cr-Mn-Cu white solid iron for utility in mining, farm equipment; etcrequiringerosive and corrosive put on resistance residences. They determined that the addition of Cu improves the corrosion resistance of Cr-Mn iron and hence decreased the price of corrosive wear of high copper, chromium and manganese solid iron.

Kumar and Gupta(1990) studied the abrasive wear conduct of mild, medium carbon, leaf and high carbon, low Cr. Steel by using a dry stand rubber wheel abrasion apparatus. They observed that the warmth treated excessive carbon low Cr. Steel and slight metallic carburized with the aid of their very own method to be the exceptional abrasion resistance substances. The abrasive put on resistance values of the two substances put on determined to be very plenty comparable with each other.

They additionally studied the abrasive wear of carburized mild metallic. They investigated the impact of carburization situations (e.G., temperature, time, residences of carbonaceous material and so forth.) at the abrasive wear loss. During the have a look at, Kumar advanced a cheaper technique of carburizing generating higher put on resistance. In this method, moderate metal samples are carburized underneath situations which includes;

1) Carburization in as received charcoal granules +BaCO3 mixtures with a thick coating (2mm approx.) of a coal tar pitch on steel pattern.

2) Carburization in used charcoal +BaCO3 mixture with bloodless tar pitches coating on the metal sample.

In both the instances carburization became accomplished at a temperature 930c for two hours (surest).All the quenched carburized metallic samples were tempered at 150c for 15min.

As outlined by means of them, the nature and reactivity of carbon used greatly affect the mechanical homes and abrasion resistance of carburized mild steel specimens. The end result obtained through their carburization technique was found to be tons advanced to those received by means of conventional technique. The tribological homes of carbon graphite had been widely documented in the literature. This carbonization approach no longer handiest offers very excessive hardness and abrasion resistance (equivalent to the ones of high carbon steel) however additionally brings about the subsequent other blessings.

1) Reduction inside the requirements of charcoal and BaCO3.

2) Saving of carburization time and removal of rehardening elements.

3) Utilization of waste cloth.

4) Saving within the composition of electricity.

Lancaster(1989) has cautioned that graphite crystallite are embedded into the floor valley aspirates and acts as nuclei as a for lubrication film building and as a consequence reduced the effectiveness of of abrasive put on of aspirates bodily.

Stevenson and hutchengs(1994) , have stated that sinter particles wear purpose to ease gross fracture of the carbide and so the ones materials with a high volume fraction of carbide shared the greatest resistance to erosive put on.

Mohamed H. Frihat[2000] done his research on low alloy metal with 0.31, 0.24, 0.23 and 0.29 % Carbon respectively. Each specimen changed into divided into four organization for extraordinary experiment. Pack carburizing changed into applied at 9000C-10500C water turned into used as quenching medium. The testing of mechanical homes turned into carried out by means of acting the tensile check on UTM, Vickers hardness testing & impact checking out on the specimens. A microscope was used to have a look at the microstructure of the specimens after each step.

Cullen M. Moleejane et.Al. [2003] conducted his studies on EN-eight grade of metallic. The specimen turned into divided into four agencies. Group A changed into austenitized at 9500C accompanied with the aid of furnace cooling , B changed into austenitized at 9140C accompanied with the aid of furnace cooling, C turned into austenitized at 9140C with furnace cooling with special preserving time. D become austenitized at 9140C and quenched in oil. To take a look at the micro structural functions optical electronic microscope(OEM) & scanning electron microscope (SEM) have been used. Micro structure evaluation changed into completed after every warmth treatment process. The elongation and yield strength were studied for each specimen after tensile testing. Hardness value after each heat remedy were discovered the usage of Brinell hardness tester.

S.D. Vetrivel et.Al. [2004] in his paintings used medium carbon steel. Surface remedy became completed by way of the usage of nitriding and induction hardening. Three specimen had been heated at 5000C,5500C and 6000C at unique soaking time and exclusive quenching medium accompanied by using tempering. The intention became to change mechanical & tribological residences through warmth

remedy approaches. Firstly, annealing was performed at 8000C on the cylindrical specimen for disposing of stresses and after that vicker hardness check, sliding abrasive wear check and XRD analysis became done.

Prof. S.R. Thakare et.Al. [2005] in his look at used EN8 metal. The specimen had been preheated at 8800C-9100C. After that numerous warmness remedy manner were implemented like hardening, quenching in distinctive mediums and subsequently tempering at two hundred-3000C. He used the Rockwell hardness tester for testing the hardness and he used the Taguchi technique to optimize all parameters.

Sakthivel Munisamy et.Al. [2006] investigated the residences of EN8 after quenching in exclusive mediums. Specimen were heated in one of a kind furnaces namely Gas carburizing furnace and seal quenching furnace where quenching is performed outside and inside furnace respectively. Heating turned into finished at 9300C and quenched in special medium like closed oil, open oil, water and air.

Ali Emamian [2007] studied the mechanical and tribological houses of Fe-based totally powdered metallurgy components. He organized the take a look at samples, sixty four round discs with 7 mm diameter and 10 mm thickness which can be fabricated from low carbon alloy and produced through powder metallurgy technique. The specimen had been firstly p.C. Carburized at almost 8500C9500C. Wear checking out changed into completed by way of the manner of a pin on disk tribometer. He applied Charpy test on widespread effect specimen with notch, at room temperature. Lastly the macro and micro hardness assessments had been applied on metallography samples.

K. Miernik et.Al. [2008] investigated on mechanical houses of low carbon structural metallic when incomplete quenching turned into accomplished. Normalizing become achieved at 8700C and quenching from numerous section range temperature changed into done accompanied with the aid of high temperature tempering after every process.

Jaykant Gupta [2009] had investigated on properties of mild metal. Different range of carburizing temperature i.E. 8500C,9000C and 9500C had been taken and heated in muffle furnace with 2 hours of maintaining time and quenched in water. Tempering was finished at 2500C after every process with 30 minutes of protecting time. Mechanical residences like hardness, tensile check and put on resistance become examined after the heat treatment of specimen.

T. Senthikumar et.Al. [2011] performed his paintings on medium carbon metal. The specimen tensile check wherein made as in line with wellknown specifications. After this warmth remedy manner has carries on. Hardening manner turned into finished at 8500C with keeping on 2 hours and water quenched. Tempering become then accompanied up at 3500C. Annealing at 8700C and normalizing at 8500C have been conduct respectively. After the process tensile check was executed the use of UTM and further analyzed.

3. SPECIMEN PREPARATION

The first and important job for the test is the specimen instruction. The specimen size should be compatible to the device specs:

We got the pattern from mild metallic dealer. The pattern that we were given changed into Mild steel. AISI8620:It is one of the American widespread specs of the slight steel having the paralytic matrix (up to70%) with relatively much less amount of ferrite (30-forty%). And so it has excessive hardness with mild ductility and excessive electricity as special under. So we can also say that it is basically a pearlitic/ferritic matrix.

3.1 CARBON STEEL

Carbon metal (simple carbon metallic) is steel which incorporate most important alloying element is carbon. Here we discover most up to one.5% carbon and different alloying factors like copper, manganese, silicon. Most of the steel produced now-a-days is obvious carbon steel. It is split into the subsequent sorts relying upon the carbon content.

1) Dead or mild steel (up to 0.15% carbon)
2) Low carbon steel (0.15%-0.45% carbon)
3) Medium carbon steel (0.45%-0.8% carbon)
4) High carbon steel (0.8%-1.5% carbon)

Steel with low carbon content has homes similar to iron. As the carbon content will increase the metal will become more difficult and stronger however much less ductile and greater difficult to weld. Higher carbon content material lowers the melting point and its temperature resistance carbon content cannot regulate yield strength of fabric.

3.1.1. LOW CARBON STEEL

Low carbon metal has carbon content of 1.5% to 4.5%. Low carbon metallic is the most common form of steel as its charge is notably low even as its offers material houses which might be suitable for lots applications. It is neither externally brittle nor ductile due to its low carbon content material. It has decrease tensile power and malleable.

3.2 HEAT TREATMENT

The technique of warmth remedy is achieved first via heating the cloth and then cooling it inside the brine, water and oil. The purpose of warmth treatment is to soften the steel, to alternate the grain size, to adjust the shape of the fabric and to relieve the pressure set up within the material after warm and cold running.

The various warmth remedy strategies normally employed in engineering exercise as follows:-

3.2.1 ANNEALING

Spherodizing

Spherodite forms when carbon metal is heated to approximately 700 for over 30 hours. The motive is to melt better carbon metallic and permit more formability. This is the softest and maximum ductile form of metal. Here cementite is present.

Full annealing

Carbon metallic is heated to about above the top important temperature (550-650) for 1 hour. Here all the ferrite transforms into austenite. The metallic must then cooled inside the realm of 38 per hour. This results in a coarse pearlite shape. Full annealed metal is tender and ductile without a inner stress.

Process annealing

The steel is heated to a temperature below or near the decrease crucial temperature (550-650), held at this temperature for a while after which cooled slowly. The cause is to relive strain in a chilly worked carbon metal with much less than 0.3p.Cwt c.

Diffusion annealing

The process consists of heating the metal to excessive temperature (1100- 1200). It is held at this temperature for three hours to 20 hours and then cooled to 800-850 within the furnace for a period of about 6 to 8 hours. It is in addition cooled in the air to room temperature. This technique is mainly used for ingots and large casting. It is likewise called isothermal annealing.

3.2.2 NORMALISING

The procedure of normalizing encompass heating the metal to a temperature of 30 to 50 c above the higher critical temperature for hypo-eutectoid steels and by way of the identical temperature above the decrease important temperature for hyper-eutectoid metallic. It is held at this temperature for a enormous time after which quenched in suitable cooling medium. The reason of normalizing is to refine grain structure, improve machinibility and enhance tensile electricity, to dispose of strain and to do away with dislocation.

3.2.3 HARDENING

The technique of hardening encompass heating the metal to a temperature of 30-50 c above the upper crucial point for hypo-eutectoid steels and by means of the same temperature above the lower important temperature for hyper-eutectoid steels. It is held this temperature for a while and then quenched. The purposes of hardening are to boom the hardness of the metallic and to make suitable cutting gear.

3.2.4 AUSTEMPERING

It is a hardening system. It's also called isothermal quenching. In this manner, the steel is heated above the higher critical temperature at approximately 875 c where the shape is composed totally of austenite. It is then unexpectedly cooled through quenching it in a salt bath maintained at a temperature of about 250 c to 525 c.

3.2.5 MARTEMPERING

This method is likewise called steeped quenching or interrupted quenching. It consists of heating metal above the upper essential temperature and quenching it in a salt bath kept at a appropriate temperature.

3.2.6 TEMPERING

This method includes reheating the hardened metallic to a few temperature beneath the decrease crucial temperature, accompanied by using any preferred charge of cooling. The cause is to relive inner stress, to reduce brittleness and to make metal tough to face up to surprise and fatigue.

3.3 SURFACE HARDENING

In many engineering applications, it's miles appropriate that steel being used should have a hardened floor to resist put on and tear. At this time, it ought to have gentle and difficult interior or core so that it can soak up any shocks. Case hardening is the manner of hardening the floor of steel, regularly a low carbon steel by using infusing factors into the steel surface forming a difficult, wear resistance pores and skin however retaining a difficult and ductile interior. This sort of remedy is carried out to gears, ball bearings, railway wheels. The diverse case hardening approaches are as follows:-

A. Carburizing

B. Cyaniding

C. Nitriding

D. Carbonitriding

E. Flame/induction hardening

3.3.1 FLAME AND INDUCTION HARDENING

Flame or induction hardening are technique in which the surfaces of the steel is heated to a high temperature (by direct application of flame or by using induction heating), then cooled swiftly using water this creates a case of martensite at the surfaces. A carbon content material of 0.4%-0.6%wt c is needed for this type of hardening.

Typically makes use of are shackles of a lock, wherein the outer layer is hardened to be file resistant and mechanical gears, wherein hard equipment mesh floor are needed to preserve an extended provider lifestyles.

3.3.2 NITRIDING

This technique heats the metal part to 482-621 c in an environment of ammonia fuel and dissociated ammonia. The hardness is completed by formation of nitrides. The benefit of this process is it causes little distortion.

3.3.3 CYANIDING

The element is heated to 1600 -1750 c in a bathtub of sodium cyanide and then quenched and rinsed in water and oil to take away any residual cyanide. This technique produces a skinny, tough shell (between zero.010 and 0.030 inches) that is more difficult than the one produced by way of carburizing and can be completed in 20 to 30 minutes. It is usually used on small components which include bolts, nuts, screw and small gears. The most important drawback of cyaniding is that cyanide salts are poisonous.

3.3.4 CARBONITRIDING

Carbonitriding is a case hardening technique wherein metal is heated in a gaseous environment of such composition that carbon and nitrogen are absorbed concurrently. The time period carbonitriding is misleading as it implies a changed nitriding method. Actually carbonitriding is a amendment of carburizing, and the name “nitro carburizing” could be extra descriptive. The method is also known as dry cyaniding, fuel cyaniding, and nicarbing. The atmosphere utilized in carbonitriding commonly comprises a aggregate of service gas, and ammonia. The carrier gasoline is often a aggregate of nitrogen, hydrogen, and carbon monoxide produced in an endothermic generator, as in fuel carburizing.

The presence of nitrogen in the austenite bills for the primary variations among carbonitriding and carburizing. Carbon nitrogen austenite is stable at decrease temperatures the apparent carbon austenite and transforms greater slowly on cooling. Carbonitriding therefore can be finished at decrease temperatures and allows slower cooling prices than carburizing in the hardening operation due to the lower temperature remedy.

3.3.5 CARBURIZING

As my assignment involved "warmness treatment of low carbon metallic" is an experimental mission which normally deals with carburizing method.

The conventional method of applying the carbon to the surfaces of the iron worried packing the iron in a mixture of floor bone or charcoal or a aggregate of leathers, hooves, salt and urine, all internal a properly sealed field. The ensuing package deal is then heated to a high temperature, but nonetheless beneath the melting point of the iron and left at that temperature for a period of time. The longer the package is held at the excessive temperature, deeper carbon will diffuse into the surface, the resulting case hardened element may display a distinct correlation at the floor.

Carburizing is a method of including carbon to floor. This is performed by using exposing the part to carbon wealthy environment on the multiplied temp (nearly melting factor) and permits diffusion to transfer the carbon atoms in the metal. This diffusion paintings at the precept of differential concentration.

$$2CO \leftrightarrow C \text{ (in Fe)} + CO_2$$

And

$$CO+H_2 \leftrightarrow C \text{ (in Fe)} + H_2O$$

1. Carburizing is the most broadly used technique of surface hardening. Here, the floor layers of a low carbon metal (<0.25) is enriched with carbon as much as 0.8-1.0%. The supply of carbon can be a strong medium, a liquid or a gasoline.
2. In all instances, the carbon enters the metal at the surface and diffuses into the metal as a feature of time at an extended temperature. Carburizing is achieved at 920-950°C. At this temperature the subsequent response takes region.

$$Fe+2CO\square Fe_2+CO_2$$

3. Where Fe(c) represents carbon dissolved in austenite. The price of diffusion of carbon in austenite, at a given temperature is dependent upon the diffusion coefficient and the carbon awareness gradient.
4. The carburizing equation given formerly, is reversible and can proceed to the left, eliminating carbon from the floor layer if the steel is heated in an ecosystem containing carbon dioxide (CO_2). This is called decarburization.
5. Decarburization can be prevented through the use of an endothermic gas atmosphere in the furnace
6. to defend the floor of the steel from oxygen, carbon dioxide and water vapor. An endothermic gasoline ecosystem is prepared by means of reacting rather rich combinations of air and hydrocarbon gas (generally natural gasoline) in an externally heated generator inside the presence of a nickel catalyst.
7. Carburizing may be completed by Pack carburizing, Liquid carburizing, Gas carburizing and vacuum carburizing.

3.4 TYPES OF CARBURIZING PROCESS

1) Gas carburizing
2) Liquid carburizing
3) Vacuum carburizing
4) Plasma(ion) carburizing
5) Salt bath carburizing
6) Pack carburizing

3.4.1 GAS CARBURIZING

Gas carburizing has come to be the maximum popular technique of carburizing in the closing two many years. The foremost carburizing agent on this technique is any carbonaceous gasoline along with methane,propane or natural gas. In this technique it's far vital that the hydrocarbon gases should be diluted with a carrier fuel to keep away from heavy soot formation. Carrier gasoline may be made by way of controlled combustion of hydrocarbon fuel. Methane may be burnt in air to methane ratio 2.5 and reacts as:

$$2CH_4+O_2 \leftrightarrow 2CO+2H_2$$

And the common endothermic carrier gas has the composition (vol. %) N2=39.8%; CO=20.7%; H2=38.7%; CH4=0.8%

The important chemical reaction occurring during gas carburizing is:

$CH_4+Fe \leftrightarrow Fe(C) + 2H_2$ (1)

$2CO+Fe \leftrightarrow Fe(C) + CO_2$ (2)

$CO+H_2+Fe \leftrightarrow Fe(C) + H_2O$ (3)

Where Fe(C) indicates carbon dissolved in austenite.

$CH_4+CO_2 \rightarrow 2CO+2H_2$ (4)

$CH_4+H_20 \rightarrow CO+3H_2$ (5)

The H2 and CO as regenerated via reaction(four) and (5), react with metal floor in keeping with the reaction (2) and (three) to cause enrichment of floor by carbon. It is consequently obvious that the remaining source of carbon in gasoline carburizing is CH4.

This is the maximum widely used technique of carburizing. It is done in retort kind, sealed quench type, or continuous pusher kind furnaces. These furnaces are either fuel fired or are heated electrically. Gas carburizing temperature varies from 870°C to 950°C. Gas environment for carburizing is produced from liquid (methanol, isopropanol) or gaseous hydrocarbons (propane and methane). An endothermic gasoline generator is used to supply endothermic fuel. A aggregate of propane or methane with air is cracked in hot retort of an endogas generator to form carrier fuel, whose dew point is adjusted at approximately +4°C by means of proper fuel/air ratio.

Such a gasoline acts as a 'provider gas' for the manner. Furnace chamber is purged with this gasoline to gasoline hold a barely superb pressure. This in flip prevents infiltration of air from ecosystem. This gas also prevents oxidation of the metal at some stage in heating. When the cloth reaches carburizing temperatures, propane or methane is introduced to keep a selected carbon potential.

During gas carburizing, the following reactions take place:

1. $C_3H_8 \rightarrow 2CH_4 + C$ (cracking of hydrocarbon)
2. $CH_4 + Fe \rightarrow Fe(C) + 2H_2$
3. $CH_4 + CO_2 \rightarrow 2CO + 2H_2$
4. $2CO + Fe \rightarrow Fe(C) + CO_2$

Carburizing occurs mainly due to conversion of CO to CO2 through reaction. Hydrogen reacts with CO2 and increases CO concentration by the reaction Average concentrations of CO2 , H2O, and O2 are 0.2%, 0.5% and 10-14 ppm respectively. One of the recent developments in the gas carburizing technique is the use of nitrogen as a carrier gas. Normally, nitrogen gas is used with some minor additives. Carbon potential is controlled by adjusting the level of oxidizing constituents. Currently the cost of equipment for this modified process is high. Also, skilled and well trained operators are required for successful operation of this process.

ADVANTAGES OF GAS CARBURIZATION

1) In gasoline carburization, the surface carbon content as well as the case depth may be accurately controlled.
2) It offers extra uniform case intensity.
3) It is much purifier and extra green method than p.C. Carburizing.
4) Total time of carburization is a great deal much less than the p.C. Carburization as the containers and the solid carburizer are not to be heated.

DISADVANTAGES OF GAS CARBURIZING

1) Furnace and gasoline generator are high priced.
2) Trays are pricey.
3) Greater degree of operating skill is needed.
4) Handling of fire hazards and poisonous gases is hard.

Since gasoline carburizing is more costly system than percent carburizing this is why the later one is favored within the gift work.

3.4.2 LIQUID CARBURIZING

Liquid carburizing is a method of case hardening steel by placing it in a bath of molten cyanide so that carbon will diffuse from the bath in to the metal and produce a case comparable to the one resulting from pack or gas carburizing. Liquid carburizing may be distinguished from cyaniding by the character and composition of the case produced. The cyanide case is higher in nitrogen and lower in carbon the reverse is true of liquid carburized cases. Low temperature salt baths (lights case) usually contain a cyanide content of 20 percent and operate between 1550 °F and 1650° F. High temperature salt baths (deep case) usually have cyanide content of 10 percent and operate between 1650°F and 1750° F.

It is also popularly known as salt bath carburizing. In this process, carburizing takes place thru molten cyanide (CN) in low carbon steel forged pot kind furnace heated via oil or fuel. Bath temperature is maintained among 815°C and 900°C. The lifestyles of pot depends on pleasant of fabric, operating temperature and mode of operation, viz. Whether or not it's far continuous or intermittent. Continuous and automated processes provide suitable stop outcomes. The bathtub floor is covered with graphite or coal to lessen radiation losses and excessive decomposition of cyanide. Different salt combinations used in this approaches are named consistent with their carbon ability pastime. Besides sodium or potassium cyanide, the bathtub contains (i) Sodium and potassium chloride (ii) Barium chloride which acts as an activator

$$BaCl_2 + 2NaCN \rightarrow Ba(CN)_2 + 2NaCl$$

$$Ba(CN)_2 + Fe \rightarrow Fe(c) + BaCN_2$$

Some useful nitrogen diffusion may also take vicinity thru oxidation of CN to CNO. In liquid carburizing, heating time is brief and heat transfer is rapid. There is complete uniformity of the carburized layer within the aspect. This procedure gives a skinny and clean hardened layer of ~0.08mm thick.

ADVNTAGES OF LIQUID CARBURIZING

1) Freedom from oxidation and sooting problems.
2) Uniform case intensity and carbon content material.
3) A speedy fee of penetration.
4) The reality that the tub affords high thermal conductivity, thereby decreasing the time required for the metal to attain the carburizing temperature.

DISADVNTAGES OF LIQUID CARBURIZING

1) Parts ought to be very well washed after warmth treatment to prevent rusting.
2) Regular checking and adjustment of the bathtub.
3) Proper composition is necessary to gain uniform case intensity.
4) Some shapes cannot be treated due to the fact they both flow or will reason excessive drag out of salt.
5) Cyanide salts are toxic and require cautious interest to fulfill.

3.4.3 VACUUM CARBURIZING

The vacuum carburizing procedure includes taking iron, steel or alloy steel and infusing it with carbon that allows you to make it more difficult. First, the steel is located in a vacuum furnace and heated to the precise temperature. Then propane gasoline is released into the furnace. As a result of the warmth, the propane breaks down into the elements carbon, hydrocarbon and hydrogen. The carbon diffuses into the metal, making it tougher.

1. The first industrial utility of vacuum carburizing began inside the early Nineteen Seventies. Vacuum carburizing is a tactics of carburizing, accomplished either in vacuum or in decreased strain. The fundamental gain of the system lies inside the brilliant strength saving associated with it.
2. Carburizing in vacuum or decreased pressure is achieved in two degrees. In the primary level, carbon is made available to the metal for absorption.
3. In the second stage, diffusion of the carbon takes vicinity inside the steel piece and results in appropriate awareness of carbon and intensity of carburizing.
4. In vacuum carburizing, there's accurate control on the quantity of carbon absorbed. Also, as the procedure takes area at a quite better temperature, carbon absorption is pretty speedy.
5. To begin the technique, the activity is delivered into the furnace that is then evacuated. After attaining the required degree of vacuum, the furnace is heated as much as a carburizing temperature which lies in the range 925-1050°C. In this temperature range, austenite which is formed is unsaturated with appreciate to carbon.
6. A gaseous hydrocarbon inclusive of methane or propane is then brought into the furnace. As quickly because the hydrocarbon in gaseous shape comes in contact with the floor of the job, it cracks. As a end result, a totally thin layer of extraordinarily high-quality carbon is deposited at the surface.
7. This carbon is straight away absorbed by the steel till saturation is attained. The system continuous till enough carbon is absorbed and the specified case depth is fashioned the influx of gasoline is

then stopped and the excess gasoline is removed by way of vacuum pumps.

ADVNTAGES OF VACUUM CARBURIZING

1) Easy integration into production. The system is easy, safe, simple to perform and smooth to maintain. Full automation capability using recipe or element-quantity manages of warmth treating cycles.

2) Capability of better temperatures and bendy cycles due to the sort of device and the nature of the system.

3) Precise manner manage executed using laptop simulations, which permit modifications to mounted cycles.

4) Consumption of strength by means of the device and process handiest when wanted due to the character of the vacuum operation.

DISADVNTAGES OF VACUUM CARBURIZING

1) Higher preliminary capital device price than atmosphere carburizing device.

2) Empirical method manage, which calls for processing hundreds to determine gold standard settings or to satisfactory music simulator.

3) Formation of soot and tar, which occur due to the kind, pressure and quantity of hydrocarbon fuel added.

3.4.4 PLASMA (ION) CARBURIZING

Any steel which may be gasoline carburised also can be floor hardened the usage of plasma carburisation. The precept of the process is the identical and it ambitions to boom the carbon content material at the surface of a factor to allow formation of a deep and difficult layer on quenching. Plain carbon steels, alloy steels and cast irons may be dealt with, but ought to have a carbon content below 0.4% and ideally below zero.25%.

The technique is undertaken in a batch kind vacuum furnace with an vital quenching tank (normally oil). The chamber is operated at a reduced pressure of 0.1 to 3kPa and at a temperature of 950°C or much less. The components are held at a poor voltage of four hundred-800V even as a hydrocarbon gasoline (methane or propane) - diluted with nitrogen, hydrogen and argon - is delivered into the chamber at some litres according to minute. A glow discharge plasma is produced as a layer surrounding the components. This plasma consists of elemental carbon which diffuses into the components' surface. Once carburisation is entire, the gasoline drift and plasma are stopped and the additives are held at temperature in the vacuum to allow in addition diffusion of the carbon into the substrate. The components are slightly cooled to approximately 925-850°C before being quenched in a bath of oil. Case depths of 0.2 to 2mm are carried out with a hardness of approximately 700HV.

The floor of the components may be wiped clean inside the chamber, prior to carburising, by sputtering and hydrogen reduction of any oxides. 'Sooting', which often happens in traditional gas carburising, is prevented because the presence of carbon is restrained to the skinny discharge layer. High capital value of device limits the system to long manufacturing runs or short runs of specialised, excessive price components.

ADVNTAGES OF PLASMA (ION) CARBURIZING

1) Reduced Cycle Time

2) Controlled Growth Of The Surface Layer

3) Elimination Of White Layer

4) Reduced distortion

5) No need of finishing

6) Higher surface, case and core hardness

7) Pore-Free Surfaces And Mechanical Masks Instead Of Copper Plating

ADVNTAGES OF PLASMA (ION) CARBURIZING

1) Limited on compound zone thickness (maximum) due to the nature of the process.

2) Relatively less superior temperature control (as compared to gas) – this can lead to variance in case depth / hardness / dimensional stability.

3) Increases surface roughness.

3.4.5 SALT BATH CARBURIZING

Salt bath heat treatment is a heat treatment process comprising an immersion of the treated part into a molten salt (or salts mixture).The method features the transfer via diffusion of carbon and nitrogen from the molten salt to the surface of a steel part. It remains a popular case hardening technique because it offers Increased hardness and wear resistance at part surfaces while cores remain softer and more ductile.

In this method, except nitrogen, carbon atoms are also diffused into the case of steel component at 570-580°C in salt baths. The salt baths are of kinds, specifically, those containing cyanide and others which do no longer comprise any cyanide. Cyanide-free salt baths are extra popular because these aren't risky. The base salt includes a combination of sodium and potassium cyanates and carbonates. The time for acquiring a case intensity of 10-15 μm is about 1½ hours for low carbon unalloyed steels. Reactions that take region in the bath are as follows.

$$4NCO^{-} \rightarrow CO_3 + CO + 2N + 2CN$$

$$XFe + N \rightarrow FexN$$

$$2CN^{-} + O_2 \rightarrow 2NCO^{-} (regeneration of CN^{-})$$

$$3CO_3 + regenerator \rightarrow 6NCO^{-} + XH_2O (regenerator of CO_3^{-})$$

One of the current tendencies is to spoil cyanate and the small percent of cyanide in the drag-out salt. This is completed via quenching in oxidizing quenching (cooling) salt. Such a treatment eliminates the want for neutralization plant. This procedure can be used for any ferrous fabric; the time taken for treatment is short. However, it is not appropriate for extremely huge objects and abnormal shaped additives. Limitation of the approaches is that the typical treated layers are very skinny and nitro carburizing atmospheres/salts are difficult to address protection

ADVANTAGE OF THE SALT BATH CARBURIZING

1) **Fast heating-** A work part immersed into a molten salt is heated by heat transferred by conduction (combined with convection) through the liquid media (salt bath). The heat transfer rate in a liquid media is much greater than that in other heating mechanisms: radiation, convection through a gas (e.g., air).

2) **Controlled cooling conditions during quenching-** In conventional quenching operation either water or oil are used as the quenching media. High cooling rate provided by water/oil may cause cracks and distortions. Cooling in molten salt is slower and stops at lower temperature.

3) **Low surface oxidation and decarburization-** The contact of the hot work part with the atmosphere is minimized when the part is treated in the salt bath.

3.4.6 PACK CARBURIZING

In this process, the component this is to be carburized is packed in a metallic box, in order that it's miles absolutely surrounded through granules of charcoal. The charcoal is handled with an alternating chemical which includes barium carbonate ($BaBo_3$) that promotes the formation of carbon dioxide (CO_2). This gas in turns reacts with the extra carbon inside the charcoal to provide carbon monoxide (CO) .Carbon monoxide reacts with low carbon metallic surface to shape atomic carbon which diffuses into the steel. Carbon monoxide materials the carbon gradient this is necessary for diffusion. The car bruising manner does not harden the metal. It handiest will increase the carbon content to a few predetermined intensity under the floor to a sufficient stage to permit next quench hardening.

$$CO_2 + C \rightarrow 2CO$$

$$\downarrow$$

$$2CO + 3Fe \rightarrow Fe_3C + CO_2$$

The oxygen of the entrapped air (in the carburizing box) initially reacts with the carbon of the carburizing medium as follows:

$$C + O_2 \rightarrow CO_2 \quad (1)$$

$$2C + O_2 \rightarrow 2CO \quad (2)$$

As the temperature rises the subsequent reactions take location and the equilibrium shifts closer to right this is fuel becomes step by step richer in CO. At excessive temperature (> 800°c) the boudoirs reaction occurs as follows

$$CO_2 + C \leftrightarrow 2CO \; \ldots\ldots\ldots \; (3)$$

At the steel surface the decomposition of CO gas occurs as follows:

$$2C + O_2 \rightarrow CO_2 + C \text{ (atomic)}$$

$$Fe + C \text{ (atomic)} \rightarrow Fe(C)$$

Where Fe(C) is carbon dissolved in austenite.

This atomic and nascent carbon is radially absorbed via the steel floor, and eventually it diffuses closer to the centre of steel sample. CO_2 as a consequence shaped react with the carbon (C) of the carburizing medium (reaction 3) to provide CO, and for this reason, the cycle of the reaction continues. Charcoal is the fundamental source of carbon for the duration of percent carburization. As entrapped air within the box may be much less to provide sufficient CO2 (reaction 1) especially inside the beginning of the carburization, it's miles therefore it's miles not unusual practice to feature energizer (generally BaCO3) which decomposes at some point of the heating up duration as:

$BaCO_3 \rightarrow BaO + CO_2$

$CO_2 + C \rightarrow 2CO$

The CO2 accordingly formed then react with the carbon of the carburizer to supply CO gas. Thus BaCO3 makes CO2 to be had at an early degree of carburization and therefore it is called energizer.

The case depth will increase with upward push in carburization temperature and time. The first-class carburizing temperature is 900°c, the metallic floor absorbs carbon at a faster charge and the rate at which it can diffuse inner, for that reason generating tremendous saturated case which might also produce cracks during quenching. In percent carburization it's miles tough to govern exactly the case depth because of many elements affecting it, together with density of packing amount of air present within the box, reactivity of carburizer, and etc.

ADVANTAGES OF PACK CARBURIZING

1) It is a cheap and easy technique if handiest few elements are to be carburized.

2) Very massive and huge components which can be too huge for gas or salt carburization may be carburized if a furnace of that length is available. Pack carburization can be executed in massive style of furnaces if these are having uniformity of the temperature.

3) In contrast to liquid and gas carburization, this approach carburization involves less capital funding.

4) No ecosystem-managed furnace is required.

5) No poisonous cyanide or fuel is used on this process.

6) It may be completed any workshop.

DISADVANTAGES OF PACK CARBURIZING

1) Carburizing time is very long, as carburizing containers as well as awful warmness accomplishing carburizing substances need to be heated.

2) It is hard to manipulate the surface carbon and the carbon gradient.

3) It is tough to govern the case depth exactly.

4) Handling carburizing fabric and packing is dirty and dusty process.

5) In p.C. Carburization it's far tough to quench the carburized parts.

3.5 APPLICATION

The possible applications of low carbon steel are very wide. The properties are such As to extend the field of usefulness of mild steel and enable it.

Some popular uses of Low carbon steel for various engineering application are for:

1) Support bracket for agricultural tractor.

2) Gear teeth profile

3) Crane wheels.

4) Crane cable drum.

5) Gear wheel and pinion blanks and brake drum.

6) Machines worm steel.

7) Flywheel.

8) Ball bearing.

9) Railway wheels.

10) Crankshaft.

11) Shackles of lock.

12) Bevel wheel.

13) Hydraulic clutch on diesel engine for heavy vehicle.

14) Fittings overhead electric transmission lines.

15) Boiler mountings, etc.

4. EXPERIMENTAL PROCEDURE

4.1 HEAT TREATMENT OF STEELS

All heat-treating operations consist of subjecting a metal to a definite time-temperature cycle, which may be divided into three parts: (1) Heating, (2) holding at temperature (soaking), and (3) cooling. Individual cases vary, but certain fundamental objectives may be stated.

The price of heating isn't particularly critical unless a stetsl is in a especially confused condition, including is imparted by way of severe bloodless working or previous hardening. In such instances the charge of heating have to be gradual. Frequently that is impracticable, due to the fact furnaces can be at working temperatures, however setting the cold steel inside the hot furnace can also reason distortion or maybe cracking. This hazard can be minimized via the use of a preheating furnace maintained at a temperature beneath the A,. The steel, preheated for a enough length, then may be transferred to the furnace at running temperature. This manner is also wonderful whilst treating steels having massive variations in phase thickness or very low thermal conductivity.

The object of maintaining a metal at heat-treating temperature is to guarantee uniformity of temperature throughout its entire volume. Obviously, thin sections need no longer be soaked so long as thick sections, but if exceptional thicknesses exist within the same piece, the length required to heat the thickest segment uniformly governs the time at temperature. A rule frequently used is to soak y2 hr/in. Of thickness.

The structure and properties of a metal rely on its fee of cooling and this, in turn, is governed with the aid of such elements as mass, quenching media, etc. It need to be found out that the thicker the section, the slower can be the charge of cooling regardless of the technique of cooling used except in such operations as induction hardening to be mentioned later.

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

4.2 HEAT TREATMENT

Low Carbon Steel are typically warmness dealt with to create matrix microstructures and associated mechanical houses not without problems acquired in the as-forged condition. As- solid matrix microstructures generally consist of ferrite or pearlite or combos of both, depending on cast phase length and/or alloy composition The principle objective of the undertaking is to carry out the heat treatment of Low carbon metallic and then to compare the mechanical residences. There are various types of heat remedy procedures we had followed.

4.2.1 ANNEALING

a) The specimen turned into heated to a temperature of 900 deg Celsius
b) At 900 deg Celsius the specimen changed into held for two hour
c) Then the furnace became switched off in order that the specimen temperature will decrease with the equal price as that of the furnace

The goal of maintaining the specimen at 900 deg Celsius for 2 hrs is to homogenize the specimen. The temperature 900 deg Celsius lies above Ac1 temperature. So that the specimen at that temperature gets enough time to get well homogenized .The specimen became taken out of the furnace after 2 days when the furnace temperature had already reached the room temperature.

4.2.2 NORMALIZING

a) At the very beginning the specimen become heated to the temperature of 900 deg Celsius.
b) There the specimen changed into kept for two hour.
c) Then the furnace turned into switched off and the specimen turned into taken out.
d) Now the specimen is authorized to chill within the everyday surroundings. I.E. The specimen is air cooled to room temperature.

The system of air cooling of specimen heated above Ac1 is called normalizing.

4.2.3 QUENCHING

This experiment turned into achieved to harden the solid iron. The technique involved setting the red hot forged iron immediately in to a liquid medium.

a) The specimen turned into heated to the temp of around 900 deg Celsius and had been allowed to homogenize at that temp for two hour.
b) An oil bathtub turned into maintained at a steady temperature wherein the specimen had to be positioned.

c) After 2 hour the specimen turned into taken out of the furnace and without delay quenched in the oil bath.

d) After around 1/2 an hour the specimen changed into taken out of the bathtub and wiped clean nicely.

e) Now the specimen attains the liquid tub temp inside couple of minutes. But the price of cooling is very speedy due to the fact the liquid doesn't launch warmness readily.

4.2.4 TEMPERING

This is the one of the crucial experiment performed with the goal of the experiment being to set off a few quantity of softness in the fabric by

heating to a mild temperature variety.

a) First the '4' specimen have been heated to 900 deg Celsius for 2 hour and then quenched inside the oil bathtub maintained at room temp.

b) Among the 4 specimen 2 had been heated to 250 deg Celsius. But for distinctive term of 1 hour, 1and half of hour and 2 hour respectively.

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

d) The closing specimens had been heated to 650 deg Celsius for same time c programming language of one hour. 1 and half and a couple of hour respectively.

After the specimens got heated to a particular temperature for a particular time period, they had been air cooled. The warmness remedy of tempering at extraordinary temp for exceptional time durations develops sort of homes inside them.

4.2.5 AUSTEMPERING

This is the maximum essential test completed for the assignment work. The objective was to increase all round belongings in the cloth.

a) The specimen become heated to the temperature of 900 degree Celsius and sufficient time changed into allowed at that temperature, so that the specimen were given nicely homogenized.

b) A salt bathtub was prepared through taking 50% NaN03 and 50 % KnO3 salt mixture. The goal behind using NaNO3 and KNO3 is even though the person melting points are high the combination of them in the tub with 1:1 homes from an eutectic aggregate this eutectic response brings down the melting factor of the mixture to 290 deg Celsius. The salt remains within the liquid country within the temp variety of 290-550 deg Celsius while the salt bathtub wished for the experiment ought to be at molten country at 350 deg Celsius

c) After the specimen getting nicely homogenized it become taken out of the furnace and installed another furnace in which the field with the salt aggregate turned into stored at 350d deg Celsius.

d) At that temp of 350 degree the specimen become held for 2 hrs In this time the austenite receives converted to bainite. The objective in the back of deciding on the temperature of 350 deg Celsius is that at this temperature will supply upper bainite which has pleasant grains so that the houses developed in the materials are wonderful.

e) An oil tub also maintained so that the specimen may be quenched.

f) So after sufficient time of two hr the salt bath changed into taken out of the furnace and the specimen have been quenched within the oil bath.

g) An oil bathtub is also maintained in order that specimen may be quenched. Now the specimens of every warmness treatment are geared up at room temperature. But all through quenching in a salt bathtub, or oil bath or cooling due to mild oxidation of the surface of forged iron, there are each possibility of scale formation on this surface if the specimens are despatched for testing with the scales in the surface then the hardness price will vary and the specimen will even not be gripped well inside the UTS .To keep away from this problems the specimens were floor with the assist of belt grinder to dispose of the scales from the floor. After the size elimination the Specimens are ready for the similarly experimentations.

4.3 STUDY OF MECHANICAL PROPERTIES

As the objective of the mission is to examine the mechanical homes of various warmth dealt with forged iron specimens, now the specimens have been despatched to hardness checking out and tensile checking out.

4.3.1 HARDNESS TESTING

The warmness dealt with specimens hardness were measured with the aid of Rockwell hardness tester. The system adopted may be listed as follows:

1) First the brale indenter changed into inserted in the machine; the load is adjusted to100 kg.

2) The minor load of a ten kg was first applied to seat of the specimen.

3) Now the main load applied and the depth of indentation is automatically recorded on a dial gage in phrases of arbitrary hardness numbers. The dial carries one hundred divisions. Each department corresponds to a penetration of .002 mm.The dial is reversed so that a excessive hardness, which results in small penetration, effects in a high hardness variety. The hardness value accordingly obtained became transformed into C scale b y the use of the usual converter chart.

4.3.2 ULTIMATE TENSILE STRENGTH TESTING

The warmness treated specimens have been treated in UTS Machine for obtaining the % elongation, Ultimate Tensile Strength, yield Strength. The strategies for obtaining these values can be listed as follows;

1) At first the go segment place of the specimen was measured by way of an electronic slide caliper and then the gauge length turned into calculated.

2) Now the space among the jaws of the USAturned into constant to the gauge duration of the specimen

3) The specimen turned into gripped by means of the jaws of the holder

4) The most load changed into set at a hundred and fifty KN.

5) The specimen changed into loaded until it fails

6) The corresponding Load vs. Displacement diagrams have been plotted via the usage of the software program. From the data acquired the % elongation, yield energy and remaining tensile strength have been calculated through the use of the following formulae:-

.% elongation = (exchange in gauge duration of specimen/initial gauge period 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

5. RESULTS ANDDISCUSSION

5.1 TABULATION FOR HARDNESS TESTING

Table.1 Different Hardness Values In Rc Scale For Various Heat Treated Low Carbon Steel Specimen

Specimen Specification	Time(in hours)	Hardness
Quenched from 900 and tempered at 250 degree celsius	1 ½ hour	39
Quenched from 900 and tempered At 450 degree celsius	1 ½ hour	34
Quenched from 900 and tempered at 650 degree celsius	1 ½ hour	28

Table.2 Hardness vs. tempering temperature for constant tempering time of 1 hour

Specimen Specification	Time(in hours)	Hardness
Quenched from 900 and tempered at 250 degree Celsius	1 hour	43
Quenched from 900 and tempered At 450 degree Celsius	1 hour	36
Quenched from 900 and tempered at 650 degree celsius	1 hour	33

Table.3 Hardness vs. tempering temperature for constant

Specimen Specification	Time(in hours)	Hardness
Quenched from 900 and tempered at 250 degree celsius	2 hour	34
Quenched from 900 and tempered At 450 degree celsius	2 hour	29
Quenched from 900 and tempered at 650 degree celsius	2 hour	22

mpering time of 1 ½ hour

Specimen specification	Time	Hardness
Quenched from 900 and tempered at 250 degree Celsius	1 hour	45
	1 ½ hour	39
	2 hour	34
Quenched from 900 and tempered At 450 degree Celsius	1 hour	38
	1 ½ hour	34
	2 hour	29
Quenched from 900 and tempered at 650 degree Celsius	1 hour	31
	1 ½ Hour	27
	2 hour	24
Austempered 350 degree celsius	1 hour	29
	2 hour	29
As Received	---------	22

Table.4 Hardness vs. tempering temperature for constant tempering time of 2 hour

5.2TABULATION FOR ULTIMATE TENSILE STRENGTH TESTING

Table.5 Tensile properties for different tempering temperature for 1 hour tempering time

Specimen Specification	Time(in hours)	UTS(in Mpa)	Yield Strength (in Mpa)	Elongation%
Quenched from 900 and tempered at 250 degree centigrade	1	548	334	9.654
Quenched from 900 and tempered at 450 degree centigrade	1	497	297	14.369
Quenched from 900 and tempered at 650 degree	1	318	234	20.476

Table.6 Tensile properties for different tempering temperature for 1 ½ an hour tempering time

Specimen Specification	Time(in hours)	UTS(in Mpa)	Yield Strength (in Mpa)	Elongation%
Quenched from 900 and tempered at 250 degree centigrade	1 ½	543	331	12.269
Quenched from 900 and tempered at 450 degree centigrade	1 ½	313	284	18.345
Quenched from 900 and tempered at 650 degree centigrade	1 ½	487	238	24.856

Table.7 Tensile properties for different tempering temperature for 2 hour tempering time

Specimen Specification	Time(in hours)	UTS(in Mpa)	Yield Strength (in Mpa)	Elongation %
Quenched from 900 and tempered at 250 degree centigrade	2	412	267.5	22.821
Quenched from 900 and tempered at 450 degree centigrade	2	382	254.6	27.514
Quenched from 900 and tempered at 650 degree centigrade	2	251	198	27.729

5.3 GRAPHS

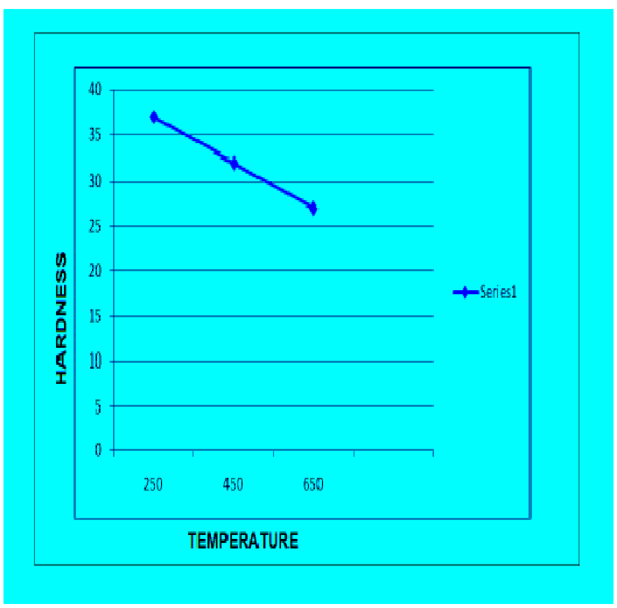

Figure.1 Hardness for different tempering temperature (in degree centigrade)

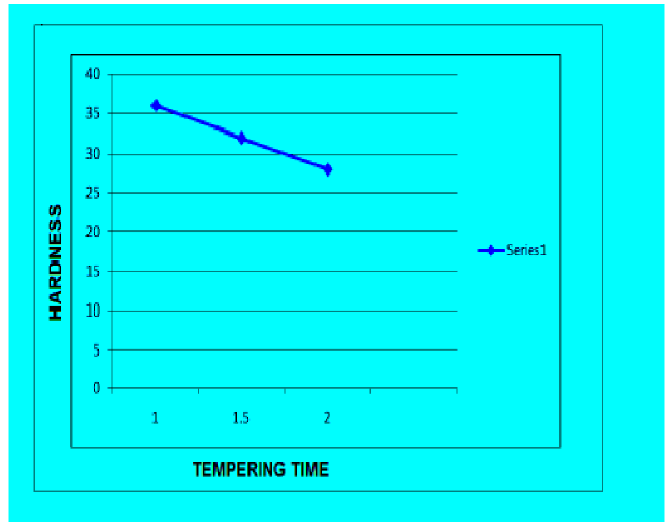

Figure.2 Variation in Hardness for different tempering time

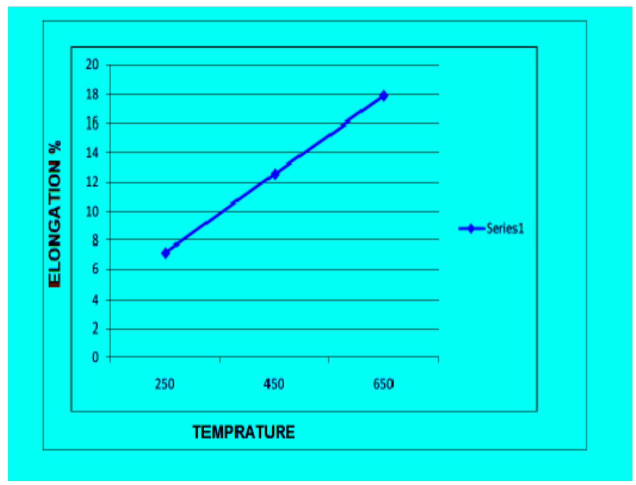

Figure.3 Variation of % elongation with different tempering temperature (in degree centigrade)

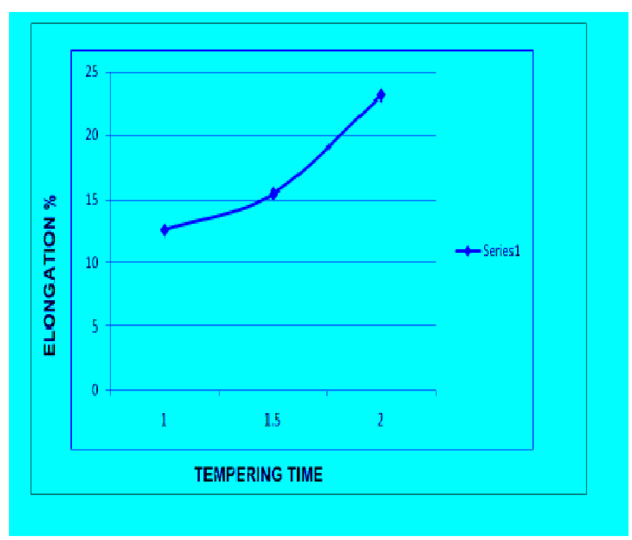

Figure.4 Variation of % elongation with different tempering time

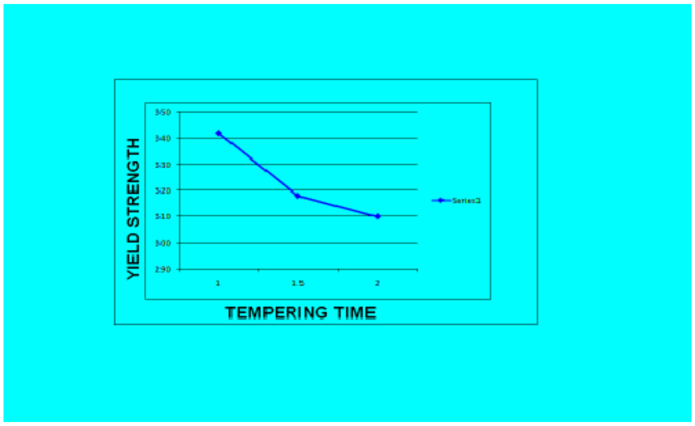

Figure.5 Variation of yield strength with different tempering time

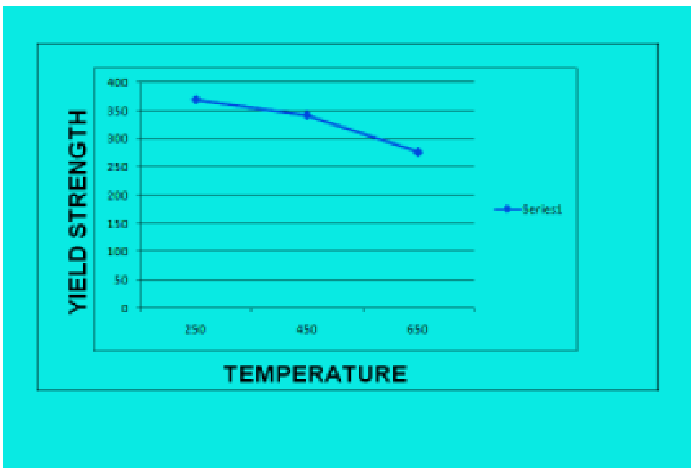

Figure.6 Variation of yield strength with tempering

5.4 EFFECT OF HEAT TREATMENT ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF MEDIUM CARBON STEEL

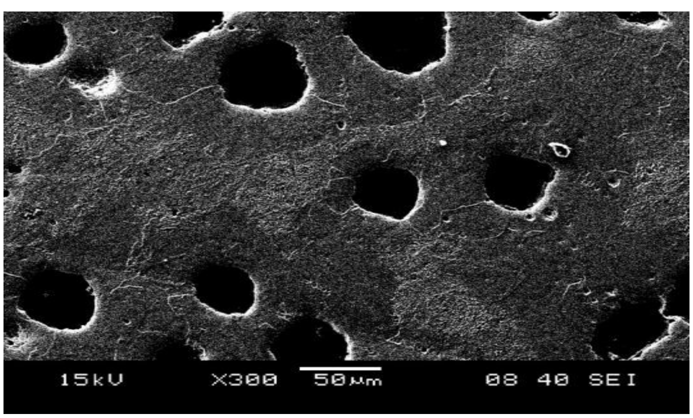

Figure 7.Tempered at 4000c with copper

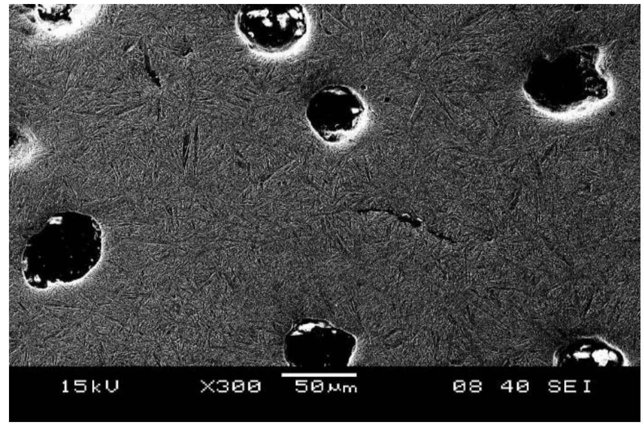

Figure 8.Tempered at 4000c without copper

5.4 DISCUSSION

From the numerous experiments performed following observations and inferences have been made. It was seen that the diverse tensile homes accompanied a specific series:

1) More is the tempering temperature, much less is the hardness or extra is the softness (ductility) triggered inside the quenched specimen. (ductility) brought on in the quenched specimen.

2) Microstructure snap shots taken with the aid of SEM and metallurgical inspections indicated that the surfaces of warmth dealt with samples are martensitic.

3) Case depth may be elevated by longer cycle of carburization. Case depth may be improved exponentially through growing carburization temperature.

4) The samples having more case intensity and floor hardness are extra put on resistant than that with low case intensity and occasional surface hardness.

5) More is the tempering time (keeping the tempering temperature regular), extra is the ductility prompted in the specimen.

6) This without a doubt means that the U.S.And additionally to a degree the yield power decreases with boom in tempering time wherein as the ductility (% elongation) increases.

7) For a given tempering time, an boom in the tempering temperature decreases the usprice and the yield power of the specimen in which as on the other hand growing the % elongation and for this reason the ductility.

6. CONCLUSIONS

From the various results obtained in the course of the project paintings it could be concluded that the mechanical houses range depending upon the numerous warmness treatment processes. Hence depending upon the houses and applications required we must move for a suitable heat treatment approaches. When ductility is the best standards tempering at high temperature for two hours offers the fine end result amongst all tempering experiments however it is actually the hardness of the low carbon steel that is preferred than we need to pass for low temperature tempering for 1 hour or so. However if electricity is also preferred in conjunction with hardness, this must now not be completed. It is visible that annealing causes a Tremendous increase in % elongation (ductility). It may be without a doubt seen comparing all the warmth treatment processes, best Combination of UTS, Yield Strength, % Elongation in addition to hardness may be Obtained through austempering only.

On growing the tempering temperature, the hardness of the medium carbon steel with copper is excessive compared to the metallic with out copper. On increasing tempering temperature, the ductility of each the metallic grade is growing. The metal with copper has low ductility as compared to metal without copper. The finest heat remedy for the examined maraging stainless-steel is at 1050̊C for 1 h at 70̊C for 8h at 535̊C for 4 h. By this remedy, the yield strain of the metal could reach1774 MPa and 1932 MPa. In the protecting temperature range of 850 to 1150̊C, increasing maintaining time should bring about moderate boom in previous austenite grain size until at 1050̊ C for 1 h. Whereas, peculiar grain boom became seen at 1050̊C for three h or longer conserving time .The ductile brittle transition temperature measured in smaller size specimen became 95°C and it become decrease than the 83°C inside the widespread specimen. The radiation hardening due to helium production in turned into detected at 330 ppm He. The measured discount place reduced with helium production in steels tested at room temperature. Yielding of low carbon steel with a ferrite + martensite grains with the aid of the technique of annealing.With the boom in temperature-time, the volume fraction of martensite is likewise improved. By the XRD analysis, there was a huge amount of gammaretained austenite paperwork compared to that of alpha-martensite.

1. Heat treatment (quenching and tempering) of low carbon metallic will increase the yield factor by way of 30–35% and the resistance to rupture 25–30%, however decreases the plasticity, in particular while the carbon awareness is low.
2. The development of the mechanical houses of the metal is due to the lower inside the grain length and to a more uniform distribution of the primary additives.
3. Steel for furnace-welded pipes should be quenched from the rolling temperature if it includes more than zero.09% C.
4. With increase in oil-quenching temperature for steel subsequently tempered at 53 8° C (1000 F) hardness, strength, and limit of proportionality increase and maximum values are obtained after quenching from 843 ° C (1550 F) which is coincident with retention of all but a small portion of the excess cementite. A higher quenching temperature results in decreased strength.

In this work two grades of steel are used, one with copper and another without copper and the samples of two grades of steel are subjected to different heat treatment sequences: annealing, normalizing, quenching and tempering at different temperatures at 2000C, 4000C, 6000C. Heat treated specimens were mechanically tested for tensile properties, ductility, and hardness.

- As the tempering temperature increases the hardness of both grades of steel is **decreasing.** The medium carbon steel with copper has the **high** hardness compared to the medium carbon steel without copper.
- As the tempering temperature increases the ultimate tensile strength of both grades of steel is **decreasing.** The medium carbon steel with copper has the **high** ultimate tensile strength compared to the medium carbon steel without copper.
- As the tempering temperature increases the ductility of both grades of steel is **increasing**. The medium carbon steel with copper has the ductility **low** compared to the medium carbon steel without copper.

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