DEPARTMENT OF MECHANICAL ENGINEERING

ADVANCED METALLURGY LAB MANUAL

R2021

Vinayaka Nagar, Old Mahabalipuram Road,
Paiyanoor-603 104,
Tamil Nadu, India.
website: www.avit.ac.in

DEPARTMENT OF MECHANICAL ENGINEERING

40221C83 - ADVANCED METALLURGY LABORATORY (PG)

LAB MANUAL

Prepared by

K.VIJAYAKUMAR M.TECH., (PHD)

ASSISTANT PROFESSOR/MECH

TABLE OF CONTENTS

METALLURGY LABORATORY

SAFETY RULES

Do's:

- ✓ Laboratory is not a place to play. Avoid distractions while working with machines.
- ✓ Always wear tight fitting clothes and thick leather shoes.
- ✓ Report immediately about the injury caused; if necessary use the first aid box available in the laboratory.
- ✓ Report immediately about the damage caused to the machines to the Instructor.
- ✓ Before operating a machine, learn completely the working procedure of it.
- ✓ Handle your materials and loads ergonomically.
- ✓ Handle the Etchants carefully as they are hazardous Chemicals.
- ✓ Take care of your fingers while polishing the specimen.

Don'ts:

- ✗ Don't touch the polished and etched surface. Avoid scratches after etching.
- ✗ Don't wipe the etched surface.
- ✗ Don't interchange the specimen positions. Store the specimen in their respective place.
- ✗ Don't keep bare hand into the furnace. Use tongs and wear gloves.
- ✗ Don't wear watches or bracelets while working in machines.
- ✗ Don't carry tools in pockets.
- ✗ Don't touch the lens of Microscopes.
- ✗ Don't remove any guards or parts of any machine.

1. STUDY OF METALLURGICAL MICROSCOPE

AIM:

To study about Metallography and Metallurgical microscope.

METALLURGY/METALLOGRAPHY:

Metallurgy is the science and technology of metals. As an art it has been practiced since ancient times. The art of smelting, refining and shaping metals was highly developed by both the Egyptians and the Chinese. Knowledge of dealing with metals was generally passed directly from master to apprentice in the middle ages, leading to an aura of superstitions surrounding many of the processes.

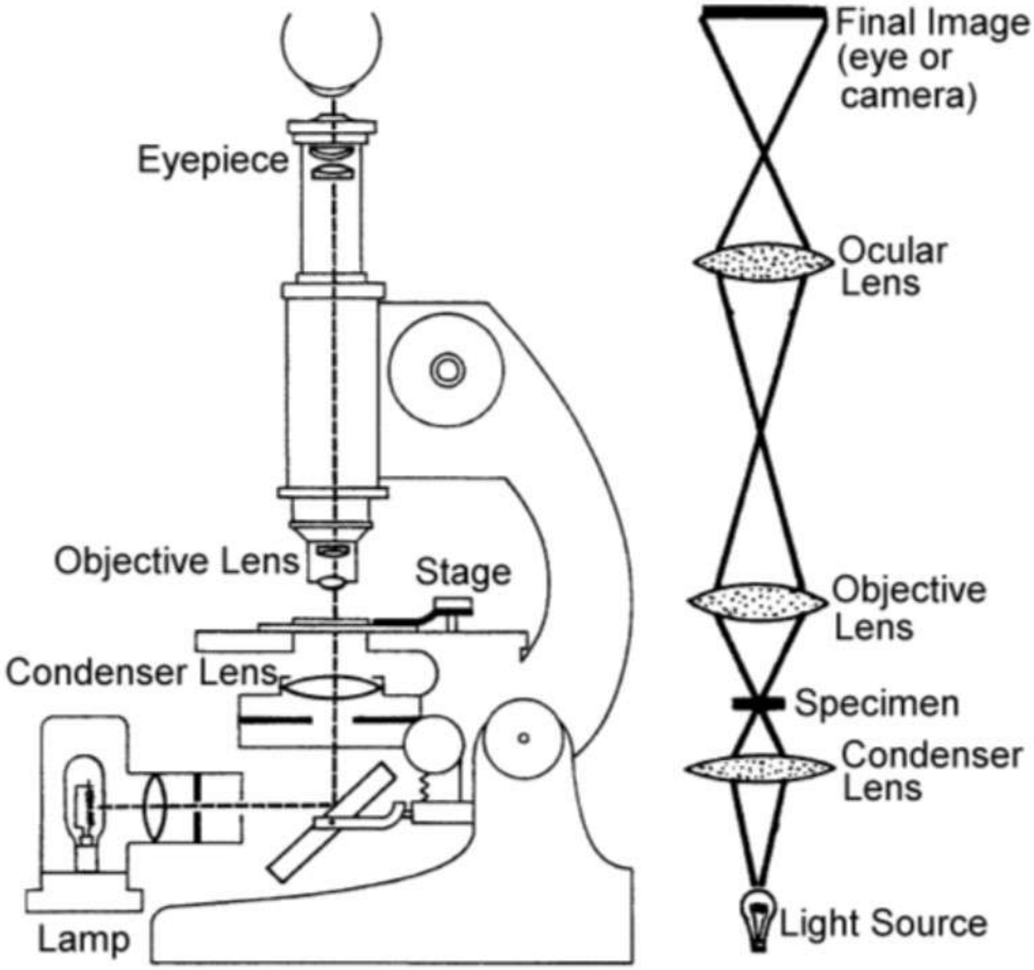
Metallurgy has become an important subject in the modern technology. Years ago, the great majority of steel parts were made of cheap low carbon steel that would machine and fabricate easily. Heat treatment was reserved largely for tools. Designers were unable to account for structural inhomogenity, surface defects etc. and it was considered good practice to use large factors of safety. Consequently, machines were much heavier than they should have been and the weight was considered a mark of quality. This attitude has persisted to some extent to the present time but has been discouraged under the leadership of the aircraft and automotive industries. They have strongly emphasized the importance of strength - weight ratio in good design and this has led to the development of new high strength, light weight alloys.

New technical applications and operating requirements pushed to higher levels have created a continued need for the development of new alloys. Metallurgy is really not an independent science since many of its fundamental concepts are derived from physics, chemistry, and crystallography. The metallurgical field may be divided into two large groups such as Extractive metallurgy and Physical metallurgy.

The science of obtaining metals from their ores, including mining, concentration, extraction and refining metals & alloys is Extractive Metallurgy.

The science concerned with the physical and mechanical characteristics of metals and alloys is termed as Physical Metallurgy. This field studies the properties of metals and alloys as affected by their chemical compositions, mechanical and heat treatments.

PRINCIPLE OF METALLURGICAL MICROSCOPE



TOOLS OF METALLURGIST:

Highly sophisticated and calibrated tools are available in the field of metallurgy. Metal expansion thermometers, liquid expansion thermometers, vapour expansion thermometers, resistance thermometer, thermo electric pyrometer, optical pyrometer, thermo electric materials, radiation pyrometer, metallurgical microscopes are some among them.

Let us study the construction and working principle of ***Metallurgical Microscope*** in detail. The microscope is by far the most important tool of the metallurgist from both the scientific and technical stand points. It is possible to determine grain size, shape and distribution of various phases and inclusions which have a great effect on the mechanical properties of the metal. The microstructure will reveal the mechanical and thermal treatment of the metal and it may be possible to predict its expected behavior under a given set of conditions. A microscope is employed to study the microstructure of material since the object is opaque it is viewed under reflected light.

In comparison with the biological type, the metallurgical microscope differs in manner by which the specimen is illuminated. Since the object is opaque, the sample must be illuminated by reflected light. As shown in figure, a horizontal beam of light from some light source is reflected, by means of a plane-glass reflector, downward through the microscope objective onto the surface of the specimen. Some of this incident light reflected from the specimen surface will be magnified in passing through the lower lens system, the objective and will continue upward through the plane-glass reflector and be magnified again by the upper lens system, the eye piece. The initial magnifying power of the objective and the eye piece is usually engraved on the lens mount. When a particular combination of objective and eyepiece is used at the proper tube length, the total magnification is equal to the product of magnifications of objective and eyepiece. It is possible to mount a camera bellows above the eye piece and use the table type microscope for photomicrography.

The maximum magnification obtained with the optical microscope is about 2000x. The principle illumination is the wave length of visible light, which limits the resolution of fine detail in the metallographic specimen. The magnification may be extended somewhat by the use of shorter wave length radiation, such as ultraviolet radiation, but the sample preparation would include more techniques. The greatest advance in resolving power was obtained by the electron microscope. Under certain circumstances, high velocity electrons behave like light of very short wave length. The electron beam has associated with it a wavelength nearly 100000 times smaller than the wave length of visible light, thus increasing the resolving power tremendously.

The lenses of the electron microscope are the powerful magnetic fields of the coils and the image is brought into focus by changing the field strength of the coils while the coils remain in a fixed position. In optical microscope the image is brought into focus by changing the lens spacing. Although the principle of electron and optical microscopes are same, the former is large. The electron microscope is much larger because of the highly regulated power supplies that are needed to produce and control the electron beam. The entire system must be kept pumped to a high vacuum since air would interfere with the motion of the electrons.

RESULT:

Thus the metallography and Metallurgical microscope & its applications were studied.

2. STUDY OF MUFFLE FURNACE

AIM:

To study about Muffle furnace.

WORKING PRINCIPLE:

The working principle of a lab muffle furnace which is also known as a retort furnace is to heat the air inside its chamber using the basic fundamentals of thermal convection and thermal radiation. The name muffle furnace is derived from the fact that the internal ceramic chamber of the furnace which is also known as muffle is wrapped up in vast layers of insulation so as to prevent heat loss and achieve high temperatures. The high temperatures inside a muffle furnace attained by utilizing heating properties of Nichrome (nickel-chromium) wires which are called electrically operated heating elements. The temperature regulation in a furnace is highly dependent on the efficiency of electronic controller unit, although best results can only be obtained by applying PID controlled units, PID stands for proportional integral derivative controller.

The laboratory muffle furnaces are not equipped with sophisticated cooling system as it is mostly not required. Most of the time a simple fan based exhaust system is installed and cooling is performed by this simple fan system supported by a chimney that too if desired in special cases. The main utility of this furnace exhaust system is to take out the toxic gases from the inner chamber which comes out during heating of the testing materiel / specimen inside the chamber. Hence the chamber gets sanitized of any toxic gases which may have evolved during the heating of materiel inside the lab muffle furnace. The muffle furnace is used when a controlled atmosphere is desired to prevent oxidation during heat treatment in high temperature.

The Muffle Furnace constitutes of 4 vital parts which can be described as:

1. The Outer chamber.
2. The Inner Chamber.
3. Digital Controller cum indicator.
4. Insulation Material.

Outer chamber of the muffle furnace is created using mild steel sheet because it has better malleability, weld ability and ductility properties than cast iron along with corrosion resistance. Outer chamber of the muffle furnace has a thick epoxy paint coating to give it an aesthetically desirable appeal and also to induce few more years to the shelf life of the equipment on being operated at elevated temperatures.

Inner chamber of the muffle furnace is made of either pre-fabricated ceramic molds or firebricks depending upon the size and temperature requirements of the finished equipment.

MUFFLE FURNACE

We use the PID Digital temperature controller cum indicator for its exemplary reputation as immaculate temperature control device. We consider Insulation as the most important factor in working of a muffle furnace and hence extra care is taken while designing this part of the furnace. The insulation being used in our muffle furnace is a combination of ceramic wool and mineral wool because we have engineered and found out that when used in combination they prove to provide better thermal insulation and less heat loss. Our lab muffle furnaces are constructed to generate heat up to 1200°C. Mostly laboratory furnaces are designed to have a working temperature range of 1100°C – 1200°C. The most critical working phenomenon which needs to be taken care of while choosing a laboratory furnace is its maximum working temperature because it needs to be in absolute accordance to the application. The use of lab muffle furnace in can be explained as its ability to burn off desired organic compounds so as to evaluate the amount of inorganic compounds inside a test materiel. Laboratory furnaces are referred by various names being relative to the application such as bench type furnaces, chamber furnace, ashing furnaces, muffle furnace and dental furnaces too. Laboratory furnaces are generally used to heat small materials or test specimens over 1000°C.

APPLICATIONS OF LABORATORY MUFFLE FURNACE:

- Research and development.
- Ceramics.
- Semiconductors.
- Heat Treatment.
- Brazing and Soldering.
- Air and Space Industry.
- Petro chemistry.
- Material Testing and Quality Control Laboratories.
- Automotive.
- Coal and Mining.
- Plastics.
- Glass.
- Medicine.
- Electronics.
- Dental.
- Nuclear

RESULT:

Thus the Muffle furnace was studied.

3. STUDY OF RECOVERY, RECRYSTALLIZATION AND GRAIN GROWTH OF COLD WORKED MATERIALS

AIM:

To study of Recovery, Recrystallization and Grain growth of cold worked materials.

DESCRIPTION:

When a metal is deformed significantly, the grains become elongated and metal are in a non-equilibrium state. Now when the metal is heated to a temperature of about 0.3-0.5 T_m, T_m being melting temperature of metal, and held at this temperature.

The metal attempts to approach equilibrium through a series of processes, namely:

1. Recovery,
2. Recrystallization and
3. Grain growth.

A systematics of these processes with the variation of time. At time T_1, new grains begin to nucleate from cold worked grains; the nucleating of grains will continue and grow upto time T_2. By this time all the cold worked grains will nucleate to from new grains. The size of these new grains increases at slower rate at time T_3.

1. RECOVERY:

It is a low temperature phenomenon which results in the restoration of the physical properties without any observable change in microstructure. The recovery is important for releasing internal stresses in forging, welded and fabricated equipment, without decreasing the strength acquired during and working.

Mechanisms of Recovery:

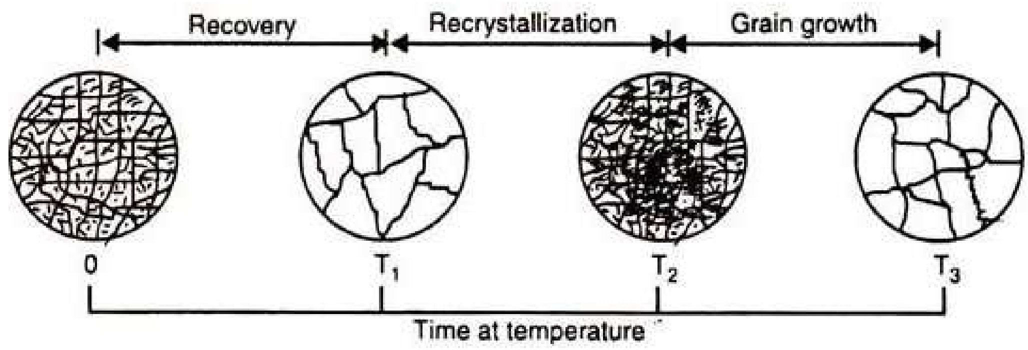
The mechanism operating at low temperature is vacancy motion. This involves (i) migration of point defects to grain boundaries and dislocations, and (ii) combination of point defects.

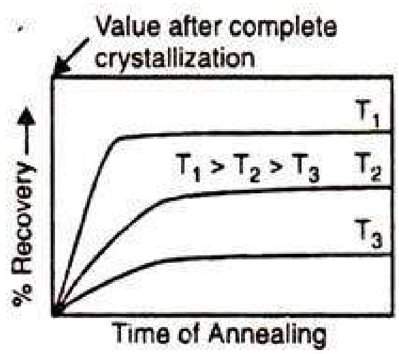
At intermediate temperature the mechanism is dislocation movement without climb. This involves (i) arrangement of dislocations within tangles (ii) annihilation of dislocation and (iii) grain growth.

At high temperature, the mechanism is dislocation movement with climb, which involves (i) dislocation climb (ii) disappearance of boundary between two sub-grain, known as coalescence (iii) polygonization (a state between recovery and recrystallization).

In recovery process, the cold worked metals are heated at low temperature; mobile imperfections (vacancies, interstitials and dislocations) undergo rearrangement in the lattice. Vacancies and interstitials are eliminated first and then some dislocations of opposite sign are annihilated. However, majority of dislocations are not removed by usual recovery treatments. The minor structural changes during recovery have pronounced effect on residual stresses and on electrical properties.

RECOVERY, RECRYSTALLIZATION AND GRAIN GROWTH OF MATERIAL





Recovery at Constant Temperatures T_1, T_2 and T_3

The characteristics of recovery process are shown in Figure. It can be observed from the figure; (i) The rate of recovery is fast initially and drops off with time, (ii) The amount of recovery increases with increasing temperature. In metals, the individual properties, recover at different rates. By recovery, stresses are relieved from cold worked alloys which prevent stress corrosion cracking. Stress relieving can be achieved without much affecting the mechanical properties. For complete removal of residual stresses, high recovery temperature is required. This high temperature treatment is useful for casted or welded parts.

2. RECRYSTALLIZATION:

It is a process by which distorted grains of cold worked metal are replaced by new strain free grains during heating above a minimum temperature called recrystallization temperature. During recrystallization, there is a sharp decrease in hardness and strength and an increase in ductility.

Mechanisms of Recrystallization:

Two mechanisms have been observed depending upon metal and degree of deformation. The deformed metal has two types of interface (a) Pre-existing grain boundaries (b) Sub-grain boundaries resulting from deformation. **Growth of Pre-Existing Grain Boundaries:** The boundary between a grain of high dislocation density and a grain of low dislocation density suddenly grows. Thus, the nucleation is essentially a growth phenomenon. The nucleation by this growth mechanism will occur at boundaries having grain boundary mobility, e.g., high-angle boundaries. **Growth of Sub-Grain Boundaries:** The sudden growth may be due to either by coalescence mechanism or by grain boundary migration. High mobility boundary forms a high angle boundary, which suddenly grows out, occurs on atomic scale.

Primary Recrystallization:

It occurs when cold worked metal is heated. It is defined as the nucleation and growth of strain-free grains, from the matrix of cold worked metal. When primary recrystallization occurs, there is some degree of recovery and sub-grain formation. Primary recrystallization is of much importance because the properties of an alloy, after primary recrystallization will be same as the properties it has before cold working. Consider a cold working operation of an alloy such as deep drawing. During cold working, it becomes hard and less ductile. It becomes difficult to continue the forming operation. A partial forming operation is done first and then the alloys (job) are given a recrystallization (annealing) treatment. This partially formed alloy (job) regains its original ductility and hardness. Now the job can be given further forming operation for deep drawing.

Secondary Recrystallization or Coarsening:

When annealing of a deformed sample is continued beyond the primary recrystallization, or the sample is heated at higher temperature, the usual grain growth is interrupted. Some grains suddenly experience very rapid growth. The dimensions of these rapidly grown grains may be of the order of few centimeters, while the rest of the grains small. These grains expand at the cost of other grains. This is called secondary recrystallization. The mechanism involved, is the rapid migration of boundaries of a few primary recrystallized grains; thus most of the small primary grains are annihilated and large secondary grains are formed.

3. GRAIN GROWTH:

It refers to the increase in the average grain size on further annealing after material has recrystallized. Large grains have lower free energy than small grains. The atoms in the smaller crystals, which have higher energy, tend to become a part of larger crystal. This tendency leads to grains growth. This can be achieved, when the material is held for longer times at a temperature above crystallization temperature. The increase in grain size decreases the hardness and strength but increases the ductility.

Factors Controlling Grain Size:

(a) Degree of Prior Deformation:

The increased amount of prior deformation favours nucleation and decreases final grain size. A minimum amount of deformation is required before recrystallization takes place. This is generally 2.8% of deformation. When deformation is small (but above the minimum deformation), the grain size is coarse because small number of nuclei are formed. As the deformation increases, the number of distorted points also increases and thus grain size decreases.

(b) Temperature:

There is some minimum temperature below which recrystallization does not take place. Above this temperature, the grain size increases slowly.

(c) Heating Time:

The effect of time of heating on grain size depends upon temperature at which the recrystallization is taking place. A certain amount of time is required in which recrystallization is to be completed but this amount of time decreases as temperature increases. The shorter the time of annealing, the finer is the grain size. For longer time of annealing, the grain is coarse. Slow heating will form new nuclei, favouring grain growth and hence the grain will be coarse.

(d) Impurities:

With greater amount and finer distribution of impurities, finer grain size will be there. The impurities increase nucleation and also act as barrier for grains to grow.

Result:

Thus the Recovery, Recrystallization and Grain growth of cold worked materials were studied.

4. PREPARATION OF METALLOGRAPHIC SPECIMEN

AIM:

To prepare a specimen for microscopic examination.

TOOLS REQUIRED:

Linisher- Polisher, Different grades of emery sheets (Rough & Fine), Disc Polisher, Metallurgical Microscopes.

PROCEDURE:

The specimen preparation consists of following stages:

i) Rough grinding
ii) Intermediate Polishing
iii) Fine Polishing
iv) Etching

(i) Rough grinding:

It is first necessary for specimen to obtain a reasonable flat surface. This is achieved by using a motor driven energy belt called Linisher-Polisher. The specimen should be kept over the moving belt which will abrade the specimen and make the surface flat. In all grinding and polishing operations, the specimen should be moved perpendicular the existing scratches, so that the deeper scratches will be replaced to a shallower one. This operation is done until the specimen is smooth, free from rust, burs, troughs and deep scratches.

(ii) Intermediate Polishing:

It is carried out using emery paper of cogressively fine grades. The emery paper should be of good quality. The different grades of emery paper used are 120,240,320,400 and 1/0, 2/0, 3/0, 4/0 (Grain size from coarse to fine). The emery paper should be kept against the specimen and moved gently until a fine matrix of uniformly spaced scratches appears on the object. Final grade is then chosen and the specimen is turned perpendicular to the previous direction. This operation is usually done dry.

(iii) Fine Polishing:

An approximate flat scratch free surface is obtained by the use of wet rotary wheel covered with abrasive of alumina powder of 0.05 microns. In this operation, water is used as lubricant and carrier of the abrasive so that it comes in contact to specimen to be polished. Fine polishing removes fine scratches and very thin layer produced due to previous operations.

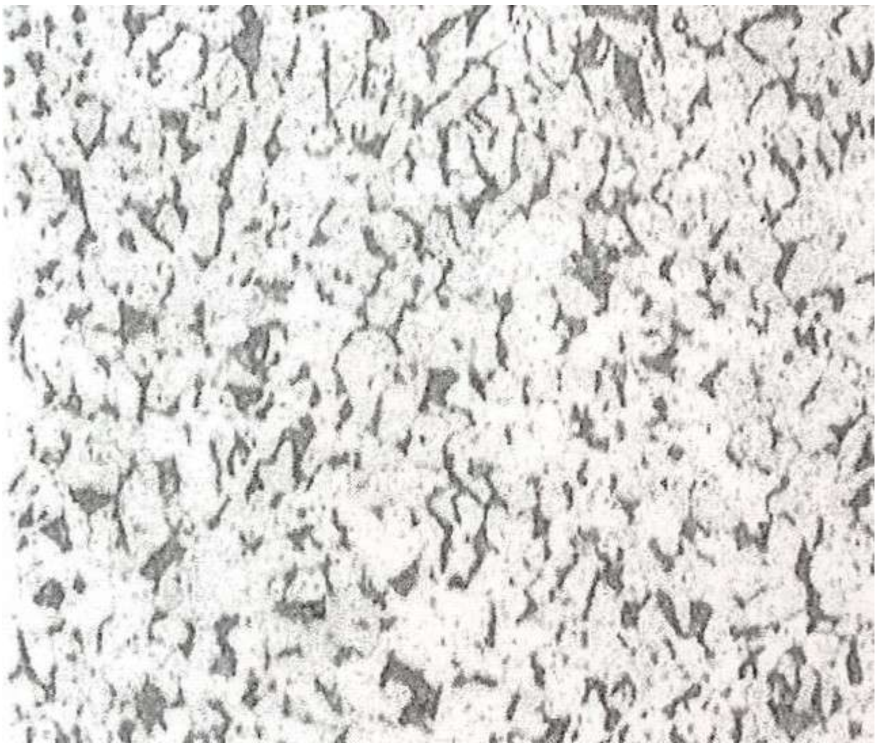
(iv) Etching:

The polished surface is washed with water and etching is done by rubbing the polished surface gently with cotton wetted with etching reagent. After etching the specimen is again washed and then dried. It is then placed under the metallurgical microscope to view the microstructure of it. Thus the specimen is identified.

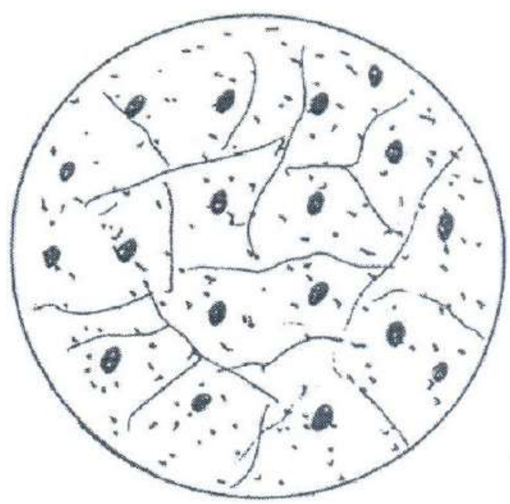
RESULT:

Thus the specimen was prepared for microscope observation for its identification.

LOW CARBON STEEL



Magnification: 100x **ETCHANT: Nital Solution**



5. IDENTIFICATION OF LOW CARBON STEEL

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with nital solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure is pearlite and the specimen is identified as **Low Carbon Steel.** The pearlite is a lamellar structure of cementite in ferrite matrix.

CHARACTERISTICS OF LOW CARBON STEEL:

- High ductility and toughness
- Possesses good formability and weldability
- Least expensive
- Low tensile strength

APPLICATIONS OF LOW CARBON STEEL:

- It is used for manufacturing products like screws, nails, nut, bolt, washers, wire fences etc.
- Automobile body components
- Structural steels, bars, grills, angles etc.

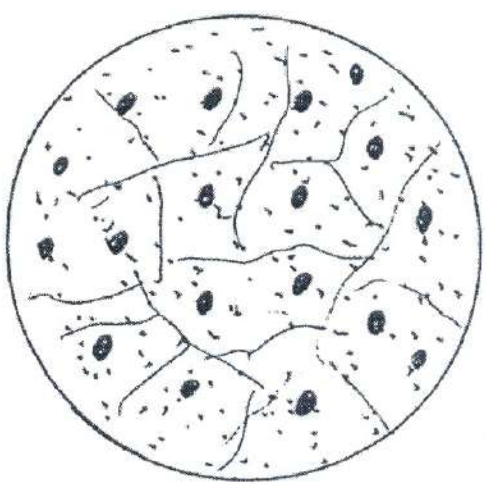
OBSERVATION:

RESULT:

Thus the given specimen is identified as **Low Carbon Steel** and its characteristics and applications were studied.

MEDIUM CARBON STEEL

Magnification: 100x **ETCHANT: Nital Solution**



6. IDENTIFICATION OF MEDIUM CARBON STEEL

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with nital solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure is pearlite and cementite then the specimen is identified as **Medium Carbon Steel.** The pearlite is a lamellar structure of cementite matrix.

CHARACTERISTICS OF LOW CARBON STEEL:

- Ductility and toughness
- Possesses good formability and weldability
- Least expensive
- Considerable hardness

APPLICATIONS OF MEDIUM CARBON STEEL:

- It is used for manufacturing products like screws, nails, nut, bolt, washers, wire fences etc.
- Automobile body components
- Structural steels, bars, grills, angles etc.

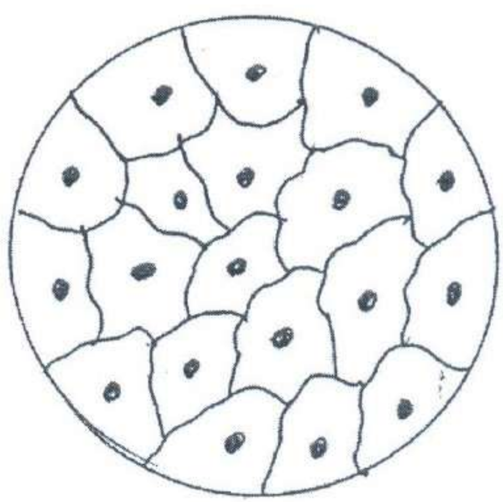
OBSERVATION:

RESULT:

Thus the given specimen is identified as **Medium Carbon Steel** and its characteristics and applications were studied.

AUSTENITIC STAINLESS STEEL

Magnification: 100x **ETCHANT: Aqua Solution**



7. IDENTIFICATION OF AUSTENITIC STAINLESS STEEL

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with aqua solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure is austenite and the specimen is identified as **Austenitic Stainless Steel.**

CHARACTERISTICS OF AUSTENITIC STAINLESS STEEL:

- Highest corrosion resistance
- Good ductility at cryogenic temperature i.e. below 0°C Non- magnetic

APPLICATIONS OF AUSTENITIC STAINLESS STEEL:

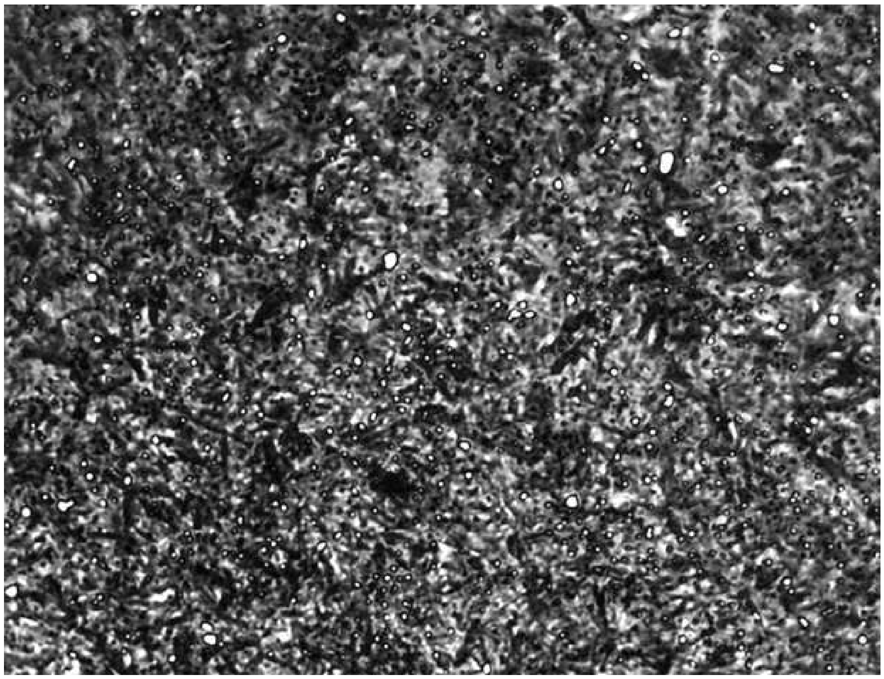
- Engine parts
- Heat exchangers
- Food processing and house hold items
- Dairy industry

OBSERVATION:

RESULT:

Thus the given specimen is identified as **Austenitic Stainless Steel** and its characteristics and applications were studied.

HIGH SPEED STEEL



Magnification: 50x **ETCHANT: Nital Solution**

8. IDENTIFICATION OF HIGH SPEED STEEL

AIM:

To identify the given specimen and study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with nital solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The microstructure is martensitic matrix with a dispersion of two sets of carbides then the specimen is identified as **High speed steel.** These carbides are usually known as primary and secondary carbides. They consist of carbon steel alloyed with tungsten or molybdenum, together with percentages of chromium, vanadium and cobalt.

CHARACTERISTICS OF HIGH SPEED STEEL:

- Excels in hardness and abrasion resistance.
- Different grades trading for toughness, hot hardness or reduced brittleness.
- Optimal combination of high strength, wear resistance, toughness and hardness.

- The alloying elements raise the temperature at which tempering occurs, allowing HSS to be used at temperatures up to about 650°C.

APPLICATIONS OF LOW CARBON STEEL:

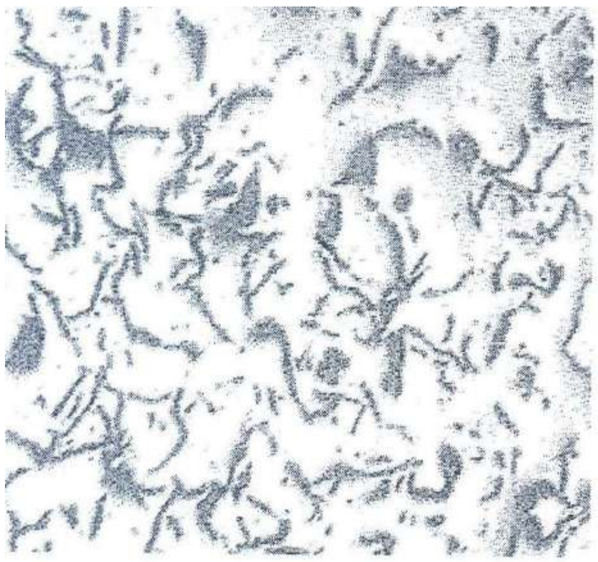
- Manufacture of various cutting tools: drills, taps, milling cutters, tool bits
- Hobbing (gear) cutters, saw blades.
- Planer and jointer blades, router bits, etc.,
- Punches and Dies.

OBSERVATION:

RESULT:

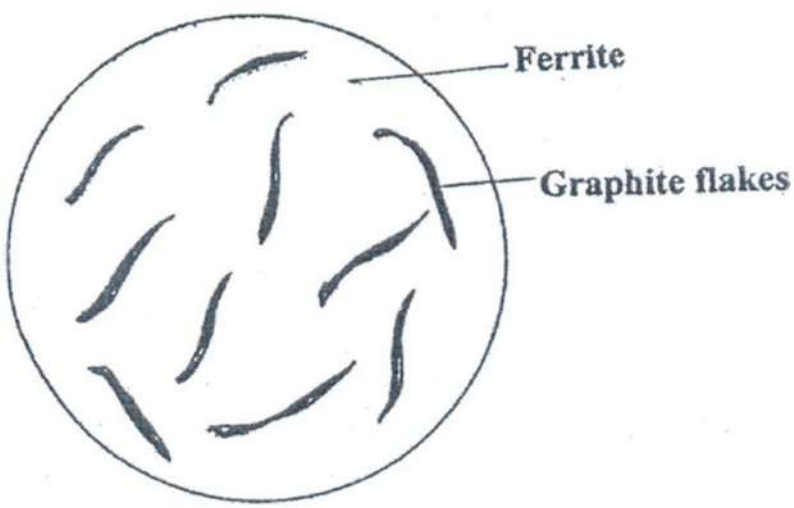
Thus the given specimen is identified as **High speed Steel** and its characteristics and applications were studied.

GREY CAST IRON



As Polished - Magnification: 100x **As Etched - Magnification: 250x**

ETCHANT: Nital Solution



9. IDENTIFICATION OF GREY CAST IRON

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher with Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with nital solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure is graphite flakes in ferrite matrix and the specimen is identified as
Grey Cast Iron.

CHARACTERISTICS OF GREY CAST IRON:

- Excellent compressive strength
- Good torsional and shear strength
- Good corrosion resistance
- High damping capacity

APPLICATIONS OF GREY CAST IRON:

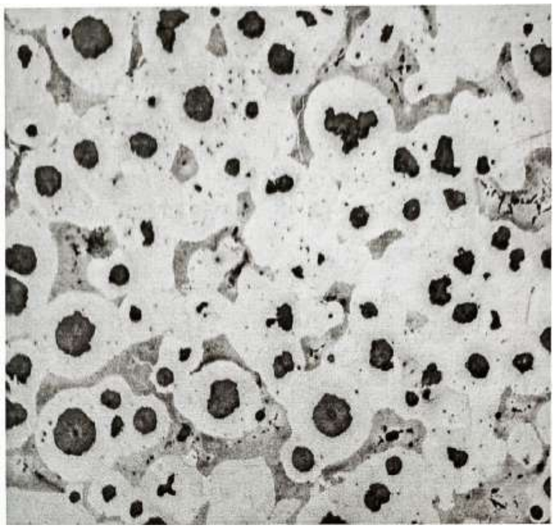
- Machine tool bodies
- Engine blocks
- Cam shafts
- Rolling mills, agricultural machineries etc.

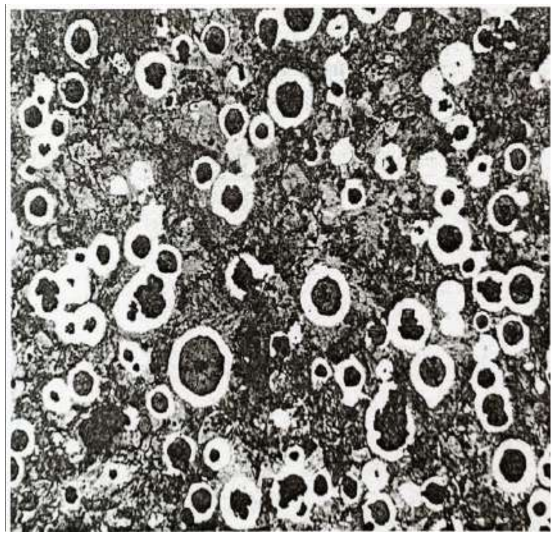
OBSERVATION:

RESULT:

Thus the given specimen is identified as **Grey Cast Iron** and its characteristics and applications were studied.

NODULAR CAST IRON

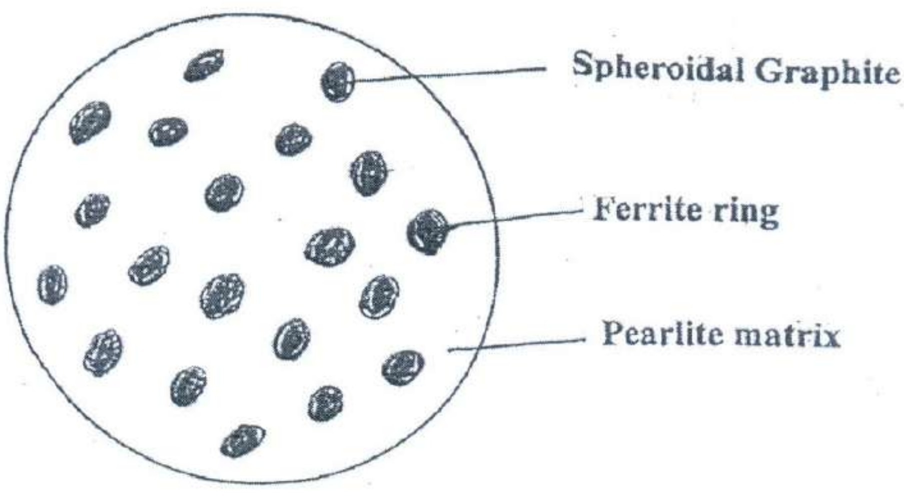




As Polished - Magnification: 100x

As Etched - Magnification: 250x

ETCHANT: Nital Solution



10. IDENTIFICATION OF NODULAR CAST IRON

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher with Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with nital solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure is graphite nodules in a matrix of ferrite and pearlite with a majority of ferrite content and the specimen is identified as **Nodular Cast Iron.**

CHARACTERISTICS OF NODULAR CAST IRON:

- Good ductility and malleability
- High yield strength and tensile strength
- Excellent impact and fatigue strength
- Excellent machinability
- Ability to resist oxidation at high temperatures

APPLICATIONS OF NODULAR CAST IRON:

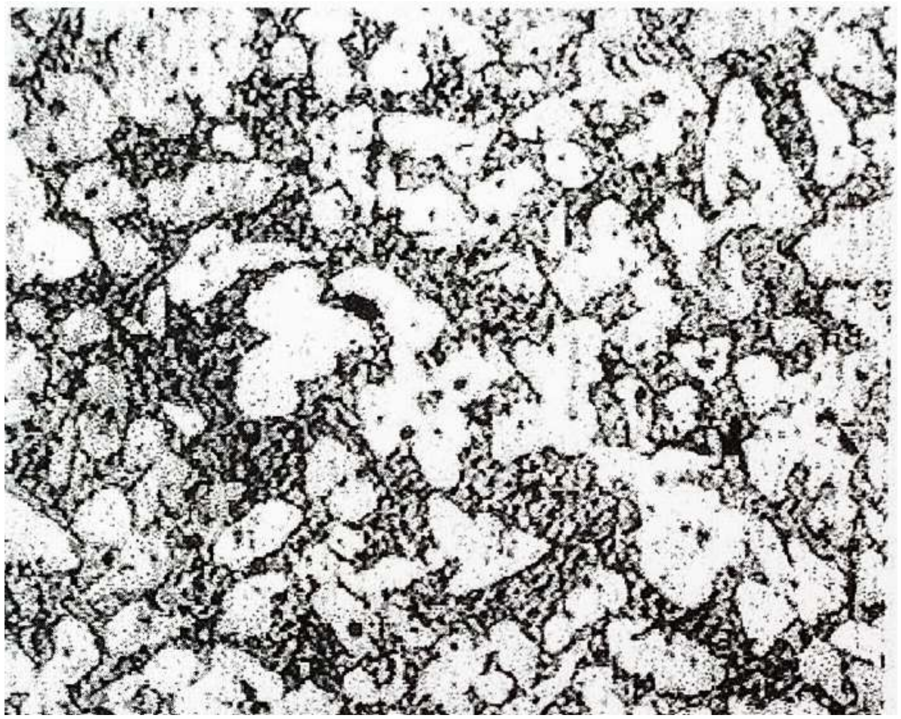
- Valves, pumps
- Gears, pinions
- Crank shafts,
- Power transmission equipments

OBSERVATION:

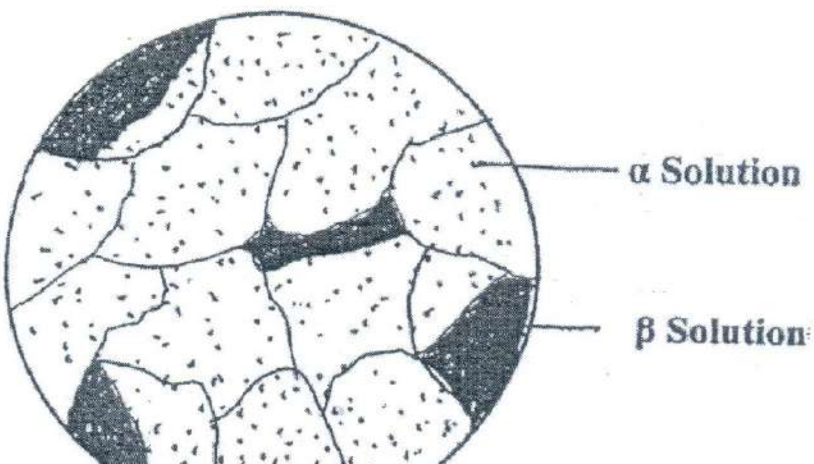
RESULT:

Thus the given specimen is identified as **Nodular Cast Iron** and its characteristics and applications were studied.

<u>**BRASS (COPPER ALLOY)**</u>



Magnification: 200x **ETCHANT: Ammonia & H_2O_2 Solution**



11. IDENTIFICATION OF BRASS (COPPER ALLOY)

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher with Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polisher using alumina powder as lubricant.
4. Then the specimen is washed thoroughly in water and then etched with ammonia and hydrogen oxide solution.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure is equiaxed grains of alpha in a matrix of beta solid solution and the specimen is identified as **Brass (Copper alloy).** The black spots are due to shrinkage cavity formed during casting.

CHARACTERISTICS OF BRASS:

- ➢ Cast into moulds, into wires into sheets etc.
- ➢ Colour of brass changes from red to white, depending on the amount of zinc present.

APPLICATIONS OF BRASS:

- Jewelleries
- Pumps, tubes Springs Screws

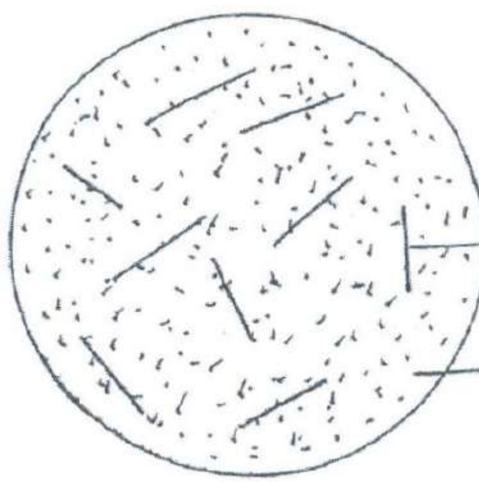
OBSERVATION:

RESULT:

Thus the given specimen is identified as **Brass (Copper alloy)** and its characteristics and applications were studied.

ALUMINIUM ALLOY

Magnification: 100x **ETCHANT: Hydrofluoric Acid**



12. IDENTIFICATION OF ALUMINIUM ALLOY

AIM:

To identify the given specimen and to study the microstructure, characteristics and applications of it.

TOOLS REQUIRED:

- Linisher - polisher,
- Emery sheets,
- Disc polisher,
- Alumina powder,
- Etchant and
- Metallurgical microscope.

PROCEDURE:

1. The specimen is abraded against the linisher polisher to remove burs.
2. Then it is polished using the various grades of emery paper.
3. The specimen is fine polished in disc polishing machine using alumina powder as lubricant.
4. Then specimen is washed thoroughly in water and etched with hydrofluoric acid.
5. After etching the specimen is washed and dried for some seconds.
6. Now view the structure under microscope.

IDENTIFICATION:

The structure shows very fine grains of aluminium-silicon in a matrix of aluminium solid solution and the specimen is identified as **Aluminium alloy.**

CHARACTERISTICS OF ALUMINIUM ALLOY:

- Light weight
- High strength to weight ratio
- High reflectivity
- Non toxicity

APPLICATIONS OF ALUMINIUM ALLOY:

- Aeroplane parts
- Precision instruments
- Furnitures, electrical conductors
- Corrugated sheets, windows etc.

OBSERVATION:

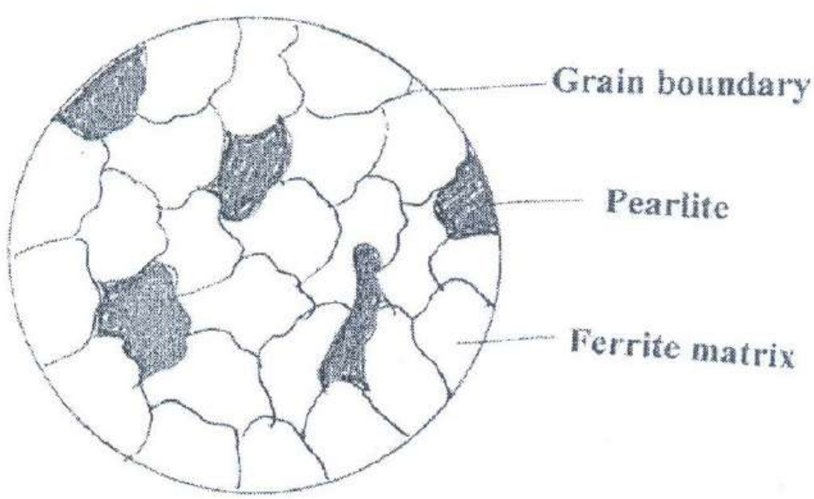
RESULT:

Thus the given specimen is identified as **Aluminium alloy** and its characteristics and applications were studied.

INDENTOR USED: ..……………..

SL. NO.	HARDNESS VALUE (SCALE: ……...)	
	BEFORE NORMALISING	AFTER NORMALISING
1		
2		
3		

NORMALISED PLAIN CARBON STEEL



Magnification: 675x **ETCHANT: Nital Solution**

13. HEAT TREATMENT - NORMALISING

AIM:

To normalise the given plain carbon steel specimen.

TOOLS REQUIRED:

- Muffle furnace
- Hardness testing machine- Rockwell Hardness Machine
- Microscope

THEORY:

Normalising is one of the heat treatment processes in which the steel is heated above 800"C,holding the specimen at this temperature for a specified period of time followed by cooling it in still air to room temperature. The cooling rate is 30-50°C per minute. The resultant microstructure is Pearlite. Normalising refines the grains, improves sub-structure, hardness, strength, toughness and machinability with the release of residual stresses.

PROCEDURE:

1. Measure the hardness of given specimen in Rockwell hardness testing machine.
2. Put on the temperature controllable furnace.
3. When the temperature in furnace is 800°C keep the specimen inside it.
4. Allow the specimen to be in furnace for 15 - 20 minutes at 800°C temperature.
5. Put off the furnace and take the specimen out.
6. Cool the specimen for 30 - 60 minutes in air.
7. Measure the hardness again in Rockwell hardness testing machine.
8. Confirm the presence of Pearlite under microscopic view.

OBSERVATION:- BEFORE NORMALISING:

AFTER NORMALISING:

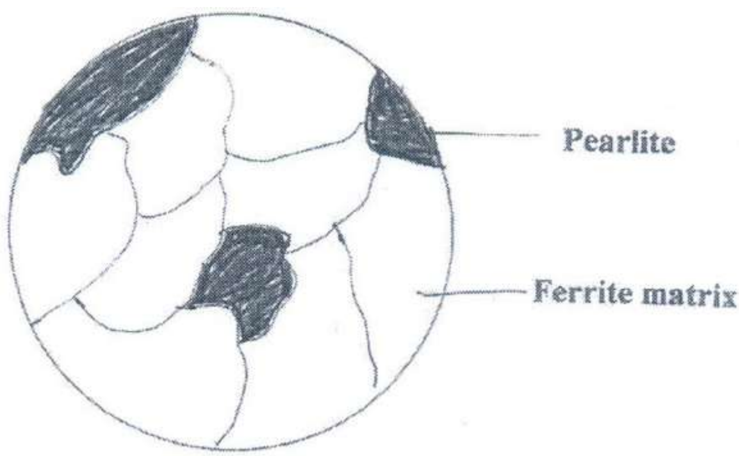
RESULT:

Thus the Normalizing- heat treatment process is carried out.

INDENTOR USED: ..………………..

SL. NO.	HARDNESS VALUE (SCALE: ……...)	
	BEFORE ANNEALING	AFTER ANNEALING
1		
2		
3		

ANNEALED PLAIN CARBON STEEL



Magnification: 675x **ETCHANT: Nital Solution**

14. HEAT TREATMENT - ANNEALING

AIM:

To anneal the given plain carbon steel specimen.

TOOLS REQUIRED:

- Muffle furnace
- Hardness testing machine- Rockwell Hardness Machine
- Microscope

THEORY:

Annealing is one of the heat treatment processes in which the steel is heated above 800°C, holding the specimen at this temperature for a specified period ohime followed by cooling it inside the furnace. The cooling rate is 20-30°C per minute. The resultant microstructure is Ferrite. As this transformation takes place inside the furnace, the cooling rate is very slow and hence it improves softness and ductility, relieves internal stresses, refines the grains and redistributes the dispersed phases i.e. uniformity of phase distribution is increased. It also improves machinability, electrical and magnetic properties. The annealing temperature depends on the percentage of carbon in steel.

PROCEDURE:

1. Measure the hardness of given specimen in Rockwell hardness testing machine.
2. Put on the temperature controllable furnace.
3. When the temperature in furnace is 800°C keep the specimen inside it.
4. Allow the specimen to be in furnace for 15 - 20 minutes at 800°C temperature.
5. Put off the furnace and Cool the specimen inside the furnace for 1- 2 hours.
6. Measure the hardness again in Rockwell hardness testing machine.
7. Confirm the presence of Ferrite under microscopic view.

OBSERVATION:- BEFORE ANNEALING:

AFTER ANNEALING:

RESULT:

Thus the Annealing - heat treatment process is carried out.

REFERENCES

Avner, Introduction to Physical Metallurgy, TMH

Dieter, Mechanical Metallurgy, SI Metric Edition, McGH.

Narula, Material Science, TMH

Prabhudev, Handbook of Heat Treatment of Steels, TMH

Ghosh and Chatterjee, Ironmaking and Steel Making: Theory and Practice, PHI

Budinski, Engineering Materials: Properties and Selection, PHI

Shackelford, Introduction to Material Science for Engineers, Pearson

Sharma, Engineering Materials: Properties & Applications of Metals and Alloys, PHI.

****