UNIVERSAL INSTITUTE OF ENGINEERING & TECHNOLOGY
LALRU , MOHALI -140501

MECHANICAL ENGINEERING
LAB MANUAL

Course Name	:	Materials Engineering
Course Code	:	BTME 408-18
Class	:	B. Tech IV Semester
Branch	:	ME
Year	:	2019 – 2020
Lab Coordinator	:	Nishant Dhiman, Assistant Professor

OBJECTIVES

- Understand metallurgical engineering concepts and properties.
- Analyze microstructures of metals and alloys and relationship to heat treatment.
- Compare properties of ceramics, glasses, composites and polymers for industrial applications.

COURSE OUTCOMES

After studying this course, students shall be able to:

- Understand the significance of structure-property-correlation for engineering materials including ferrous and nonferrous.
- Explain the use and importance of various heat treatment processes used for engineering materials and their practical applications.
- Understand the various structural changes occurred in metals with respect to time temperature transformations.
- Understand the significance of Fe-C and TTT diagram for controlling the desired structure and properties of the materials.
- Identify suitable metals, non-metals for various industrial products

CONTENTS

LAB PRACTICE

Aim:

To study about the Materials Engineering lab practice.

Theory:

Metallography consists of the microscopic study of the structural characteristics of metal oran alloy. The microscopes by far the most important tool of the metallurgist from both the scientific and technical stand points. It is possible to determine grain size and the 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.

Tools Used In Lab Practice:

1) **Cut-Off Machine:** Fig (1) The specimen is cut into a small piece in order to facilitate easy mounting. The specimen is held in between two jaws in the job-vice firmly and is cut using a circular blade connected to a pump. The circular blade is fixed inside the machine in a vertical position and is lowered on to the horizontally held sample by means of a handle. To avoid excess heating up of the blade and the sample, a recalculated (coolant (water with small amount of oil) is applied over the cutting area through a pipe placed near the blade.

Fig: 1 Cut-Off Machine

2) **Belt Grinding:** Fig (2) the sample surface after mounting is rather uneven. Therefore the sample is polished on Belt grinder in one single direction to make the surface flat enough for further polishing. The machine consists of a belt sander of grit 18, which moves circularly over a pair of rolls, and when the specimen is kept on it, the belt grinder removes the surface irregularities.

Fig :2 Belt Grinding

3) **Sand Paper Polishing:** Belt grinding is followed by polishing on sand papers of grade 180, 220,320, 400, 600, numbered in the order of decreasing abrasive particle (SiC) size. Starting with 180 papers, polishing is done in a direction perpendicular to those of the scratches made by belt Grinder. After 180 grades, polishing is done on subsequent sand paper changing the direction by 90ºC every time the paper is changed.

4) **Emery Paper Polishing:** The sample is then polishing on emery papers (1/0, 2/0,3/0,4/0)following the same procedure as for sand papers.

5) **Disc Polishing:** fig (3) Fine polishing is done on variable speed tabletop single disc polishing machine. The machine consists of brass topped A1 disc of 8” ϕ over which a Micro cloth 240 (Billiard or Slyveth cloth) is fastened firmly. Then the cloth is charged with alumina suspension in distilled water (1:5). Sample is polished on the disc rotating at slow speed. Once a mirror like surface is obtained the sample is cleaned with distilled water.

Fig (3) **Disc Polishing**

7) **Etching:** fig (4) on completion of polishing the sample is dabbed with the appropriate etchant. Etchant is a combination of chemicals that attacks the various phases and regions of a microstructure to a different extent, thus making them distinctly visible under the microscope. Phases attacked to a greater extent will appear darker than those lightly attacked as they will reflect light to a greater extent. This is called etching contrast. For example, grain boundaries being regions of instability and of high free energy, will be

Fig (4) Etching

Attacked to a larger extent and will appear dark. Similarly, in a multi-phase structure, each phase will appear differently depending on its etching properties. However, even in a single-phase structure, some of the grain will appear dark. This is due to the orientation difference between various grains. Some of the etchants and their uses are given below.

Etchant	Composition	Materials Etched
Nital	4% HNO3 + 96% C2H5OH	All steels (except stainlesssteels)
FeCl3	FeCl3 + HCl + Water	Brass
Aqua Regia	60% HCl + 20% HNO3 +20% H2O	Stainless steel
HF	% HF + 98% H2O	AL & its alloys
Kellars	1% HF + 1.5% HCl + 2.5%	Duralumin
Reagent	HNO3+95% H2O	
H2O2	5% H2O2+5% NH3OH+90% H2O	Cu, Brass, Bronze

.

8) **Observing Under Microscope:** fig (5) Then the microstructure is studied under microscope

Fig (5) Microscope

Precautions:

1. While cutting the sample, excess down feed force should not be applied on the cutting wheel and that the sample gets sufficient amount of coolant.
2. Before and after mounting clean the die walls only with a soft cloth or cotton so as to not damage the surface and use a thin smear of lubricant (grease).
3. Do not apply pressure while belt grinding, paper polishing or fine polishing the specimen.
4. Before and after disc polishing wash the sample neatly under running water.
5. After use the disc polisher must be cleaned carefully to avoid contamination of grit.
6. Over-etching or insufficient etching must be avoided.

Result:

The general procedure of metallurgy lab practice has been studied and followed.

STUDY THE CRYSTAL MODELS FOR SIMPLE CUBIC, BODY CENTERED CUBIC, FACE CENTERED CUBIC AND HEXAGONAL CLOSE PACKEDSTRUCTURES

Objective:

Preparation and Study the Crystal Models for Simple Cubic, Body Centered Cubic, Face Centered Cubic and Hexagonal Close Packed Structures.

Theory:-

BCC:

In body centered cubic structure each one atom is placed at the corner of the cube and one atom is placed at the centre of the cube. Iron has BCC structure. At room temperature the unit cell of iron has an atom at each corner and another at the body centre of the cube. Each iron atom in BCC structure is surrounded by eight adjacent iron atoms. The unit cell of a cubic cell contains eight atoms at corners which are shared by the adjoining eight cubes.

Hence the share of each cube = $\frac{1}{8}$ of each corner atoms

Total no of atoms = $\frac{1}{8} \times 8 = 1$ atom BCC crystal has one atom at center.
So, total no. of atoms in BCC = 2 atoms

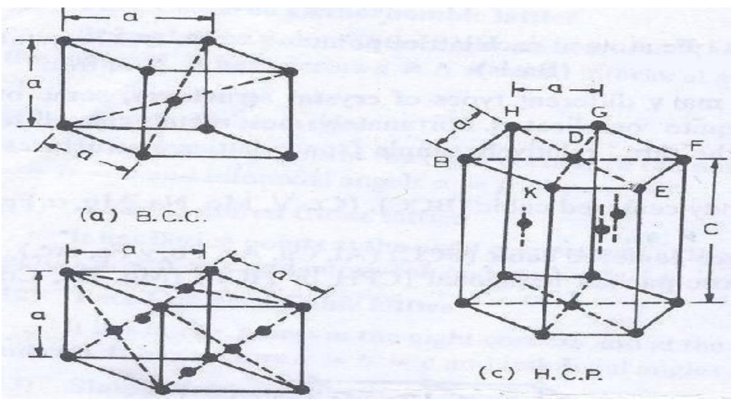
FCC:-

In this type of structure the unit cell contains one atom at center of each corner plus at each face. Examples of such type of crystal structure are copper, silver, gold etc. In FCC crystal the atom on each face is surrounded or shared by two cubes. Son contribution of each towards crystal is ½, one atom at each corner. i.e., shared by eight other cubes so that its contribution towards crystal is $\frac{1}{8}$.

So total no of atoms = $\frac{1}{8} \times 8 + ' \times 6 = 4$ atoms

HCP:-

In case of hexagonal closed packing structure there are 12 atoms at corner. One atom at the center of two hexagonal faces and three atoms symmetrically arranged in the body of unit cell.
Total no of atoms per unit cell = $1/6 \times 6 + 1/6 \times 6 + \frac{1}{2} \times 2 + 3 = 6$ atoms



Atomic Radius:-

It is defined as half the distance between the nearest neighbors in the crystal structure of a pure element. It is expressed in terms of the cube edge element a and denoted by r.

BCC:-

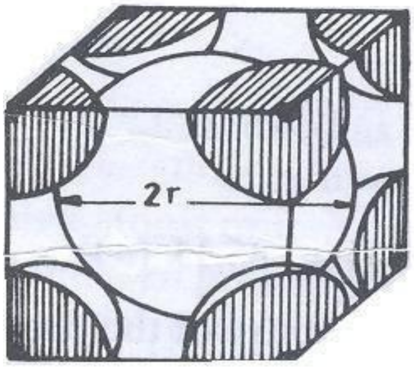
In this structure, the atoms touch each corner along the diagonal of the cube. So,

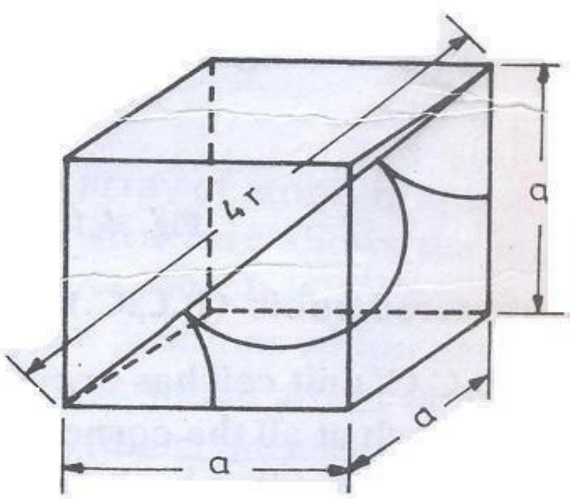
$AB^2 = a^2 + a^2$

$AB^2 = 2a^2$

$(AC^2) = (AB^2) + (BC^2)$ $(AC^2) = 2a^2 + a^2$

$4r = \sqrt{3}\ a^2$ $r = \sqrt{3}/4a$





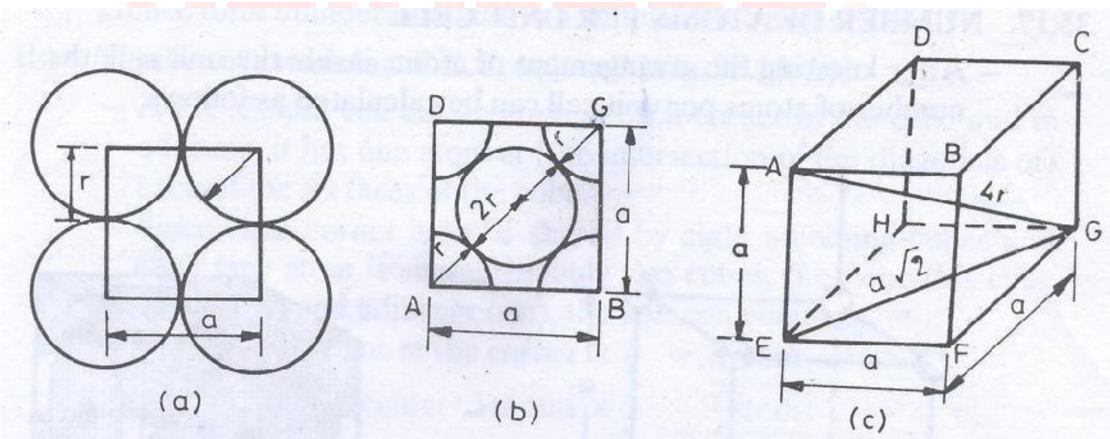
FCC:-

In this structure, one atom at each eight corners in addition to one atom at each face is present. From the geometry of the fig.

$BD = 4r = \sqrt{a^2 + a^2}$

$4r = \sqrt{2}\ a$

$R = \sqrt{2}/4 \times a$



Atomic Packing Factor:-

It may be defined as the fraction of volume occupied by spherical atoms as compared to the

total available volume of the structure.
A.P.F. = volume of atoms in a crystal / volume of unit cell =H/V

FOR BCC CRYSTAL:-

Atoms per unit cell = 2
Volume = $2 \times 4/3\ \pi\ r^3$
$V = 2 \times 4/3\ \pi \times (\sqrt{3}/4 \times a)^3$
APF= $(2*4/3\pi r3)/(4r/\sqrt{3})^3$

=0.68
Atomic packing factor for BCC crystal is 0.68.

FOR FCC:-

Total noofatoms=4 Volume of 4atoms = $4x4x\pi xr^3$

$$APF = \frac{4 * \frac{4}{3}\pi r3}{(2\sqrt{2}\,r3)3}$$
$$= 0.74$$

Atomic packing factor for FCC crystal is 0.74.

MICRO STRUCTURES OF PURE METALS LIKE IRON, AL, CU

Aim:

Observation of microstructure of Aluminium specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: ALUMINIUM

Etchants:30ml distilled water +5ml nitric acid+HF2.3 ml

Theory:

Aluminium is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery white, soft, nonmagnetic, ductile metal. Aluminium is the third most abundant element (after oxygen and silicon), and the most abundant metal in the Earth's crust. It makes up about 8% by weight of the crust, though it is less common in the mantle below. Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals. The chief ore of aluminum is bauxite. Aluminium is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminum and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials. The most useful compounds of aluminum, at least on a weight basis, are the oxides and sulfates.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Remarks:

Aim:

Observation of microstructure of Copper specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier

Sample: COPPER

Etchants: 30ml distilled water 2% + nitric acid(12 to 30%)

Theory:

Copper is a chemical element with symbol Cu (from Latin: cuprum) and atomic number 29. It is a ductile metal with very high thermal and electrical conductivity. Pure copper is soft and malleable; a freshly exposed surface has a reddish-orange color. It is used as a conductor of heat and electricity, a building material, and a constituent of various metal alloys. The metal and its alloys have been used for thousands of years. In the Roman era, copper was principally mined on Cyprus. Architectural structures built with copper corrode to give green verdigris (or patina). Art prominently features copper, both by itself and as part of pigments.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder.
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed

with water to remove all loose particles.

- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching	**After Etching**
Magnification:	**Magnification:**
Name of the sample:	**Name of the sample:**
Heat/Mechanical Treatment:	**Heat/Mechanical Treatment:**
Etchant:	**Etchant:**
Etching Time:	**Etching Time:**
Composition:	**Composition:**
Phase's description:	**Phases description:**
Properties (if any):	**Properties (if any):**

Applications:

Wire and cable, Electronics and related devices, Electric motors windings, Architecture, Antimicrobial applications, Copper is commonly used in jewelry, and folklore says that copper bracelets relieve arthritis symptoms. Copper is used as the printing plate in etching, engraving and other forms of intaglio (printmaking) printmaking. Copper oxide and carbonate is used in glassmaking and in ceramic glazes to impart green and brown colors.

Remarks:

Aim:

Observation of microstructure of Brass specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: BRASS

Etchants: 5% nitric acid + methyle achol

Theory:

Brass is an alloy made of copper and zinc; the proportions of zinc and copper can be varied to create a range of brasses with varying properties. It is a substitution alloy: atoms of the two constituents may replace each other within the same crystal structure. By comparison, bronze is principally an alloy of copper and tin. However, the common term "bronze" may also include arsenic, phosphorus, aluminum, manganese, and silicon. The term is also applied to a variety of brasses, and the distinction is largely historical. Modern practice in museums and archaeology increasingly avoids both terms for historical objects in favour of the all-embracing "copper alloy".

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0

- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching	**After Etching**
Magnification:	**Magnification:**
Name of the sample:	**Name of the sample:**
Heat/Mechanical Treatment:	**Heat/Mechanical Treatment:**
Etchant:	**Etchant:**
Etching Time:	**Etching Time:**
Composition:	**Composition:**
Phase's description:	**Phases description:**
Properties (if any):	**Properties (if any):**

Applications:

Brass is used for decoration for its bright gold-like appearance; for applications where low friction is required such as locks, gears, bearings, doorknobs, ammunition casings and valves; for plumbing and electrical applications; and extensively in brass musical instruments such as horns and bells where a combination of high workability (historically with hand tools) and durability is desired. It is also used in zippers. Brass is often used in situations in which it is important that sparks not be struck, such as in fittings and tools around explosive gases.

Remarks:

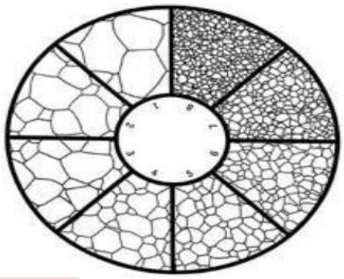
ASTM GRAIN SIZE ANALYSIS

Aim:

To find out the grain size in single and multi phase alloy systems

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope



Sample:

Etchants:

Theory:

For the grain size determination the commonly used methods are :

- ASTM Method
- Heyn's intercept method
- Jeffries planimetric method

Grain Size Determination:

- **ASTM Method:**

American Society for Testing Materials (ASTM) has developed a method to specify the grain size in a specimen by a number G called grain size number. The grain size number. The grain size number is related to the number of grains per square mm at a magnification of 1X (linear). The measurement is made directly under the microscope or on a photomicrograph of the specimen.The observed grain structure can also be compared with the ASTM chart carrying grainsize numbers. By proper matching the grain size number of the microstructure underexamination is known from which the grain size diameter can be found out. In ASTMmethod the standard number of the grain per mm^2 is related to the grain size number atmagnification of 01X by the following relation:

$$G = -2.9542 + 1.4472 \ln n$$

$$\ln n = \frac{G + 2.9542}{1.4472}$$

$$n = e^{(G+2.9542)/1.4472}$$

Note: The ASTM grain size number, N, is related to the number of grains per square inch at 100X magnification, n, by the relationship, $N=2^{n-1}$Where, N is the ASTM grain size number, and n is the number of grains per square inch at 100X.

The micrographs are always taken at magnifications other than 01X of the area not exactly 1 mm2. Conversion to 1X magnification and to 1 mm2 area should be made to find out the

grainsize number. For example, a photomicrograph of a microstructure shows 30 grains in an area of30 X 40 mm2 at 250X.
The ASTM data for the grain size number, number of grain/mm2 and average grain size diameterin mm is given in Table 1

ASTM no	Grains/mm^2	Grains/mm^3	Ave. Grain Dia. (mm)
-1	3.9	6.1	0.5
0	7.8	17.3	0.36
1	15.5	49.6	0.26
2	31.0	138.0	0.18
3	62.0	391.0	0.125
4	124.0	1105.0	0.090
5	248.0	3126.0	0.065
6	496	8842.0	0.045
7	992	25010.0	0.032
8	1986.0	70706.0	0.022
9	3976.0	200,000.0	0.016
10	7940.0	566,000.0	0.011
11	15870.0	1600,000.0	0.008
12	31700.0	4527000.0	0.006

The number of grains per mm2 at 1X and the grain size number can be found out as given below:
Area of the photomicrograph = 1200 mm2

At 250X (linear), the actual area will be = $\frac{1200\ mm^2}{250\times250} = 0.0192\ mm^2$

Equivalent number of grains at 1X can be obtained by the following relationship.

$$\frac{n}{1\ mm^2} = \frac{30}{0.0192\ (mm^2)}$$

$$n = \frac{30}{0.0192} = \frac{30\times10^4}{192} = 1.5\times10^4 = 1500$$

The ASTM chart (Table 1) gives the grain size number 'G' as 11 for this value of n. The value of G can also be calculated by using equation "G = -2.9542 + 1.4472 *ln* n"

$$G = -2.9542 + 1.4427 \ln 15000$$

$$G = -2.9542 + 1.421 \times 9.6158 = 10.76 \approx 11$$

The same value of G is found from the ASTM chart (Table 1) for 15000 grains/mm^2 From Table 1, the diameter of the grain is 0.008 mm. Let us compare it with the value obtained from direct observation. From the direct measurement, the n = 15000/mm^2

No of grains in 1mm (linear) = $15000^{1/2}$ =122.47 ~ 123

Diameter of the grain = $\frac{1}{123} = 0.008\ mm$ (same as ASTM Table)

- **Heyn's intercept Method:**

This method is easier than ASTM method. The number of grain boundaries intercepting a test line passing through the grains in any direction is counted. An eyepiece calibrated with a micrometer scale is required to take the measurement while viewing the microstructure. The number of boundaries intercepted per unit length of the test line, NL, can be computed if the number of boundaries intercepted by L mm length of the test line be n at a magnification of M.

No of intercepted boundaries per unit length (actual mm), $N_L = \frac{n}{L/M} = \frac{n.M}{L}$

Average, intercepted grain diameter, $\bar{l} = \frac{1}{N_L} = \frac{L}{n \times M}\ mm$

Other parameters related to grain boundaries like N_V , the number of grains per unit volume; S_V the surface areaof the grain per unit voulume; $\bar{A}$, the mean planar area per grain, are related to each other and are given in Table 2. These relationships have been experimentally found to be correct, $\bar{l}$ and $\bar{A}$ are mostly used to characterize the grain size.

Table 2: Interrelationship of Grain Size Parameter

N_L	N_A	N_V	l	A	V
$S_V = \frac{6N_L^2}{3}$	$\frac{7N_A^2}{3}$	$\frac{8N_V^{1/3}}{3}$	-	-	-
$N_V = 0.422N_L^3$	$\frac{2N_A^{2/3}}{3}$	-	-	-	$\frac{1}{\bar{V}}$
$N_A = 0.735N_L^2$	-	-	-	$\frac{1}{\bar{A}}$	-
$N_L =$	-	-	$\frac{1}{\bar{l}}$	-	-

- **Jeffery's Planimetric Method:**

In this method a rectangle or a circle of known area commonly 5000 mm2 is engraved or drawn, as the case may be, on the eye piece of the microscope or on the photomicrograph. The magnification which gives about 50 grains inside the circle or rectangle is used for the study. All the grains which intersect the boundary of the circle or rectangle are summed up and reduced by half and are added into the number of grains, which fall well inside the boundary line to get the number of equivalent grains. This number multiplied by jeffery's multiplier gives the number of grains per mm2. Jeffery's multiplier gives the number of

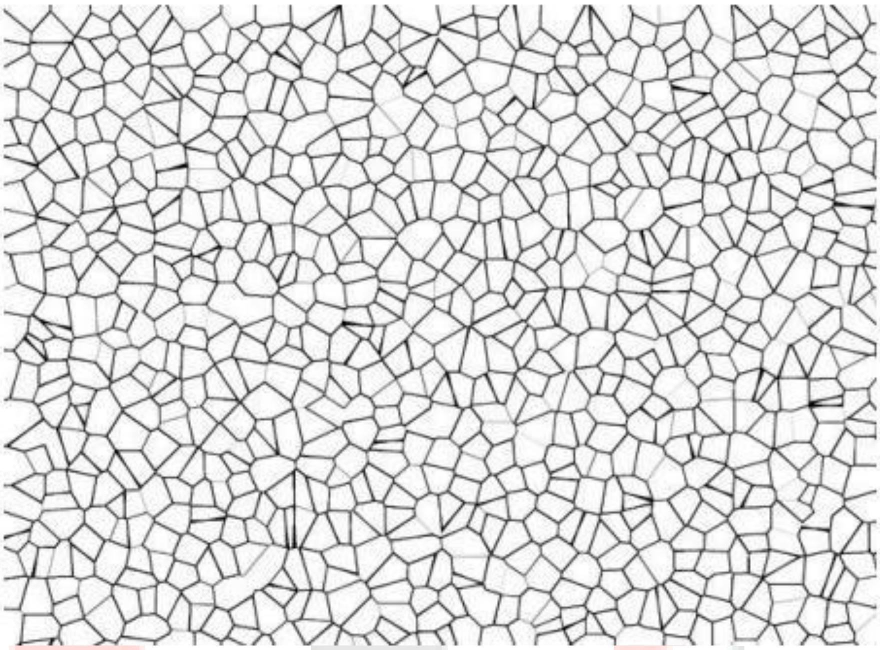
grains per mm^2. Jeffery's multiplier $k = \frac{M^2}{5000} = \frac{100\times100}{5000} = 2.0$; No. of grains per mm^2 = (4.2 * 2.0) = 84.0 ; Grain size = 84.0 grains / mm^2

Relationship between magnification used and Jeffries Multiplier, k, for an area of 5000mm² (a circle of 79.8 mm diameter) ($f=0.0002M^2$)

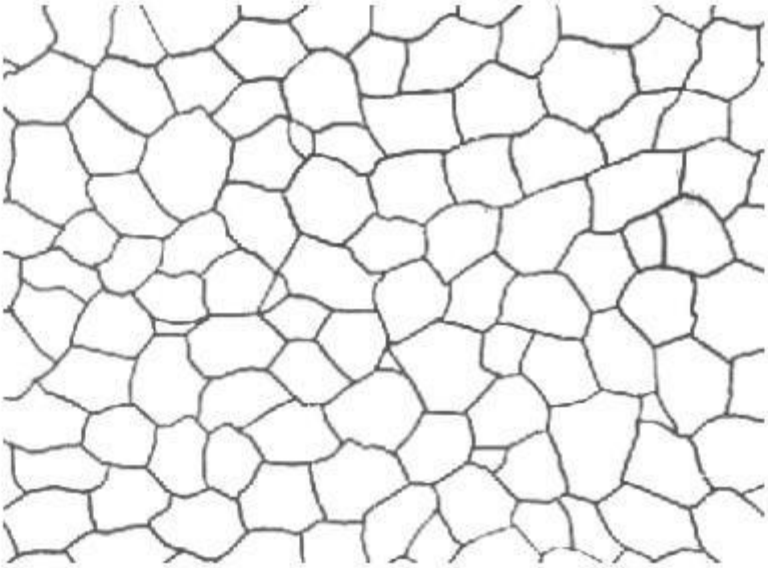
Magnification Used, X	Jeffries Multiplier, k, to obtain Grains/mm^2
1	0.0002
10	0.02
25	0.125
50	0.5
75	1.125
100	2.0
150	4.5
200	8.0
250	12.5
300	18.0
500	50.0
750	112.5
1000	200.0

OBSERVATIONS

1. The microstructure obtained at 200X magnification is given below. Determine the ASTM grain size of by grain counting method.



2. The microstructure obtained at 200X magnification is given below. Determine the ASTM grain size of by Heyn intercept method.



Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
4. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600,

grade), and emery papers (1/0, 3/0, 4/0, grade).

5. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), thewheel is fitted with a Polishing cloth and suspension of fine alumina powder inwater used as a polishing medium.
6. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
7. After fine polishing specimen is thoroughly washed with water and dried.
8. Observe the micro-structure of specimen under microscope and note it down.
9. Apply approximate etchant to the specimen and avoid under or over etching.
10. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on thespecimen
- While going to the next grade of emery papers, the specimen has to berotated through 90^0
- While switching over to new emery paper, specimen should be thoroughlywashed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks).

Observation:

Draw the microstructure obtained at_______X magnification is given below. Determine the ASTM grain size of by grain counting method and intercept method.

Remarks:

STUDY OF THE MICROSTRUCTURE OF MILD STEELS, LOW CARBON STEELS, HIGH C STEELS

Aim:

Observation of microstructure of **Medium Carbon Steel** specimen under metallurgic microscope

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Medium Carbon Steel

Etchants:2%Nital

Theory:

Medium carbon steel is carbon steel that contains between 0.30 and 0.60 percent carbon. It also has manganese content between 0.6 and 1.65 percent. This type of steel provides a good balance between strength and ductility, and it is common in many types of steel parts. Additional carbon makes the steel harder but also more brittle, so manufacturing carbon steel requires a balance between hardness and ductility. The most common uses of medium carbon steel are in heavy machinery, such as axles, crankshafts, couplings and gears. Steel with carbon content between 0.4 and 0.6 percent is commonly used in the railroad industry to make axles, rails and wheels.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks).

Observation:

Before Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications:

M.C.S used in manufacturing and making of Gears, Pins, Rams, Shafts, Axles, Rolls, Sockets, Spindles, Bolts, Ratchets, Light gears, Guide rods, Hydraulic clamps, Studs, Connecting rods, Crankshafts, Torsion bars etc

Remarks:

Aim:

Observation of microstructure of Low **Carbon Steel specimen** under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Low Carbon Steel

Etchants: 2% Nital

Theory:

Carbon steel is steel in which the main interstitial alloying constituent is carbon in the range of 0.12–2.0%. Low-carbon steel contains approximately 0.05–0.15% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed, for example as structural steel. The density of mild steel is approximately 7.85 g/cm3 (7850 kg/m3 or 0.284 lb/in3) and the Young's modulus is 210 GPa (30,000,000 psi).

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through

90^0

- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks).

Observation:

Before Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications:

Low carbon steels offer many applications. Truck bed floors, automobile doors, domestic appliances. The automobile industry employs a considerable amount of this steel for making parts that require simple bending or moderate forming. Truck cab backs, tailgate access covers, floor pans, and bed floors are often made of this steel.

Remarks:

Aim:

Observation of microstructure of High Carbon Steel specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: High Carbon Steel

Etchants:4%picral

Theory:

High carbon steel will be any type of steel that contains over 0.8% carbon but less than 2.11% carbon in its composition. The average level of carbon found in this metal usually falls right around the 1.5% mark. High carbon steel has a reputation for being especially hard, but the extra carbon also makes it more brittle than other types of steel. This type of steel is the most likely to fracture when misused.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

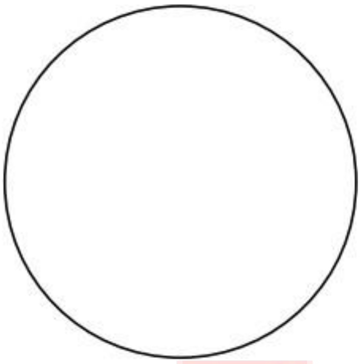
Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.

- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

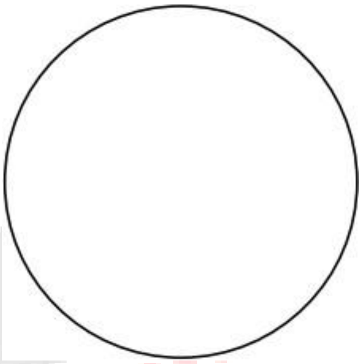
Etching Time:

Composition:

Phase’s description:

Properties (if any):

After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications:
Depending on the specific needs of the person using it, high carbon steel can have many advantages over other options. This type of steel is excellent for making cutting tools or masonry nails. The hardness levels and metal wear resistance of high carbon steel is also rated very highly. High carbon steel is also preferred by many manufacturers who create metal cutting tools or press machinery that must bend and form metal.
High carbon steel remains popular for a wide variety of uses. This type of steel is preferred in the manufacturing of many tools such as drill bits, knives, masonry nails, saws, metal cutting tools, and woodcutting tools.

Remarks:

STUDY OF THE MICROSTRUCTURE OF CAST IRONS.

Aim:

Observation of microstructure of **Grey Cast Iron** specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Grey Cast Iron

Etchants:3%Nital

Theory:

Gray iron, or grey cast iron, is a type of cast iron that has a graphitic microstructure. It is named after the graycolor of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight.

It is used for housings where the stiffness of the component is more important than its tensile strength, such as internal combustion engine cylinder blocks, pump housings, valve bodies, electrical boxes, and decorative castings. Grey cast iron's high thermal conductivity and specific heat capacity are often exploited to make cast iron cookware and disc brake rotors.

Procedure:

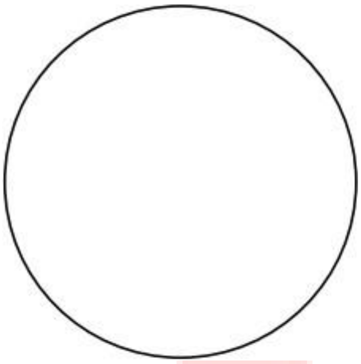
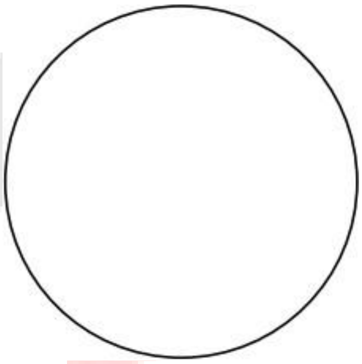
1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), thewheel is fitted with a Polishing cloth and suspension of fine alumina powder inwater used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction

- While polishing the specimen uniform pressure should be exerted on thespecimen
- While going to the next grade of emery papers, the specimen has to berotated through 90^0
- While switching over to new emery paper, specimen should be thoroughlywashed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks).

Observation:

Before Etching	After Etching
	
Magnification:	**Magnification:**
Name of the sample:	**Name of the sample:**
Heat/Mechanical Treatment:	**Heat/Mechanical Treatment:**
Etchant:	**Etchant:**
Etching Time:	**Etching Time:**
Composition:	**Composition:**
Phase's description:	**Phases description:**
Properties (if any):	**Properties (if any):**

Applications:
Gray iron is a common engineering alloy because of its relatively low cost and good machinability, which results from the graphite lubricating the cut and breaking up the chips. It also has good galling and wear resistance because the graphite flakes self lubricate. The graphite also gives gray iron an excellent damping capacity because it absorbs the energy

Remarks:

Aim:

Observation of microstructure of **Malleable Cast Iron** specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Malleable Cast Iron

Etchants:3% Nital

Theory:

Malleable iron is cast as white iron, the structure being Meta stable carbide in a pearlitic matrix. Through an annealing heat treatment, the brittle structure as first cast is transformed into the malleable form. Carbon agglomerates into small roughly spherical aggregates of graphite leaving a matrix of ferrite or pearlite according to the exact heat treatment used. Three basic types of malleable iron are recognized within the casting industry: blackheart malleable iron, white heart malleable iron and pearlitic malleable iron

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

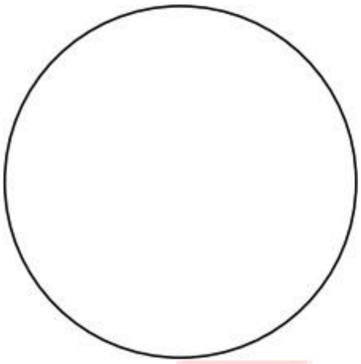
Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0

- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

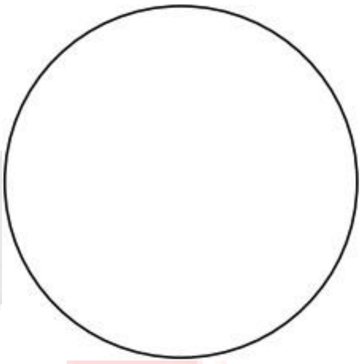
Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications:
It is often used for small castings requiring good tensile strength and the ability to flex without breaking (ductility). Uses include electrical fittings, hand tools, pipe fittings, washers, brackets, fence fittings, power line hardware, farm equipment, mining hardware, and machine parts.

Remarks:

Aim:

Observation of microstructure of **Nodular cast iron** specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample: Nodular cast iron

Etchants: 2% Nital

Theory:

Cast irons are basically the alloys of Iron & Carbon in which carbon content varies between 2.02 to 6.67% (Theoretically). Cast irons are brittle, and can not be forged, rolled, drawn etc., but can only be „**cast**‟ into a desired shape and size, by pouring the molten alloy of desired composition into mould of desired shape and allowing it to solidify. As casting is the only and exclusively suitable process to shape these alloys, these alloys are called cast irons. Carbon in cast iron may be in the form of cementite, i.e., in the combined form or graphite, the free form, or both. Nodular cast iron is the one type in which carbon is in uncombined form spheroids. Graphite is formed in spherical or nodular shapes instead of the flakes form in Gray Cast Iron, the formation of spherical graphite is due to the addition of "Mg" to the Gray CastIron. It is also known as ductile / Nodular Cast Iron.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen

- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Remarks:

STUDY OF MICROSTRUCTURES OF DIFFETERENT ALLOYSTEELS

Aim:

To identify the different phases and to draw the microstructures of alloy steels.

Apparatus And Specimens Required:

Metallurgical microscope, specimens of different Alloy steels

Theory:

Steels are to be alloyed for improving their mechanical properties. Common alloying elements are Al, Ni, Mn, Cr, etc., however, the properties of alloy steels are not so much superior to plain carbon Steels in untreated condition. Different heat treatments are given to alloy steels to fully exploit their Properties.

Effect of Alloying Elements:
Alloying elements may have one or more of the following effects.

a) **Solid Solution Strengthening/Hardening:** Most of the alloying elements are soluble in ferrite to some extent and form solid solutions when added to steel. Solid solutions are harder and stronger than the pure metals and hence these elements increase strength and hardness ofsteels.

   Examples: Mn, Cr, W, Mo, V, Ti, Ni, Si, Al, Zr………

b) **Formation of carbides:** Some of the alloying elements combine with carbon in steel and form respective carbides. These alloy carbides are hard and increase wear and abrasion resistance ofsteels.

   Examples: Mn, Cr, W, Mo, V, Ti, Zr, and Nb………

c) **Formation of Intermediate Compounds:** Some of the elements form intermediate compounds withiron.

   Examples: Fe, Cr(sigma phase in high chromium alloys) and Fe3W2 (in tool steels).

d) **Formation of inclusions:** they may combine with oxygen and form oxides when added tosteel.

   Examples: Si, Al, Mn, Cr, V, and Ti……

e) **Shifting of critical temperature and eutectoid carbon:** the alloying element may lower or raise the transformation temperature of steel. Elements, which are austenite stabilizers like Ni, and Mn, lower the eutectoid temperature (A) while the elements, which are ferrite stabilizers, raise the abovetemperature.Most of the alloying elements shift the eutectoid carbon to lower values e.g. the carbon content of Eutectoid in a 12% Cr steel is less than 0.4% as against to 0.8% in plain carbon steels.

f) **Loweringofcriticalcoolingrate:**Mostofthealloyingelements(exceptCo)shiftthe

T.T.T diagram to the right side, thus decreasing the critical cooling rate. This effect is very useful for increasing thehardenability.\

Changes in volume during transformation: Elements may be chosen in proper proportion sp as to reduce the volume change to reduce distortions and the risk of quench cracking duringhardening.

Othereffects:

1. The transformation may becomesluggish.
2. The corrosion and oxidation resistance may increase e.g. chromium increases corrosion resistance by forming a thin film of chromium oxide on the surface. This is found in stainless steels.
3. Creep strength may get increased due to the presence and dispersion of finecarbides.
4. Fatigue strength may also getincreased.

Classification of AlloyingElements:

With respect to relation with Carbon, alloying elements can be classified into 3groups.

a) **Carbide forming elements:** They form carbides when added to steels or castirons.
Examples: Ti, Zr, V, Nb, W, Mo, Cr, Mn……

b) **Neutral Elements:** Cobalt is the only element in this category, which neither forms carbides nor causesgraphitization.

c) **Graphitizing elements:** They try to decompose the carbides into graphite, in castirons.
Examples: Ni, Si, Cu, Al

a) **Austenite stabilizers:** the elements from this group raiseA_4, temperature and lower A_3temperature, thus increasing the range of stability of Austenite.
Examples: Mn, Ni, Cu, C, N………

b) **Ferrite Stabilizers:** These elements lower A_4temperature and raise A3 temperature, thus increasing the range of stability offerrite.
Examples: Cr, W, Mo, V, Ti, Ni, Si, Al, Zr, B Nb, P……

Uses of Alloying Elements:

a) **Sulphur:** Sulphur combines with iron and forms iron sulphide and induces brittleness phase.

b) **Phosphorus:** Phosphorus dissolves in ferrite and increases its tensile strength andhardness.

c) **Silicon:** it is ferrite solid solution strengthener. It dissolves in ferrite increasing strength, hardness and toughness without loss of ductility. It is a strong graphitizer in castirons.

d) **Manganese:** It dissolves in ferrite and increases yield strength tensile strength, toughness and hardness. It combines with Sulphur and forms MnS reducing the detrimental effect of FeS.

e) **Nickel:** It is ferrite solid solution strengthener. It dissolves in ferrite and increases hardness, tensile strength and toughness without decreasing ductility. It increases impact resistance of steels at low temperature i.e. it reduces ductile-brittle transition temperature.

a) Chromium:
Chromium has several functions as given below:

i) It increases hardenability ofsteels.
ii) It forms carbides and increases hardness and wear resistance ofsteels.
iii) It increases corrosion and oxidation resistance when added in substantialamount.

Chromium has following disadvantages:

i. It makes the steel susceptible to temper embrittlement.
ii. These steels are liable to form surface markings, generally referred to as chrome lines.

b) Tungsten:
It as following functions:

i) It increaseshardenability.
ii) It forms carbides and increases wear and abrasionresistance.
iii) It refines the gain size and the carbides inhibit the graincoarsening.
iv) It reduces the tendency ofdecarburization.

c) Molybdenum:
Molybdenum has similar functions as Tungsten. However, its resistance to grain coarsening and decarburization is less as compared to Tungsten.

d)Vanadium:
The properties of vanadium containing steels are on similar lines as tungsten or/and molybdenum containing steels. However, vanadium containing steels have improved distinct properties as stated below.

i) The resistance to grain coarsening isexcellent.
ii) The carbides of vanadium are extremely hard and hence, vanadium promotes secondary hardening duringtempering.
iii) It effectively improves the fatigue and creepresistance.
iv) It is strong deoxidizer.

e) Titanium: It is strong carbide former it effectively inhibits grain coarsening and also acts as a grain refiner.

f) Cobalt: It is neither carbide former nor a graphitizer. It is the only element, which reduces hardenability ofsteels.

g) Aluminium: It is a powerful deoxidizer and hence is used for killing of steels. It is a grain refiner and alsoinhibitor.

h) Boron: Small additions of boron (0.001 – 0.003%) sharply increase hardenability of medium carbonsteels.

g) The microstructure of following Alloy steels are studied in thisexercise

a. High Speed Tool Steel: The important characteristics of Tools steelsare

i) High hardness ateleveatedtemperatures ii) Highwear resistance
iii) High hardenbility iv) Goodtouhness.

These steels maintain high hardness up to a temperature about 550^0C. These are designated by T- Series.

Specimen : High speed steel

Composition : 0.7%C, 18%W, 4%Cr, 1%V

Heat treatment : Heated to a temperature of 1250-1300^0C, soaked at this temperature for very Short period of time.

The steel is then quenched in oil to room temperature

Etchant : Nital

Etching time : 20seconds

The microstructure consists of tempered marten site, alloy carbides and low carbon retained austenite.

Applications : Cutting tools

a) Stainless steel: these steels have high corrosion resistance specimen : Stainless steel (Austenitic) Composition : <0.15%C, 18%Cr, 10%Ni Etchant : Nital

Etching time : 20seconds

The microstructure consists of Austenitic grains. The dark regions are due to alloy carbide precipitation.

Applications: Utensils, Chemical plant equipment, Medical equipment Blades etc,

b) High Carbon Chromium steel: These steels have very high hardenability and shows very less distortion during hardening.

Specimen : High carbon high chromium steel

Composition: 1.5%C, 12%Cr, And 1% Mo

Heat treatment: Hardened and tempered

Etchant: Nital

Etching time: 20seconds

The microstructure consists of tempered marten site. The dark area are alloy carbides.

Applications: Drawing dies, Blanking dies etc.

En36:

Specimen : En36

Composition : 015%C, 0.6%Mn, 3.35%Ni, 1.1%Cr,0.35%Si

Heat treatment: Case carburising.

Etchant : Nital

Etching time : 10seconds

The microstructure shows a white compound layer of few microns thick at the surface and Ferrite and pearlite at the core.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).

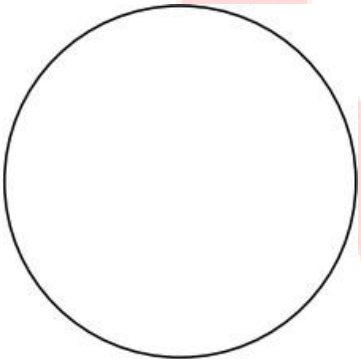
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

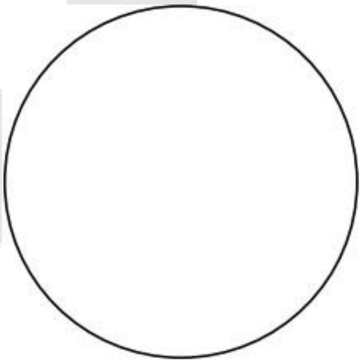
- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching



After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Applications: These are used where a hard case and a tough core is required. Boring bits etc

Result:

Hence identified the different phases and obtained and draw the structures of the alloy steels.

STUDY OF MICROSTRUCTURES OF NON-FERROUS ALLOYS
METALLOGRAPHY OF BRASS

Aim:

Identification of micro – constituents present in the brass.

Equipment &Materials:-

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Theory:-

Brasses are alloys of copper; contain zinc as a principal alloying element. The equilibrium solubility of Zn in Cu is around 38% and is sharply influenced by cooling rate. Under the conditions of usual cooling rates encountered in industrial practice, the solubility limit may go down to 30%. With Zn additions exceeding the solubility limit, a second phase β is formed Beta intermediate phase exhibits order-disorder transformation between 453 and 470^{0}C. Below this temperature, the structure of β is ordered and above this is disordered. With more than 50 % Zn another phase (intermediate phase) is formed Brasses are classified eitheron the basis of structure i.e. α brasses and α – β Brasses or colouri.e red brasses and yellow brasses.

α - brasses are soft, ductile malleable and have fairly good corrosion resistance. Commercial α – β Brasses contain zinc between 32 to 40%. They are hard and strong as compared to α-brasses and are fabricated by hot working process .these two phases alloys become single phase β (disordered) alloys at higher temperatures. Disordered β has more ductility and malleability as compared to β and therefore, α – β brasses are hot worked at a temperature of above 600 ^{0}C. Since zinc is cheaper than copper, α – β brasses are cheaper compared to α – Brasses.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), thewheel is fitted with a Polishing cloth and suspension of fine alumina powder inwater used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.

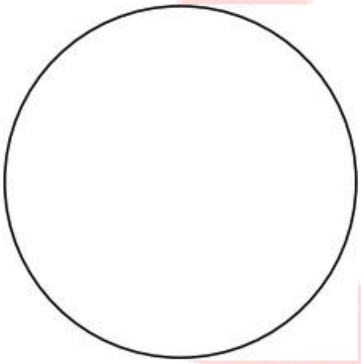
7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on thespecimen
- While going to the next grade of emery papers, the specimen has to berotated through 90^0
- While switching over to new emery paper, specimen should be thoroughlywashed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks)

Observation:

Before Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

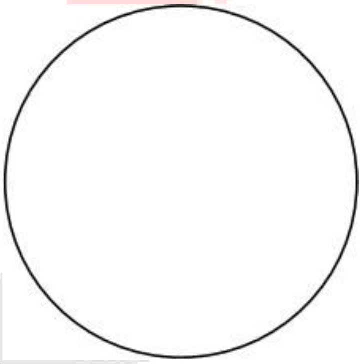
Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching



Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

STUDY OF THE MICRO STRUCTURES OF HEAT TREATED STEELS

Aim:

Observation of microstructure of **Heat Treated Steels** specimen under metallurgic microscope.

Apparatus:

- Sample Specimen ,
- Belt Grinder
- Sand paper (80,150,180, 220, 400, 600),
- Emery Paper(1/0, 3/0, 4/0, grade),
- Disc polisher machine
- Etchant
- Drier
- Metallurgical Microscope

Sample:

Etchants:2% Nital

Theory:

Heat treatment is a process of heating the metal below its melting point and holding it at that temperature for sufficient time and cooling at the desired rate to obtain the required Properties. The various heat treatment processes are annealing, normalizing, tempering, hardening, mar tempering, and austempering.

The final mechanical properties depend on the microstructure formed due to various heat treatment processes (due to various cooling rates). An annealed specimen was cooled in the furnace or any good heat insulating material; it obtains the coarse grain structure of ferrite and pearlite in case of hypo eutectoid steels and coarse grain structure of ferrite and cementite in case of hyper eutectoid steel. It possesses high ductility.

A normalized specimen was cooled in the presence of air so cooling rate increases, it obtains the fine grain structure of ferrite and pearlite in case of hypo eutectoid steels and fine grain structure of ferrite and cementite in case of hyper eutectoid steel. It possesses high ductility. A hardened specimen was quenched in oil (in case of alloy steels) or in water (in case of carbon steel).due to faster cooling rate martensite (hard steel) structure was formed.

Procedure:

1. Cut the specimen into required shape by using cutoff machine.
2. The mounted specimen surface is ground until unevenness of surface is eliminated using Belt Grinder
3. Then polish the specimen again by using sand papers (80,150,180, 220, 400, 600, grade), and emery papers (1/0, 3/0, 4/0, grade).
4. Fine Polishing is done on a disc Polisher (Rotating Polishing Wheel), the wheel is fitted with a Polishing cloth and suspension of fine alumina powder in water used as a polishing medium.
5. A Scratch free surface is obtained after fine polishing for sufficient period (15minutes).
6. After fine polishing specimen is thoroughly washed with water and dried.

7. Observe the micro-structure of specimen under microscope and note it down.
8. Apply approximate etchant to the specimen and avoid under or over etching.
9. Observe the micro scope structure and note it down.

Precautions:

- Grinding should be done on the emery papers only in one direction
- While polishing the specimen uniform pressure should be exerted on the specimen
- While going to the next grade of emery papers, the specimen has to be rotated through 90^0
- While switching over to new emery paper, specimen should be thoroughly washed with water to remove all loose particles.
- After etching the specimen should be washed away within a few seconds
- Operate the Microscope Knobs gently (with out jerks).

Observation:

Before Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phase's description:

Properties (if any):

After Etching

Magnification:

Name of the sample:

Heat/Mechanical Treatment:

Etchant:

Etching Time:

Composition:

Phases description:

Properties (if any):

Remarks:

HARDEN ABILITY OF STEELS BY JOMINY END QUENCH TEST

Aim:

To determine the hardenability of a given steel.

Apparatus:

Jominy test apparatus, furnace, Rockwell hardness tester and a grinder.

Theory:

Jominy end quench test is used to determine hardenability of steels. The process of increasing the hardness of steel is known as Hardening. Specific specimen with standard dimensions, used for the test is given in fig.1. The hardness of hardened bar is measured along its length.

3.1 Hardenability:

The depth up to which steel can be hardened is defined as hardenablity. A steel having high hardness need not have high hardenability. Hardenability may be defined as susceptibility to hardening by quenching. A material that has high hardenablity is said to be hardened more uniformly throughout the section that one that has lower hardenability.
M.A Gross man devised a method to decide hardenablity.

3.1.1 Critical diameter:

The size of the bar in which the zone of 50% martensite occurs at center is taken as critical diameter. This is a measure of harenablity of steel for a particular quenching medium employed.

3.1.2. Severity of Quench:

The severity of quench is indicated by heat transfer equivalent.

$$H = f/k$$

f = Heat transfer factor of Quenching medium and the turbulence of the bath.
k = Thermal conductivity of bar material.

The most rapid cooling is possible with severity of quench as infinity.

3.1.3 Ideal Critical Diameter;

The hardenbility of steel can be expressed as the diameter of bar that will form a structure composed of 50% martensite at the center when quenched with H = infinity. This diameter is defined as ideal critical diameter.

Description ofApparatus:

Jominy end quench apparatus is shown in fig 2.
The apparatus consists of a cylindrical drum. At the top of the drum provision is made for fixing the test specimen. A pipe line is connected for water flow, which can be controlled by means of a stop cock.

Procedure:

1. Out of the given steel bar, the standard sample is to be prepared as per the dimensions shown in thefig.
2. The austenitising temperature and time for the given steel is to be determined dependingon its chemicalcomposition.
3. The furnace is setup on the required temperature and sample is kept in thefurnace.
4. The sample is to be kept in the furnace for a predetermined time (based on chemical composition of steel) then it is taken out of the furnace and is kept fixed in the testapparatus.
5. The water flow is directed onto the bottom end of the sample. The water flow isadjusted such that it obtains shape of umbrella over bottom ofsample.
6. T he quenching to be continued for approximately 15minutes.
7. A flat near about 0.4 mm deep is grounded on thespecimen.
8. The hardness of the sample can be determine at various points starting from thequenched end and the results aretabulated.
9. The graph is plotted with hardness values versus distance from quenched end. From the results and graph Plotted the depth of hardening of the given steel sample can bedetermined.

Precautions:

1. The specimen is to be handled carefully while transferring from furnace to testapparatus.
2. Proper water flow (at high pressure) over the bottom end of specimen is to beensured.

Observation Table

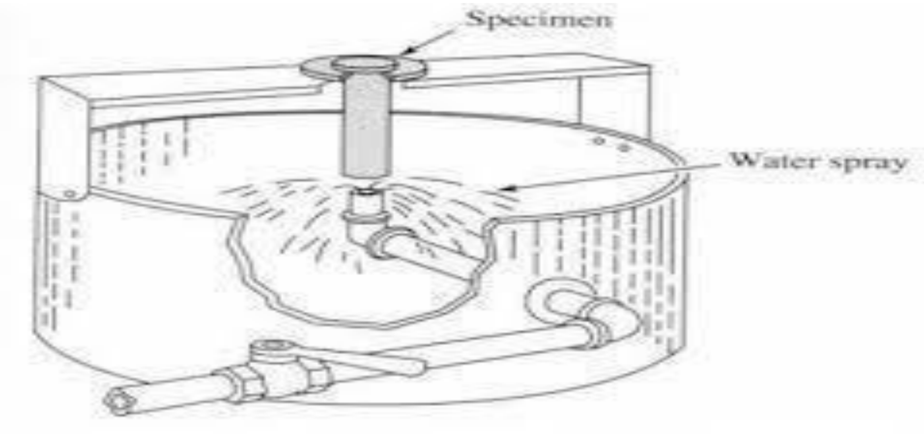
S.No.	Distance from quenched end	Hardness

RESULTS:

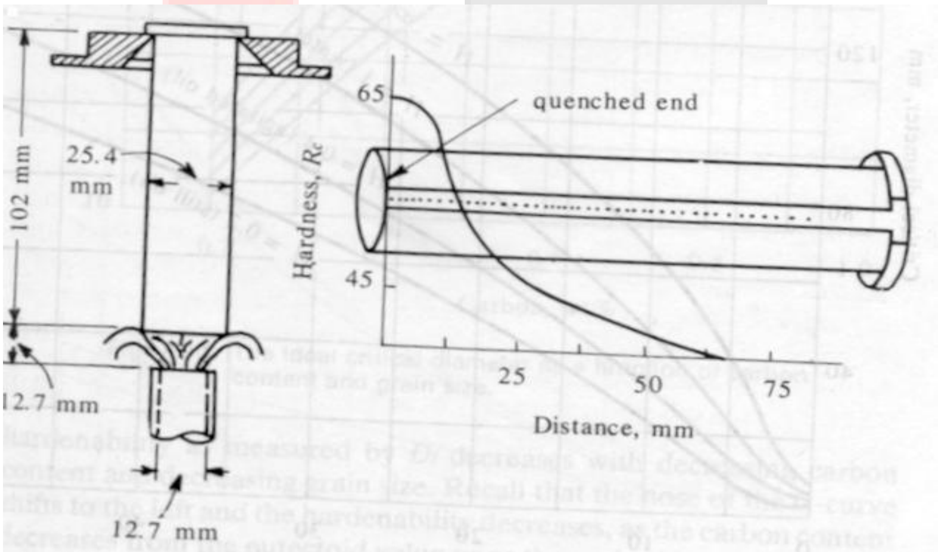
Hence determine the hardenability of steel.

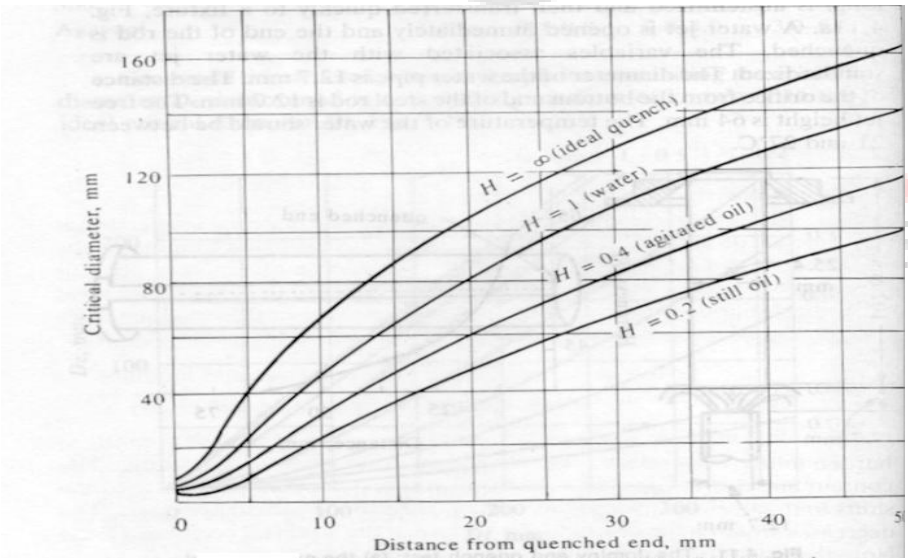
Fig 1
MUFURNACE

Fig 2
Jominey End Quench Test Apparatus



Jominy End Quench Test Setup





The relationship between the Jominy distance and the critical diameters for various quenching media and H values.

FIND THE HARDNESS OF THE VARIOUS TREATED AND UNTREATED STEELS.

Aim:

To find the hardness of the given treated and untreated steel specimens by conducting the hardness test.

Apparatus:

The given specimens Hardness tester .

Theory:

The method of testing introduced by J.A.Brinell in 1900 consisting of indenting the metal with a "d" mm diameter and tempered steel ball subjected to a definite load. ball of10 mm , 5 mm , ad 2.5 mm are generally used. The load is maintained for a definite period (usually 10 or 15 sec) after which the load is removed and the diameter of the impression or indentation is measured. The hardness of the material expressed as number and represented by the symbol "HB".

h= depth of indentation

$$(D-\sqrt{(D^2 - d^2)}/ 2$$

Brinnel's hardness number HB = Total load / surface area of indentation

$$\frac{2F}{\Pi D (D- \sqrt{(D^2 - d^2)})}$$

Proceducre:

1. The face of the specimen is lightly grind and rubbed with fine emery paper ifrequired.
2. Select the proper test table basedo the size and shape of the specimen and place it onmain screw or elevating screw
3. Select the diameter of the indenter as 10mm or 5 mm based on the thickness of thespecimen and place it I the corresponding ball holder and fix the ball holder.
4. Place the required weights on the weight hanger based on the type of material of thespecimen and diameter of the indenter
5. Check and keep the operating level in horizontal position
6. Place the specimen securely on testing table
7. Turn the hand wheel in clock wise direction so that the specimen touches the ball Indenter
8. Lift the operating lever fro the horizontal position upwards slightly, after which it Rotates automatically.
9. Wait for 10 to 15 sec after lever becomes stand still.
10. Bring the lever back to horizontal position
11. Turn back the hand wheel and remove the specimen
12. Measure the diameter of impression of indentation by Brinnel microscope and find the Brinnel hardness number.
13. Repeat the above procedure for three to four times

Precautions:

1. Apply the load slowly and gradually on the sample
2. Distance between old impression and location for new impression should be 3D (three times the ball diameter)
3. After applying the specified load wait for 15 sec then remove the load
4. The thickness of the test piece must not be less than 8 times the depth of impression
5. The surface o which the brinnel impression is to be made should be sufficiently smooth and clean.

Observation Table

S.No.	Distance from quenched end	Hardness

Result:

The Brinnel hardness number of the give material is -------

Fig 1
Jominey End Quench Test Apparatus

Fig 2
Brinnel HardnessTest

Fig 3
Rockwell HardnessTest