MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

Affiliated to JNTUHApproved by AICTE, NBA- Tier 1& NAAC – ‘A’ Grade ISO 9001:2015 Certified)

Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India

Aircraft Composite Materials Lab

MANUAL

B.TECH III YEAR – I SEM

NAME ______________________

ROLL NO: ______________ BRANCH ______________

YEAR: ______________ SEM: ______________

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
Affiliated to JNTUH Approved by AICTE, NBA- Tier 1 & NAAC – 'A' Grade ISO 9001:2015 Certified)
Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India

CERTIFICATE

Certified that this is the Bonafide Record of the work done by Mr. /Ms.____bearing Roll No.___________________________ of B.Tech III Year ________________Semester for the Academic year 2023-2024 in_____________________________________

Date: Faculty In-charge HOD

Internal Examiner External Examiner

INDEX

S.No	Date	Title	Page No	Faculty Sign

INDEX

S.No	Date	Title	Page No	Faculty Sign

DEPARTMENT OF AERONAUTICAL ENGINEERING

VISION

Department of Aeronautical Engineering aims to be indispensable source in Aeronautical Engineering which has a zeal to provide the value driven platform for the students to acquire knowledge and empower themselves to shoulder higher responsibility in building a strong nation.

MISSION

a) The primary mission of the department is to promote engineering education and research.

(b) To strive consistently to provide quality education, keeping in pace with time and technology.

(c) Department passions to integrate the intellectual, spiritual, ethical and social development of the students for shaping them into dynamic engineers.

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: PROFESSIONALISM & CITIZENSHIP

To create and sustain a community of learning in which students acquire knowledge and learn to apply it professionally with due consideration for ethical, ecological and economic issues.

PEO2: TECHNICAL ACCOMPLISHMENTS

To provide knowledge-based services to satisfy the needs of society and the industry by providing hands on experience in various technologies in core field.

PEO3: INVENTION, INNOVATION AND CREATIVITY

To make the students to design, experiment, analyze, interpret in the core field with the help of other multi-disciplinary concepts wherever applicable.

PEO4: PROFESSIONAL DEVELOPMENT

To educate the students to disseminate research findings with good soft skills and become a successful entrepreneur.

PEO5: HUMAN RESOURCE DEVELOPMENT

To graduate the students in building national capabilities in technology, education and research.

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design / development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, tomanage projects and in multi-disciplinary environments.

12. **Life- long learning:** Recognize the need for, and have the preparation and ability to engage inindependent and life-long learning in the broadest context of technological change.

MALLA REDDY COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF AERONAUTICAL ENGINEERING

PROGRAM SPECIFIC OBJECTIVES

1. To mold students to become a professional with all necessary skills, personality and sound knowledge in basic and advance technological areas.

2. To promote understanding of concepts and develop ability in design manufacture and maintenance of aircraft, aerospace vehicles and associated equipment and develop application capability of the concepts sciences to engineering design and processes.

3. Understanding the current scenario in the field of aeronautics and acquire ability to apply knowledge of engineering, science and mathematics to design and conduct experiments in the field of Aeronautical Engineering.

4. To develop leadership skills in our students necessary to shape the social, intellectual, business and technical worlds.

CODE OF CONDUCT FOR THE LABORATORIES

- All students must observe the Dress Code while in the laboratory.
- Sandals or open-toed shoes are NOT allowed.
- Foods, drinks and smoking are NOT allowed.
- All bags must be left at the indicated place.
- The lab timetable must be strictly followed.
- Be PUNCTUAL for your laboratory session.
- Program must be executed within the given time.
- Noise must be kept to a minimum.
- Workspace must be kept clean and tidy at all time.
- Handle the systems and interfacing kits with care.
- All students are liable for any damage to the accessories due to their own negligence.
- All interfacing kits connecting cables must be RETURNED if you take from the lab supervisor.
- Students are strictly PROHIBITED from taking out any items from the laboratory.
- Students are NOT allowed to work alone in the laboratory without the Lab Supervisor
- USB Ports have been disabled if you want to use USB drive consult lab supervisor.
- Report immediately to the Lab Supervisor if any malfunction of the accessories, is there.

Before leaving the lab

- Place the chairs properly.
- Turn off the system properly
- Turn off the monitor.
- Please check the laboratory notice board regularly for updates.

MATERIALS ENGINEERING LAB

LIST OF EXPERIMENTS

S. No.	Name of the Experiment
1	Preparation of multi layered glass fiber reinforced composite using hand-lay method
2	To the study of Microstructure of Low, Medium & High carbon steels.
3	To the study of Microstructure Cast Irons. (Grey cast Iron & White cast Iron).
4	To the study of Microstructure Non – Ferrous pure metals. (Copper &Aluminum).
5	Determination of compressive strength of composite material using UTM
6	Determination of tensile strength of composite material using UTM

Exercise-1

Preparation of multi layered glass fiber reinforced composite using hand-lay method

a. To prepare the given specimen for metallographic examination.

b. To Study the constructional details of Metallurgical Microscope and observe the micro structure of the prepared specimen.

b. APPARATUS AND MATERIALS REQUIRED:

Metallurgical microscope, emery belt 1/0, 2/0, 3/0, 4/0 emery papers, lapping cloth, alumina powder, etchants, sample of metal.

c. THEORY:

The microstructure of metal decides its properties. An optical microscope is used to study the microstructure. A mirror polished surface of the metal is required for metallographic study.

d. PROCEDURE OF SPECIMEN PREPARATION:

1. Cut the specimen to the required size (small cylindrical pieces of 10 to 15mm diameter with 15mm height or 10mm cubes)
2. **Mounting of Specimens:**

   The primary purpose of mounting is to make it convincement to handle specimens of arbitrary shape and/or small sizes during various steps of metallographic sample preparation and examination. A secondary purpose is to protect and preserve extreme edges or surface defects during metallographic preparation. Specimens may also require mounting to accommodate various types of automatic devices used in metallographic laboratories or to facilitate placement on the microscope stage. An additional benefit of mounting is the identification of the sample (name, alloy number or laboratory code number) without damaging the specimen.

   Compression mounting:

   It is most common mounting method, which involves molding around the metallographic specimen by heat and pressure using the molding materials such as Bakelite, Diallyl Phthalate resins, and acrylic resins. Bakelite and Diallyl phthalate are thermosetting, and acrylic resins are thermoplastic. Not all materials or specimens can be mounted in thermosetting or thermoplastic mounting. The heating cycle may cause changes in the microstructure, or the pressure may cause delicate specimens to collapse or deform. The size of the selected specimen may be too large to be accepted by the available mold sizes. These difficulties are usually overcome by cold mounting.

   Cold Mounting requires no pressure and little heat, and is a mean of mounting large numbers of specimens more rapidly than possible by compression mounting. Epoxy resins are most widely used cold mounting materials. They are hard, and adhere tenaciously to most metallurgical, mineral and ceramic specimens.
3. **Belt grinding:-** One of the faces of the specimen is pressed against the emery belt of the belt grinder so that all the scratches on the specimen are unidirectional.

Intermediate:- The sample is to be polished on 1/0, 2/0, 3/0, 4/0 numbered emery papers with increasing fineness of the paper. While changing the polish paper, the sample is to be turned by 90° so that new scratches shall be exactly perpendicular to previous scratches.

Disc polishing (fine polishing):- After polishing on 4/0 paper the specimen is to be polished on disc polishing machine (Buffing machine). In this disc-polishing machine a disc is rotated by a vertical shaft. The disc is covered with velvet cloth. Alumina solution is used as abrasive. Alumina solution is sprinkled continuously over the disc and the specimen is gently pressed against it. In case of Non-ferrous metals such as Brass, Brass is used instead of Alumina and water. The polishing should be continued till a mirror polished surface is obtained.

1. The sample is then washed with water and dried.

Etching: the sample is then etched with a suitable etching reagent, detailed in article 5. After etching the specimen should be washed in running water and then with alcohol and then finally dried. The sample is now ready for studying its microstructure under the microscope.

ETCHING:

Except for few cases a polished metallic surface can't reveal the various constituents (phases). Hence specimen should be etched to reveal the details of the microstructure i.e. a chemical reagent should be applied on the polished surface for a definite period of time. This reagent preferentially attacks the grain boundaries revealing them as this lines. Thus under the microscope the grain structure of the metal becomes visible after etching i.e. grain boundary area appears dark and grains appear bright. The rate of etching not only depends on the solution employed and composition of the material but also on the uniformity of the material. A few etching reagents, their composition and their application are given below.

S.No.	Name of Etchant	Composition	Application
1.	Nital		General structure of Iron and steel
	a) 5% Nital	Nitric acid(5ml)and Abs. Methyl alcohol(95ml)	
	b) 2% Nital	Nitric acid(2ml) and Abs. Methyl alcohol (98ml)	
2.	Picral	Picric acid(4gm) and Abs ethyl alcohol(96ml)	General structure of Iron and steel
3.	Marbel's reagent	Copper sulphate (4gm), HCL(20ml) & H_2O (20ml)	Stainless steels

4.	Murakami's reagent	Potassium ferry cyanide, (10grms), KOH(10grms) and Water(100ml)	Stainless steels
5.	Sodium hydroxide	Sodium hydroxide(10gm) and Water (90ml)	Aluminum & its alloys
6.	Keller's reagent	Hydro fluoric acid(20ml) Nitric acid(10ml) and Glycerin (30ml)	Aluminum & its alloys
7.	Keller's reagent	Hydro fluoric acid(1ml) Hydrochloric acid(1.5ml) Nitric acid(2.5ml) and Water(95 ml)	Duralumin
8.	Ammonium phosphate solution	Ammonium persulphate solution(10gms and water (90ml)	Copper and copper alloys
9.	Fecl3 solution	FeCl3 (5gms), HCl acid(2ml) and Ethyl alcohol (96gms)	brass

METALLURGICAL MICROSCOPE:

Metallurgical microscope is used for micro and macro examination of metals. Micro examinations of specimens yield valuable metallurgical information of the metal. The absolute necessity for examination arises from the fact that many microscopically observed structural characteristics of a metal such as grain size ,segregation, distribution of different phases and mode of occurrence of component phases and non metallic inclusions such as slag, sulfides etc., and other heterogeneous condition(different phases)expert a powerful influence or mechanical properties of the metal. It is possible to predict as to how metal will behave under a specific stress. Microstructure of metals at magnifications ranging from 50x to 2000x is carried out with the aid of metallurgical microscope.

a) PRINCIPLE:

A Metallurgical microscope is shown in fig.1.1.Metallurgical microscope differs with a biological microscope in a manner by which specimen of interest is illuminated .As metals are opaque their structural constituents Are studied under a reflected light. Is shown fig.1.2. a horizontal beam of light from appropriate source is directed by means of plane glass reflects downwards and through the microscope objective on to the specimen surface. A certain amount of this light will be reflected from the specimen surface and that reflected light, which again passes through the objective, will form an enlarged image of the illuminated area.

A microscope objective consists of a number of separate lens elements which are compound group behave as positive and converging type of lens system of an illuminated object. Specimen is placed just outside the equivalent front focus point of objective. A primary real image of grater dimension than those of object field will be formed at some distance beyond the real lens element. Objective size of primary image w.r.t. object field will depend on focal length of objective and front focus point of objective. By appropriately positioning primary image w.r.t. a second optical system, primary image be further enlarged by an amount related, to magnifying power of eyepiece. As separation between objective and eye piece is fixed at same distance equivalent to mechanical tube length of microscope, primary image may be properly positioned w.r.t eye piece. By merely focusing microscope i.e. increase or decrease or the distance between object plane and front lens of objective the image is formed by objective in conjunction with field of eyepiece and microscope is so focused that primary image is located at focal point. Such precise positioning of primary image is essential in order that final image can be formed and rendered visible to observe when looking into eyepiece. If now entrance pupil of eye is made to coincide with exit pupil eyepiece. Eyepiece lens in conjunction with cornea lens will form a second real image on retina. This retrieval image will be erect, un reversed owing to the manner of response of human brain to excitation of retina. The image since it has no real existence, known as virtual image and appears to be inverted and reversed with respect to object field.

i. a) MAGNIFICATION:

The total magnification is the power of objective multiplied by power of eyepiece

$$\frac{\text{(Power of eye piece) (distance from eye piece to object)}}{\text{Focal length of object}}$$

The magnification is marked on the side objective

b) construction:

The micro scope consists of a body tube (refer fig 1.1), which carries an objective below, and an eyepiece above with plane glass vertical illuminator above the objective. Incident light from a source strikes illuminator at 45^0, part of which is reflected on to the specimen, Rays after reflection pass through the eye again, working table is secured on heavy base. The microscope has compound slide to give longitudinal and lateral movements by accurate screws having scale and verniers. Vertical movement of specimen platform is made by a screw for proper focusing. For getting perfect focusing fine adjustment of focusing can be made use of.

Light Filters: These are used in metallurgical microscope and essentially of three types

c) Gelatin sheets connected between two planes
d) Solid glass filters
e) Liquid dye solution

Solid glass filters are more preferable as they are more durable. Usually light filters are used principally to render a quality of illumination. Hence filters improve degree of resolution.
A METZ-57 model microscope is used in the laboratory.

Optical compilation

Eye pieces and objectives of different magnifications are available. Huygens eyepieces: 5x, 10x Achromatic objectives 5x, 10x, 45x.

PRECAUTIONS:

a. Ensure mirror polished surface of specimen before etching.
b. Fine focusing should be done only after correct focusing has been done.
c. The glass lens should not be touched with fingers.

REVIEW QUESTIONS:

i. What is the use of micro structural study?
ii. What is the difference among 1/0, 2/0, 3/0 and 4/0 emery papers?
iii. What is lapping?
iv. Why the specimen has to be etched before in lapping?
v. What are the different abrasives used in lapping?
vi. Why the specimen has to be etched before micro structural study?
vii. What is the etchant used for mild steel?
viii. In a microstructure how the grain boundary area appears?
ix. Why specimen is to be rotated through 90(between. Polishing on 1/0 and 2/0 emery papers?
x. What is etching reagent used for duralumin?
xi. Why should a specimen be prepared following the set procedure before its observation under a microscope?
xii. Is the specimen preparation necessary at all? If not why not?
xiii. What is the difference between Metallurgical microscope and Biological microscope?
xiv. What is the magnification of the microscope?
xv. What are the different magnifications available in the microscope of our laboratory?
xvi. What are the precautions to be observed while studying microstructure under microscope?

.

Exercise-2

To the study of Microstructure of Low, Medium & High carbon steels.

1. **AIM:** To identity the different phases and to draw the microstructures of Plain Carbon Steels.
2. **APPARATUS AND SPECIMENS**:
   Metallurgical Microscope, specimens of Plain carbon steel of different composition (untreated)
3. **THEORY**

Alloy:

Combination of two or more metals is called alloy. The substances that make the alloy are called its components. The metals are mixed together in required proportion when they are in molten form and then they are allowed to solidity together. After solidification the components of alloy may be in the form of solid solution, chemical compound, mechanical mixture.

If the constituents of the alloy completely soluble in both liquid and solid state a solid solution is formed. If constituents of the alloy are completely soluble in liquid state and completely insoluble in solid state a mechanical mixture is formed.

Phases

A homogeneous, Physically distinct and Mechanically separable part of the system under study is known as phase.

Cooling Curve:

For a molten metal that is cooled from state to room temperature the graph drawn between time on x-axis and temperature on Y-axis is known as cooling curve. A pure metal solidifies at constant temperature.

3.2a. Cooling Curve of Pure metal:

Cooling Curve of pure metal is show in fig.2.1. at 'A' metal is in liquid state. As metal is cooled the solidification starts at "B". As metal is further the temperature of metal remains constant but metal is converted from liquid state to solid state. Solidification is completed at point 'C'. From 'C' to 'D' there is no change in the solidified metal(except fall in temperature).

3.2b. Cooling curve of a solid solution:

If the components of the alloy are completely soluble in both liquid and solid state a solid solution is formed. Cooling curve of solid solution is shown in fig 'A' to 'B' the alloy is in liquid state. Solidification starts at 'B' and solidification ends at 'C'. From 'C' to 'D' there is no change in solid state of alloy. From 3.2 it can be observed that a solid solution alloy is solidified over a range of temperature.

c. Cooling curve of an eutectic alloy:

Cooling curve of a binary eutectic alloy is shown in fig.2.3. from 'A' to 'B' the alloy is in liquid state. As alloy is further cooled from 'B' the temperature of alloy remains constant, and two solids S_1, S_2 start separating out from the liquid separately. The alloy gets completely solidified at ‘C’ and gives a mixture of S1 and S2 (eutectic mixture). From ‘C’ to ‘D’ there is no change in the solidified alloy.

Cooling curve of pure Iron

Cooling curve of pure Iron is shown in fig.2.4 Depending on the temperature Iron exists in separate crystalline forms (α, γ, and δ). Above1539^{0}C Iron is in further cooled to 1400^{0}C Iron is in the form of δ – Iron and at1400^{0}c ALL δ-Iron is converted to γ-Iron. As the iron is still cooled from 1400^{0}C to 910^{0}C Iron is in the form of γ-Iron and at 910^{0}C all γ –Iron is converted to nonmagnetic α-Iron. If the further cooled from 910 at 7680C non magnetic α – Iron is converted to Magnetic α –Iron. If the Iron is further cooled to room temperature Iron exists as magnetic α - Iron only.

4Iron-Iron Carbide equilibrium diagram:

Iron-Iron Carbide equilibrium diagram is shown in fig.2.5

Iron carbon alloys contain less than 2% carbon are called steels and Iron carbon alloy that contains >2 % Carbon alloys cast irons. Steels having <0.8% Carbon, 0.8% carbon and >0.8 carbon are called Hypo eutectoid steels, eutectoid steels and Hyper eutectoid steels respectively.

Curie temperature (768^{0}C):

At curie temperature on cooling Non- magnetic α-iron becomes magnetic.

ABCD is the liquids line and AHJECF the solidus line of the system.(i.e. the alloy will be completely in liquid state at all temperatures above liquids line and will be under solid state at all temperatures below solidus line).

Critical points:

The temperature at which the transformation in solid state occurs are called critical points. In hypo eutectoid steels GS (A3 line) represents upper and lower critical points. In hyper eutectoid steels the line SE(Acm) and SK(A13) and SK(A13) represents upper and lower critical temperatures respectively.

Different phases that appear in Fe-Fe3C diagram:

a. Ferrite(α): It is an interstitial solid solution of carbon in α-iron, maximum solubility of carbon in α-iron is 0.025% at 723^{0}C

b. Austenite (γ): It is an interstitial solid solution of carbon in γ -iron, maximum solubility of carbon in γ -iron is 0.2% at1130^{0}C

c. Cementite(Fe3C): It is a chemical compound of Iron and carbon that contains 6.67%carbon by weight.

d. Pearlite: The eutectoid mixture of Ferrite and cementite is called Pearlite.

e. Ledeburite: The eutectic mixture of austenite and cementite is called Lideburite

the three horizontal lines in the diagram (HJB,ECF and PSK) indicate three isothermal reactions at fixed composition and temperature.

Slow Cooling of Hypo Eutectoid steel(0.18% Carbon):

In fig 2.5 alloy 1 represents 0.18% carbon steel. Initially at X, the alloy is in completely liquid state as shown in fig 3.0a. As it is cooled when it crosses 'AB' line δ-iron neucli start forming in liquid Iron. The Micro structure of the alloy at X2 is shown in fig 2.6b. as alloy is further cooled When it crosses' BJ line at J liquid Iron and δ-Iron are combined together at constant temperature to form δ-iron. This reaction is known as peritectic reaction.

$$\underset{\text{(Liquid)}}{L} + \underset{\text{(δ-Iron)}}{\delta} \xrightarrow{\text{Cooling}} \underset{\text{(Austenite)}}{\gamma}$$

If the alloy is further cooled at X3 the microstructure of the alloy consists of homogeneous solid solution of - γ Iron as shown in fig.2.6c.
Upon slow cooling of alloy from X3 nothing happens until 'A3' line is crossed. As alloy is cooled below' A3' line ferrite begins to form at austenite grain boundaries. The micro structure of alloy at X4 is shown if fig. 2.6d. As cooling progresses amount of ferrite increases and remaining and remaining austenite becomes richer in Carbon

On further cooling of alloy from X4 it crosses A1 line(lower critical temperature line)at X6. The microstructure of alloy 1 at X5(just above A1 line) is shown in fig 2.6e. the microstructure shows austenite (around 22%) and proeutectoid ferrite (77%).

At X6 the Austenite gets converted into ferrite and cementite(a Mechanical mixture) at constant temperature. This is known as eutectoid reaction.

$$\text{Austenite} \xrightarrow{\delta\ \text{Cooling}} \text{(Ferrite + Cementite) (pearlite)}$$

The eutectoid mixture of ferrite and cementite is known as pearlite. At temperature just below X6 the micro structure shows pearlite and proeutectoid ferrite as shown in fig.2.6f.

On further cooling of the alloy to room temperature no more phase changes are observed. Hence at room temperature micro structure shows pearlite and proeutectoid ferrite.

Cooling of Eutectoid steel(0.8% Carbon):

In fig 2.5 alloy 2 represents 0.8% Carbon steel. Initially at X1 the alloy is completely in liquid state as shown on in fig.2.7a. On slow cooling once it crosses 'BC' line (liquids line) - γ-iron dendrites start forming in the liquid Iron. At X2 alloy consists of uniform solid solution of γ-iron as shown in fig.2.7c. On further cooling cooling of alloy from X3 no change is observed unit it crosses 'PSK' line (lower critical temperature (7230C) and gets converted into pearlite (mechanical mixture of ferrite and cementite).

Just below the eutectoid temperature ('PSK') at X4 the alloy consists of 100% pearlite as shown in fig. 2.7d. There is no change in microstructure on cooling of the alloy from X4, to room temperature.

Cooling of Hyper eutectoid steel (1% Carbon):

In fig 2.5 alloy 3 represents 1% carbon steel, initially at X1 the alloy is completely in liquid state as shown in fig.2.8a. on a slow cooling from observed till 'BC' line (liquid line) is crossed. Once 'BC' line is crossed on further cooling of alloy to X2 austenite crystals start neucleating from liquid iron as shown in fig.2.8b. as cooling is continued more and more amount of austenite is formed. By the time it crosses the line 'JE' all liquid iron is converted to austenite. At X3 the alloy consists of uniform solid solution of austenite as shown in fig.2.8c. On show cooling of alloy from X3 nothing happens until 'Acm' line is crossed at X4. Above X4 austenite is an unsaturated solid solution. At X4 austenite is saturated with carbon. As the temperature is decreased, carbon content of austenite (maximum amount of carbon that be disolved in austenite) decreases along grain boundaries. The micro structure of alloy at X5 in shown in fig.2.8d. On further cooling of alloy, once temperature of alloy crosses lower critical temperature line ('PSK' line) at X7 the austenite present in the alloy undergoes eutectiod reaction and gets converted into pearlite. Just below A3.1, line ('SK' line) at microstructure of alloy shows around 96% pearlite and continuous network of cementite (around 4%) as shown fig 2.8e.

Plain Carbon Steels:

The usual composition of plan carbon steel is as follows

Carbon 0.08 to 1.7%; Mn 0.3 to 1.0%; silicon 0.05 to 0.3%; Sulphur 0.05(max); Phosphorus %(max)

In plain carbon steels, carbon percentage plays a vital role in deciding the properties of steels. Depending on the carbon percentage plain carbon steels are divided into three types.

ow carbon steel(Mild steel) b. Medium carbon steel c. High Carbon steel

The microstructure of low carbon steel (Mild Steel) consists of single phase ferrite, (equi axial grains) i.e., it doesn't respond much to the heat treatment. The properties don't vary to any treatment given to the mild steel. It remains mild.

The following specimens are to be studied for their Microstructures in this exercise

a. Mild Steel

Specimen : Mild Steel

Composition : Very low carbon(0.05%), remaining iron

Heat treatment : Nil

Etchant : Nital

Etching time : 10 seconds

The structure is single phase equiaxed grains of ferrite.

Application: nuts, bolts, rivets, shafts etc.

b. Hypo eutectoid steel:

Specimen	:	Hypo eutectoid steel
Composition	:	0.5% carbon, remaining iron
Heat treatment	:	Nil
Etchant	:	Nital
Etching time	:	10 Seconds

The microstructure shows ferrite and pearlite.

c. Eutectoid steel:

Specimen	:	Eutectoid steel
Composition	:	0.8% carbon, remaining iron
Heat treatment	:	Nil
Etchant	:	Natal
Etching time	:	10 Seconds

The microstructure of eutectoid steel consists of 100% pearlite

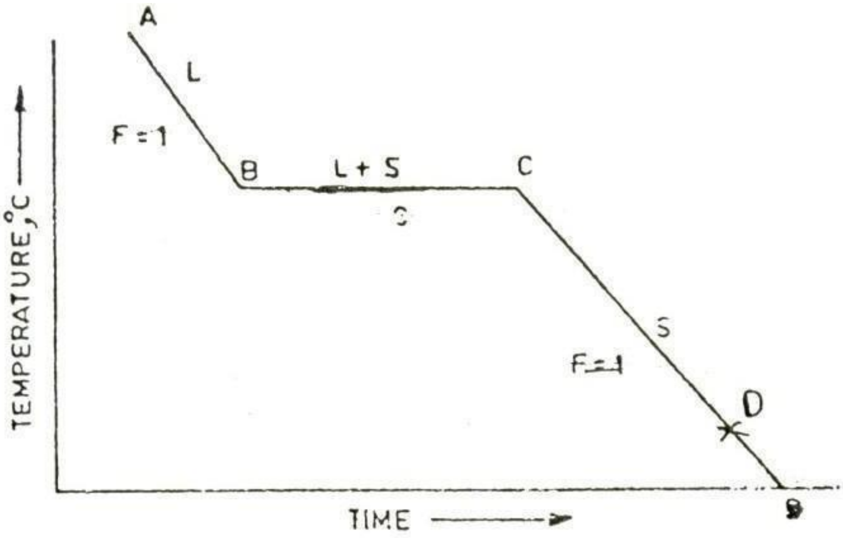
d. Hyper eutectoid steel

Specimen	:	Hyper eutectoid steel(High carbon steel)
Composition	:	1% carbon, remaining iron
Heat treatment	:	Nil
Etchant	:	Natal
Etching time	:	10 Seconds

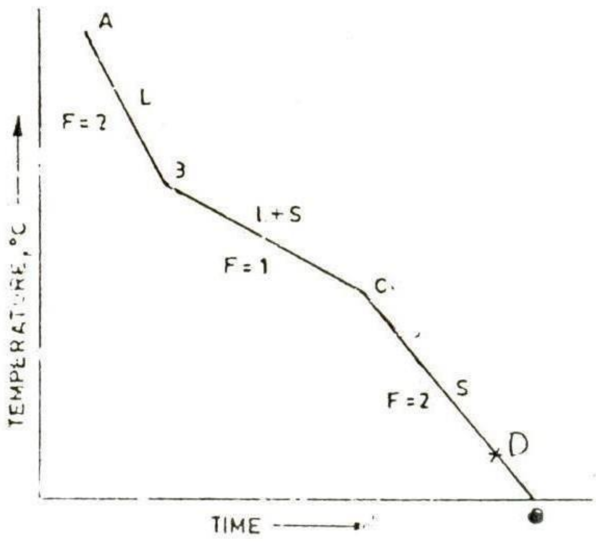
The microstructure shows continuous network of cementite along the grain boundaries of coarse pearlite.

5. REVIEW QUESTIONS:

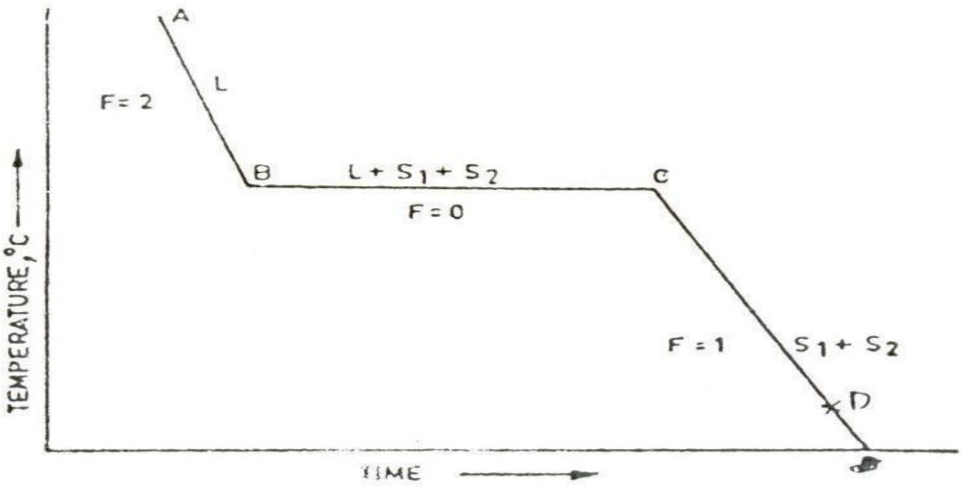
I. What is a cooling curve?
II. What is the use of equilibrium diagram?
III. What is curie temperature?
IV. What is the percentage of carbon in cementite?
V. What are the different phases in Fe-Fe3C equilibrium diagram?
VI. How Cast iron and steel are distinguished with respect to carbon percentage?
VII. What is eutectoid reaction?
VIII. What is peritectic reaction?
IX. Draw the microstructure of eutectoid steel?
X. Draw the microstructure of Hypo eutectoid steel?
XI. Draw the microstructure of Hyper eutectoid steel?
XII. What is the maximum solubility of carbon in ferrite?
XIII. What is the maximum solubility of carbon in Austenite?
XIV. What are the properties & applications of mild Steel?
XV. What are the properties & applications of medium carbon steel(hypo eutectoid steel)?
XVI. What is curie temperature?
XVII. What is the percentage of carbon in cementite?



Cooling curve of a pure metal.



Cooling curve of a solid solution alloy.



Cooling curve of an eutectic alloy.

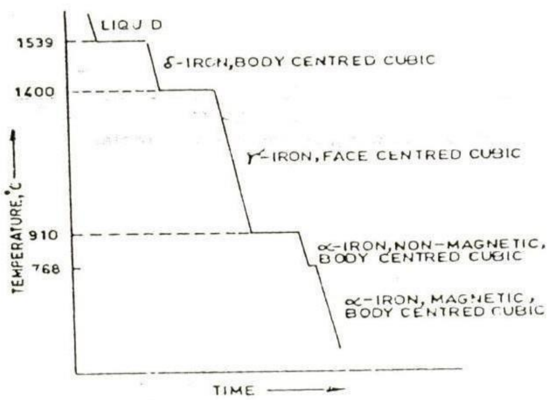


Fig. 2.4 Cooling curve of pure iron

Cooling curve of pure Iron

.

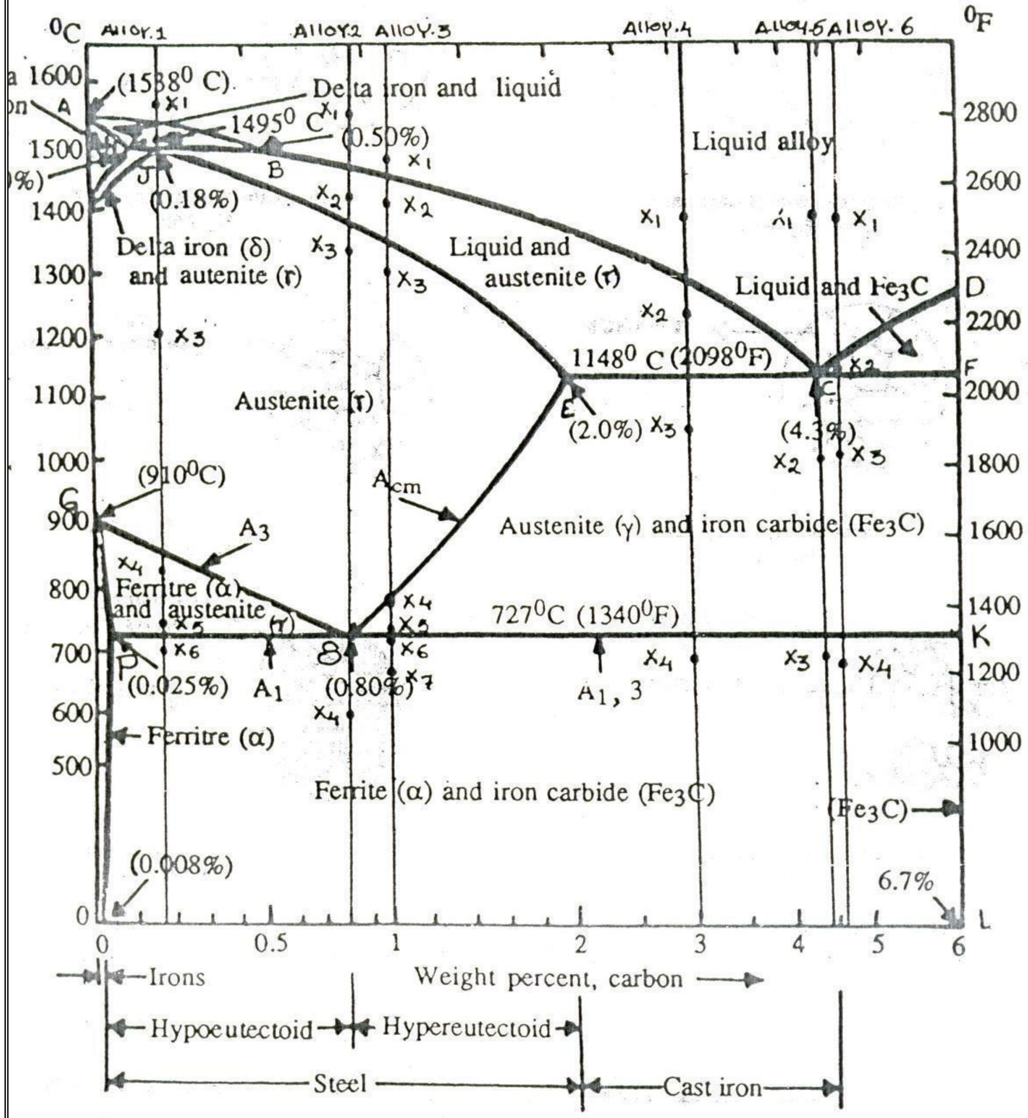


Fig. 2.5 Iron - Iron carbide equilibrium diagram.

Iron-Iron carbide equilibrium diagram

Exercise-3

To the study of Microstructure Cast Irons (Grey cast Iron & White cast Iron).

1. **AIM:**

   To Identify the different phases and to draw the microstructures of different cast Irons.

2. **APPARATUS AND SPECIMENS REQUIRED:**

   Metallurgical microscope, specimen of different cast irons

3. **THEORY**

   Cast irons are Iron carbon alloys in which carbon content varies from 2 to 6.67%. cast- iron that contain carbon percentage between 2 to 4.3% are called Hypo eutectic cast irons. If carbon content of cast-iron is 4.3% it is called Eutectic cast iron. If the carbon content is above 4.3% it is called Hyper eutectic cast iron.

Cooling of a Hypo eutectic cast iron (3% carbon):

Alloy in fig.2.5(Iron-Iron carbide equilibrium diagram) represents Hypo eutectic cast iron with 3% carbon. Initially at point X1, the alloy is in completely liquid state as shown in fig.5.1a. as it is slowly cooled no change is observed until it crosses 'BC' line (liquid line). After crossing 'BC' line austenite dendrites start forming from liquid iron. At X2 the microstructure of alloy shows dendrites of protectoid austenite in liquid iron as showing in fig.5.1b. on further cooling of alloy when it crosses 'ECF' line(eutectic temperature line) liquid of alloy undergoes eutectic reaction at constant temperature (1130^{0}C) and transforms into lideburite (eutectic mixture of austenite and cementite)

The microstructure of alloy at X3 consists of dendrites of primary austenite, eutectic austenite and cementite as shown in fig.5.1c. on further cooling of alloy there is no considerable change in microstructure except increase of cementite (This cementite is separated from austenite because of decrease of solubility of carbon n austenite as temperature is reduces).

On further cooling of alloy when 'PSK' line (eutectoid temperature line) is crossed the austenite (primary as well as eutectic) undergoes eutectoid reaction at constant temperature (723^{0}C) and is converted to pearlite. At X4 the microstructure of alloy consists of dendritic areas of transformed austenite (i.e. pearlite) in the matrix of transformed lideburite (pearlite + cemetite).

Cooling of Eutectic cast iron (4.3% carbon):

Alloy 5 in fig.2.5 represents eutectic cast iron with 4.3 % carbon. Initially at X1 the alloy is completely in liquid state as shown in fig.5.2a. on further cooling of the alloy no change is observed until it crosses 'ECF' (eutectic temperature line) at C. At 'C' liquid iron undergoes eutectic reaction at constant temperature (113^{0}C) and transforms into lideburite. At X2 the alloy consists of completely lideburite (Austenite + Cementite) as shown in fig. 5.2b. On further cooling of alloy no change is observed till it crosses 'PSK' line. When alloy crosses eutectoid temperature line('PSK') eutectic austenite undergoes eutectic reaction at 723^{0}C and transforms into pearlite. The microstructure of alloy at X3(Just below 'PSK' line) consists of transformed austenite (pearlite and cementite as shown in fig.5.2c. On further cooling of alloy to room temperature there is no change in the microstructure.

Cooling of hyper eutectic cast Iron(4.5% Carbon)

Alloy 6 in fig.2.5 represents Hyper eutectic cast-iron with 4.5% carbon. Initially at X1 the alloy consists of only liquid iron as shown in fig.5.3(a). On cooling of alloy no change is observed till it crosses 'CD' line. After crossing 'CD' line cementite starts nucleating from liquid iron. The microstructure of alloy at X2 consists of proeutectic cementite dendrites in liquid iron shown in.

.3b. on further cooling of alloy no change is observed till it crosses 'ECF' line (eutectic temperature line). When 'ECF' line is crossed liquid of the alloy undergoes eutectic reaction at constant temperature (1130^{0}C) and is transformed into lideburite (eutectic mixture of austenite and cementite). The microstructure of alloy at X3(just below 'ECF' line) consists of eutectic austenite, cementite and proeutectic cementite as shown in fig.5.3c. On further cooling of alloy no change is observed till it crosses 'PSK' line (eutectic temperature line). When it crosses 'PSK' line the austenite of alloy undergoes eutectoid reaction at constant temperature(723^{0}C) and transforms into pearlite. At X4(just below 'PSK' line) the microstructure consists of cementite and pearlite as shown in fig.5.3d. the alloy is further cooled to room temperature there is no change in the microstructure.

The useful properties of cast iron are

i) Good fluidity (ability to fill narrow cavities in casting in liquid steel ii) Low melting point iii) Good machinability iv) Less dimensional changes during solidification.

Cast irons are brittle and have low tensile strength than most of the steels. Specially in the case of Grey cast iron, the graphite present will act line cracks and reduce tensile strength, toughness etc.,

a Types of cast irons:

Depending on the form of carbon, cast irons are divided into

a) White cast iron b) Gray cast iron c) Malleable cast iron d) Spheroidal cast iron e) Chilled cast iron

3.5a White cast iron:

In white cast iron most of the carbon is present in combined form as cementite. This is obtained by rapidly cooling the cast iron from its molten state. These are hard and wear resistant. These are used only for hard and wear resistance applications and also used as raw material to produce malleable iron. At room temperature microstructure of Hypo eutectic C.I consists of dendritic areas of transformed austenite in a matrix of transformed lideburite. At room temperature microstructure of eutectic cast iron consists of cementite and pearlite. At room temperature microstructure Hyper eutectic C.I consists of dendrites of primary cementite in the matrix of transformed lederburite.

b Grey cast iron:

In Grey cast iron carbon in present as free graphite flakes. They contain more carbon and silicon content than white cast irons. It is a low melting alloy having good cast ability and good damping capacity. The tendency of carbon to form graphite flakes is due to increase in carbon and silicon content and decreasing cooling rate. Grey cast iron receive its name from the color of a freshly made fracture. At room temperature the microstructure of Grey cast iron consists of graphite flakes and pearlite.

Malleable cast iron:

Malleable cast iron is produced by heating white cast iron to 90 to 1000^{0}C for about 50 hours followed by slow cooling to room temperature. On heating white cast iron, cementite structure tend to decompose into ferrite and tempered carbon. The lubrication action of graphite imparts high machineability to malleable cast iron. Malleable castings are tough, strong and shock resistant. These are used for wide range of applications such as automobile parts, railroad equipment, manhole covers etc., At room temperature the microstructure of Malleable cast iron consists of rosettes of tempered carbon graphite in the matrix of pearlite.

Spheroidal graphite cast iron (Nodular cast iron or Ductile cast iron):

Spheroidal graphite cast iron is an iron carbon alloy having a structure composed of nodules (spheroids) of graphite formed directly during the process of solidification and embedded in matrix of steel. The formation of spherical graphite is due to addition of Magnesium for hypo eutectic cast iron and cerium for hyper eutectic cast iron. This is used for hydraulic cylinder, valves cylinder heads for compressor and diesel engine etc., Due to spheroidization tensile strength, ductility and toughness are improved. This cast iron combines the advantages of cast iron and steel. The graphite in spherical shape reduces stress concentration effect and hence higher strength and toughness results.

e Chilled cast iron:

Chilled cast iron is produced by adjusting the composition of white cast iron and then cooling it rapidly to room temperature. Rapid cooling promotes hard, thin layer on the surface of a soft iron casting. It is used where surface hardness is important. It finds applications in making dies and rolls for crushing.

The Micro structures of following cast irons are studied in this exercise

4.a Grey cast iron:

Specimen : Grey cast iron

Composition : 3.5% carbon 2%silicon 0.5% manganese 0.4% phosphorous 0.09% Sulphur

Heat treatment : Nil

Etchant : Nital

Etching time : 20 seconds

The micro structure shows uniformly distributed and randomly oriented graphite flakes in the matrix of ferrite and pearlite.

Applications: These are widely used for machine bases, engine frames, cylinders and pistons of

·

I.C engines etc.,

A. White cast Iron:

Specimen : White cast iron

Composition : 4% carbon 0.5% silicon 0.4% manganese 0.05% phosphorous0.3% sulphur

Heat treatment : Nil

Etchant : Nital

Etching time : 20 seconds

The micro structure shows dendrites of transformed austenite(pearlite) in the matrix of transformed Ledeberite(i.e. pearlite and cementite). Majority of these cast irons are Hypo eutectic cast irons.

Applications: Used for wearing plates, pump liners, dies, etc., and also for production of Malleable castings.

B. Malleable cast iron:

Specimen : Malleable

Composition : 4%carbon 0.5% silicon 0.4% manganese 0.1% phosphorus 0.1% sulphur

Heat treatment : Nil

Etchant : Nital

Etching time : 20 seconds

The micro structure shows irregular nodules of tempered carbon (graphite) in the matrix of white ferrite phase, (if cooling rate is low) or pearlite phase (if cooling rate is high).

Applications: Cam shafts, crank shafts, Axles, etc.,

d. Spheroidal graphite cast iron (Nodular cast iron or Ductile cast iron):

Specimen : Ductile cast iron/Nodular/Spheroidal cast iron

Composition : 3.3% carbon, 2.4 silicon 0.05% manganese, small amount of Mn, Phosphorous & sulphur

Heat treatment : Nil

Etchant : Nital

Etching Time : 20 Seconds

Time micro structure shows a typical structure. It contains nodules (spheroids) of graphite surrounded by ferrite in the matrix of pearlite.
Applications: Used for gears, punches, dies, metal working rolls, furnace doors, etc.,

4. REVIEW QUESTIONS:

i. What are the different types of cast irons?
ii. What is the difference between white cast cast iron and Grey cast iron?
iii. What are the important properties of Grey cast iron?
iv. Why white cast iron has limited applications?
v. What is the structure of Malleable cast irons? Explain the heat treatment cycles used for black heart and white heart malleable iron?
vi. What is the additional metal added for spherodisation for Hypo and Hyper eutectic cast irons? How they act?
vii. What is chilled cat iron?
viii. What is the difference between Ferrite malleable, pearlitic malleable and Pearlitic-ferrite malleable cast irons?
ix. Why Gray cast irons has got that name?
x. Why Gray cast iron is o brittle?
xi. Explain important properties of different types of cast irons?

Exercise-4

To the study of Microstructure Non – Ferrous pure metals.(Copper & Aluminum).

1. AIM: To determine the present and to draw the microstructures of copper, Aluminum & Magnesium.

2. APPARATUS AND SPECIMENS REQUIRED:
Metallurgical microscope, specimens of Aluminum, copper and Magnesium.

3. THEORY:

3. INTRODUCTION TO NON METALS

Non ferrous metals don't contain as base. A wide range of Non metals are employed for various engineering applications. Most Non ferrous metals posses good corrosion resistance, formability, castablity and special electrical and magnetic properties. Important Non –ferrous metals their melting points and crystal structures are tabulated here under.

S. No.	Name of the Metal	Melting Temp. (®C)	Crystal Structure
4.	Aluminum(Al)	660	FCC
5.	Antimony(Sb)	630	Rhombohydral
6.	Bismuth(Bi)	271	Rhombohydral
7.	Cadmium(Cd)	321	CPH
8.	Chromium(Cr)	1900	BCC
9.	Copper(Cr)	1083	FCC
10.	Gold(Au)	1064	FCC
11.	Lead(Po)	327	FCC
12.	Magnesium(Mg)	650	CPH
13.	Manganese(Mn)	1250	Complex cube
14.	Nickle(Ni)	1453	FCC
15.	Silver(Ag)	961	FCC
16.	Tin(Sn)	232	BCT
17.	Zinc(Zn)	419	CPH

18. The microstructures of following specimens are in this experiment

a. Copper:

Specimen : Pure Copper
Heat treatment : Nil
Etchant : Ferric chloride solution
Etching time : 100 seconds
The micro structure shows equi axed grains of copper

b. Aluminium:

Specimen	:	Pure Aluminum
Heat treatment	:	Nil
Etchant	:	Ferric chloride solution
Etching time	:	60 seconds

The microstructure shows grains of Aluminum

c. Magnesium

specimen	:	Pure Aluminum Heat treatment	:	Nil
Etchant	:	Ferric chloride solution		
Etching time	:	60 seconds		

The microprocessor shows grains ofmagnesium.

REVIEW QUESTIONS :

i. What are the important properties of Non-Ferrous metals and alloys?

ii. List out some important Non-Ferrous metals?

iii. What is melting point temperature of Aluminum?

iv. What is the crystal structure of Magnesium?

v. FCC metals are usually ductile and have high strain hardening tendency. Explainwhy?

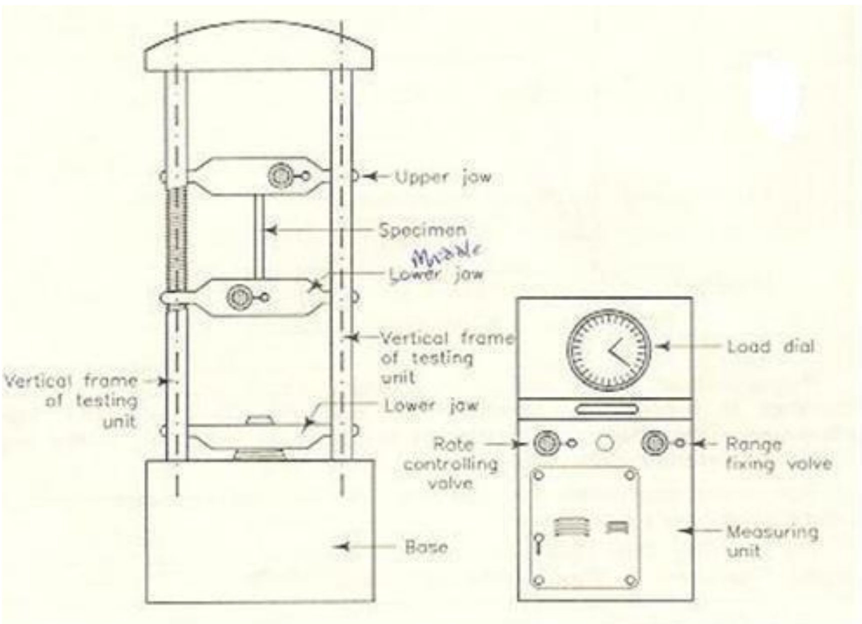
.

Exercise-5

Study of the Composite Material with the help of UTM.

1. **AIM:** To Study of the Composite Material with the help of UTM.
2. **Objective:** To conduct a tensile test on a composite material specimen and determine the following: (i) Limit of proportionality (ii) Elastic limit (iii) Yield strength (iv) Ultimate strength (v) Young's modulus of elasticity (vi) Percentage elongation (vii) Percentage reduction in area.
3. **Apparatus:** (i) Universal Testing Machine (UTM) (ii) Mild steel specimens (iii) Graph paper (iv) Scale (v) Vernier Caliper, (vi) composite material of aluminium and polyethylene material.
4. **Theory:**

Automotive industry is on the verge of development. More and more comforts are being incorporated in a vehicle. On other hand customers have stringent demand of fuel economy, high performance at low cost. In order to have high fuel economy the auto-motive manufacturers are induced to reduce weight. In this research work flat plate is selected as a target weight reduction composite material. This can be achieved either using high strength low weight material or by using low weight composite sandwich panel. Aluminium composite (Aluminium skin, polyethylene core, resin binder material) material being light and strong, it is selected as an alternative material by considering peer reviewed papers and industrial guidance. By using this flat plate sandwich panel, tensile strength, bending strength, flexural limit have been carried out for optimization of composite material for sandwich panel construction. Tensile test, bending test is tested on Universal Testing Machine (UTM). One can use composite material to optimize mass and cost of various automobile, marine, aerospace and various structures.



Universal Testing Machine

5. **About of utm & its specifications:**

The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment. The pipes connecting the lift

.

and right parts are oil pipes through which the pumped oil under pressure flows on left parts to more the cross-heads.

6. Specifications:

1. Load capacity = 0-40 Tones.
2. Least count = 8 kgf.
3. Overall dimn. =
4. Power supply = 440 V

6. Procedure:

1. Measure the original length and diameter of the specimen.
2. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
3. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
4. Begin the load application and record load versus elongation data.
5. Take readings more frequently as yield point is approached.
6. Measure elongation values with the help of dividers and a ruler.
7. Continue the test till Fracture occurs.
8. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

7. Observation:

(a) Initial diameter of specimen d1 =
(b) Initial gauge length of specimen L1 =
(c) Initial cross-section area of specimen A1 =
(d) Load of yield point Ft. =
(e) Ultimate load after specimen breaking F =
(f) Final length after specimen breaking L2 =
(g) Diameter of specimen at breaking place d2 =
(h) Cross section area at breaking place A2 =

8. Observation table:

S.No	Load (N)	Original Gauge Length	Extension (mm)	Stress = (N/mm2)	Strain
1					
2					
3					
4					
5					

9. Result:

(i) Ultimate tensile strength =_______________N/mm2

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
III Year B. Tech ANE - I SEM

AIRCRAFT MATERIALS AND METROLOGY LAB

PART-B METROLOGY

1. Measurement of lengths, heights, diameters by Vernier calipers micrometers etc.
2. Measurement of bores by internal micrometers and dial bore indicators.
3. Use of gear teeth, Vernier calipers and checking the Chordal Addendum and Chordal Height of spur gear.
4. Angle and taper measurements by Bevel protractor, Sine bars, etc.
5. Thread measurement by Two wire/ Three wire method or Tool makers microscope.

OUT COMES:

- Various job Operation on machine tools.
- To know about various grinding and shaping machines.
- Exposure to various measuring systems.

EXP. 1:

MEASUREMENT OF LENGTHS, HEIGHTS, DIAMETERS BY VERNIER CALIPERS MICROMETERS ETC.

AIM: 1. To measure the height of the object using vernier height gauge.

2. To measure the depth of the object using Depth gauge.
3. To measure the diameter of the object using Vernier calipers.

INSTRUMENTS USED:

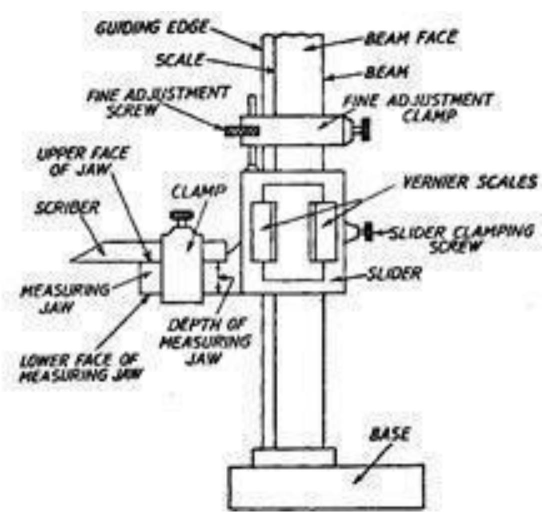
1. Surface Plate 2. Vernier height gauge 3. Specimens 4. Depth Gauge

THEORY: VERNIER HEIGHT GAUGE:

Vernier height gauge is a sort of Vernier calipers equipped with a special with a base and other attachment, which make the instrument suitable for height measurement. Along with the sliding jaw assembly arrangement is provided to carry a removable clamp.

The upper and lower surfaces of the measuring jaws are parallel to the base, so that it can be used for measurements over or undersurfaces.

The vernier height gauge is mainly used in the inspection of parts and layout work. The vernier height gauge can be used to scribe lines at a certain distance above the surface with a scribing attachment in place of measuring jaw. Dial indicators can also be attached in the clamp and many exact measurements can be made as it exactly gives the indication when the dial tip is touching the surface. Surface plates as datum surface are used for the above measurements.



PROCEDURE:

1. Place the object and the vernier height gauge on the surface plate.
2. Note the value on the scale when the moving jaw is touching the bottom of the object.
3. Take the moving /sliding jaw to the top of the object and note down the valueon the scale.
4. The difference between 3&2 will give the height of the object.

VERNIER DEPTH GAUGE:

Vernier Depth Gauge is used to measure the depth of holes, slots and recesses, to locate center distances etc. It consists of

1. A sliding head having flat and true base free from curves waviness.
2. A graduated beam known as main scale. The sliding head slides over the graduated beam.
3. An auxiliary head with a fine adjustment and a clamping screw.
4. A beam is perpendicular to the base in both direction and its ends square and flat. The end of the sliding head can be set at any point with fine adjustment locked and read from the Vernier provided on it.

PROCEDURE:

1. Held the base on the reference surface.
2. Lower the beam into the hole until it contacts the bottom surface of the hole.
3. Make final adjustment with fine adjustment screw.
4. Tighten the clamping screw and remove the instrument from the hole and take the reading in the same way as vernier.
5. Least count=------------- mm.

S.NO.	Main scale reading MSR(mm)	Vernier Scale Reading VSR(mm)	Measured reading = mm MSR+ (VSR*L.C)

PRECAUTIONS:

1. The height gauges should be kept in their case when not in use.
2. Measuring jaws should be handled carefully.
3. While using the Dept gauge, it should be ensured that the reference surface, on which the depth gauge is rested, is satisfactorily true, flat and square.

RESULT:

- The heights of the given objects measured by vernier height gauge are tabulated above.
- The depth of the holes measured by Vernier depth gauge is tabulated above.

ADVANTAGES :

- Height gauges may also be used to measure the height of an object by using the underside of the scriber as the datum.
- The datum may be permanently fixed or the height gauge may have provision to adjust the scale, this is done by sliding the scale vertically along the body of the height gauge by turning a fine feed screw at the top of the gauge; then with the scriber set to the same level as the base, the scale can be matched to it.
- This adjustment allows different scribers or probes to be used, as well as adjusting for any errors in a damaged or resharpened probe.

APPLICATIONS:

- These are used to mark out lines and widely used on surface plates and on machine tables.
- The height gauge with an indicator attachment is used for checking for surface holes.
- The height is scribe attachment is used to mark reference lines and location on castings and forgings.
- Ideal for marking and measuring work for molds, jigs, and tooling.
- Sliding main carriage for fast, easy adjustment.
- Easy to read scale using 3x magnifying lens.
- Carbide tipped scribe.
- Made of stainless steel for rust protection.
- Dial Indicator mounting arm accepts φ6mm, φ8mm, and dovetail type indicators.

VIVA-VOICE QUESTIONS:

- What is the difference between vernier height gauge, vernier depth gauge, and vernier caliper?
- A height gauge is a measuring device used either for determining the height of objects, or for marking of items to be worked on.
- What is the purpose of vernier height gauge?
- What is the least count of vernier height gauge?
- What are the various types of linear measuring instrument?

EXP:2

MEASUREMENT OF BORES INTERANAL MICROMETERS AND DIAL BORE INDICATORS.

AIM:

The objective is to familiarize students with the use of vernier calipers, Micrometer screw gauges. The write –up for this experiment will be submitted at the end of the laboratory period. Drawings of the parts to be measured in the lab are available from the Teaching Assistant for the purposes of dimensioning. No aids other than calculators are allowed to be used.

THEORY:

Least Count – the smallest degree by which two measurements may be differentiated with a particular instrument; generally considered to be of the same order as the smallest division in the instruments ‘scale.

The Least Count is a measure of the accuracy of a measuring instrument.

VERNIER CALLIPERS:

A vernier caliper consists of a rule with a main engraved scale and a movable jaw with an engraved vernier scale. The main scale is calibrated in centimeters (cm) with a millimeter (mm) least count, and the movable vernier scale that divides the least count on the main scale in to 50 equal sub-divisions. The span of the upper jaw is used to measure the inside diameter of an object such as hollow cylinders or holes. The leftmost mark on the vernier scale is the zero mark, which is often unlabeled. The measurement is made by closing the jaws on the object to be measured and reading where the zero mark on the vernier scale falls on the main scale. The first two significant figures are read directly from the main scale. This is known as the main scale reading.

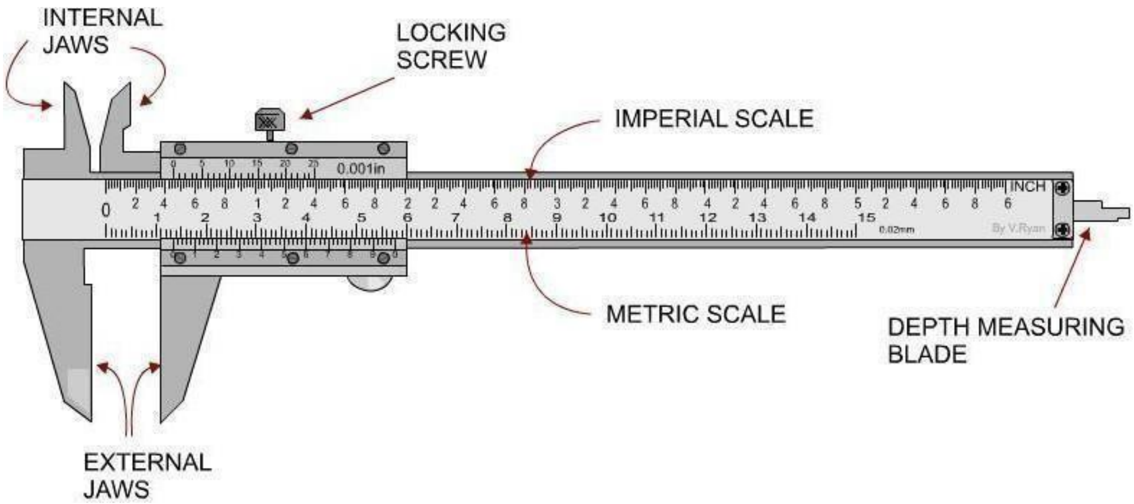
The next significant figure is the fractional part of the smallest subdivision on the main scale (in this case, mm). If a vernier mark coincides with a mark on the main scale, then the mark number is the fractional part of the main scale division. Before making a measurement, the zero of the vernier caliper should be checked with the jaws completely closed. It is possible that the caliper not being properly will produce systematic error. In this case, a zero correction must be made for each reading. The least of the vernier caliper is calculated by equation

A large range of measurements can be made using the one measuring device. Against The majority of vernier calipers do not provide sufficient accuracy for close tolerance measurements.

In the machining process, we use vernier calipers or a micrometer for taking measurements. General analog vernier calipers can measure with the minimum unit of 1/20 mm. Several types of digital vernier calipers can measure with the minimum unit of 1/100mm.

1) Least Count = $\frac{\text{Value of the smallest division on main scale}}{\text{Number of divisions on vernier scale}}$

2) Measurement = Main scale reading + conceding vernier scale division ×Least count



PROCEDURE:

Least Count:

Least count is the minimum distance which can be measured accurately by the Instrument. Least Count of Vernier Caliper is the difference between the value of main scale division and Vernier Scale Division.

Thus, Least Count = (Value of Smallest Division on Main Scale)- (Value of Smallest Division on Vernier Scale) = 1-49/50 = 0.02 mm. (or) Least Count = (Value of Minimum Division on the Main Scale)/ (Number of Division on Vernier Scale) = 1/50 = 0.02 mm

The given component is fixed between the jaws firmly, i.e., in between fixed jaw and movable jaw.

The reading is to be noted down. Procedure for taking the Reading:

1. After closing the jaws on the work surface, take the readings from the main as well as Vernier Scale. To obtain the reading, the number of divisions on the main scale is first read off.

The Vernier Scale is then examined to determine which of its division coincide or most coincident with a division on the main scale.

2. Before using the instrument should be checked by zero error. The zero line on Vernier Scale

should coincide with zero on the main scale.

3. Then take the reading in mm on main scale to the left of zero on sliding scale.
4. Now Count the no. of divisions on Vernier Scale from zero to a line which exactly Coincides with any line on the main scale.

Thus, total reading = [Main scale reading] + [No. of divisions with a division on Main Scale] X Least Count. (OR) TR = MSR + VC X LC

5. Take the reading for 4times.

OBSERVATIONS :

S. No	MSR	VSR	Total Reading= MSR+ (VSRXLC)

MICROMETER SCREW GAUGE:

THEORY:

A micrometer consists of a movable spindle (jaw) that advances toward another parallel-faced jaw, called an anvil, by rotating the thimble. The thimble rotates over an engraved sleeve or barrel that is mounted on a solid frame. Most micrometers are equipped with a ratchet, at the far right in figure 2, which allows slippage of the screw mechanism when a small constant force is exerted on the jaw. This permits the jaw to be tightened on an object with the same amount of force each time. The axial main scale on the sleeve is calibrated in mm and the thimble scale is the vernier scale and is usually divided into increments of 0.01mm.

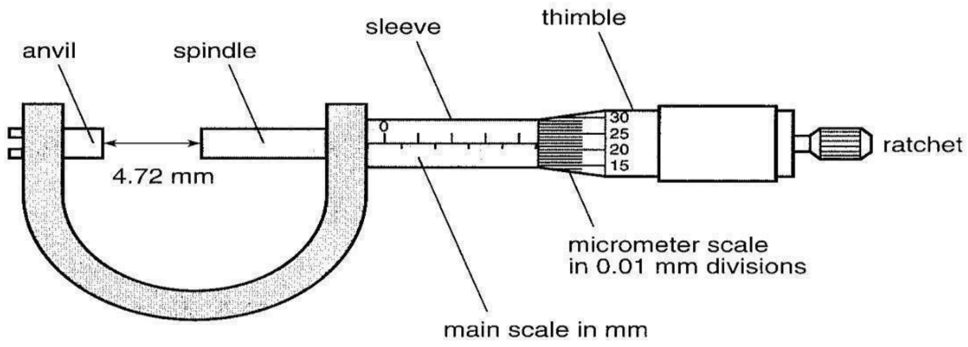
The pitch of a screw is the distance between two consecutive screw threads and is the lateral linear distance the screw moves when turned through one rotation. The axial line on the sleeve main scale serves as a reading line. If a micrometer does not have 0.5 mm divisions on the main scale, you must determine whether the thimble is in its first rotation or second. If it has 50 divisions on the thimble and completes 1 mm in two rotations, each division on the thimble gives 0.01mm.

Measurements are taken by noting the reading *x* on the main scale of the sleeve. Note the position of the edge of the thimble on the main scale and the position of the reading line on the thimble scale. Multiply this reading with 0.01 mm and add to x

3) Least Count = Pitch (Distance between two consecutive threads of screw) ÷ Number of divisions on thimble scale
4) Measurement = Main scale reading + coinciding thimble scale division ×Least count

How to Use a Micrometer

When close tolerances are required, measurements are taken with a micrometer due to its superior accuracy over a vernier caliper. The micrometer as can measure with the minimum unit of 1/1000mm.



PROCEDURE:

The work piece is held between the 2 anvils without undue pressure.

This is Accomplished by having a retched drive to turn the thimble when the anvils contact each other directly or indirectly through work piece placed in between the ratchet tips over the screw cap without moving the screw forwards and thus avoids undue pressure.

Least Count = Pitch of the screw/ No. of Divisions on Circular Scale. If Pitch of screw is mm and Circular Scale has 50 divisions on it, then Least Count = 0.5 / 50 ~ 0.01mm

In measuring, the dimension of work piece the main scale up to the leveled edge of thimble and no. of divisions of thimble scale to axial line on barrel are observed addition of two given result.

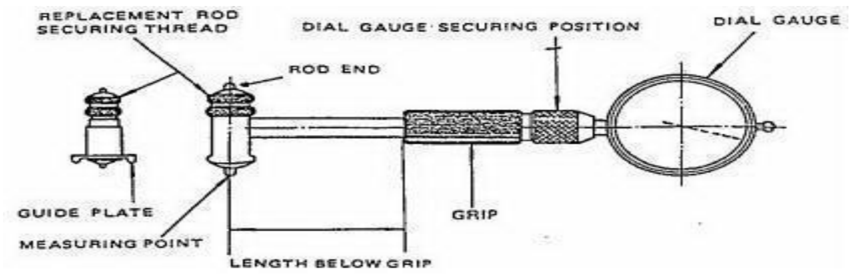
OBSERVATIONS:

S.No	PSR	HSR	PSR+(HSRXLC)	READINGS

BORE DIAL GAUGE:

THEORY:

It is used for measuring internal diameter of a hole, which is machined. The bore dial gauge consists of one fixed measuring head and one movable measuring head. The movement of the movable measuring rod is transmitted to dial indicator by push rod through a spring actuated hinged member. Thus, the horizontal movement of the rod is transmitted into vertical direction gives indication of variation of size. The calibrated rods are made in different sizes and sometimes number of short rods threaded at the ends are used in combination to get different desired lengths



PROCEDURE:

The measuring head is placed in contact with the surface of hole & movement of measuring head contact point is transmitted to the amplifying mechanism by the calibrated rods and it’s shown on the dial indicator. These calibrated rods are located in tabular supports between the head and dial units. The readings from dial indicator are tabulated

OBSERVATIONS:

S.NO	DIAMETER	TRIAL 1	TRIAL 2	AVERAGE	MEASURED DIAMETER

Note: Please avoid dropping the tools as this can lead to irreparable damage to the precision instruments. The tools are coated with a light film of oil to prevent corrosion. Please do not remove this oil. A cloth has been provided to clean your hands after use.

RESULTS:

The specifications of the given component are measured with vernier caliper, outside micrometer & bore dial gauge.

ADVANTAGES OF VERNIER CALIPER

- Vernier Calipers are precision measuring instruments with a higher accuracy level.

- It is one of the best calipers to measure least count of any object. However, there are certain number of advantages and disadvantages about these instruments which are discussed below.

- Vernier Caliper is very important tool in manufacturing industry and has lot of benefits.

- Precision & accuracy are two hallmarks of Vernier calipers, this instrument has robust tendency to give precise and accurate measurements of various dimensions.

- **Twin Scales:**

  Main or primary scale and Vernier or secondary scale are constructed together into the measuring equipment, an additional measuring gadget like a ruler or tape measure is not needed.

- **Adaptability for Measurements:**

  Vernier calipers can be used for variety of applications. It can measure inner, outer, steps and depth dimensions of any geometrical objects.

- **Strength:**

  Majority of manufacturers make Vernier calipers by using pure stainless steel to give strength and durability. As we know stainless steel have a higher strength & corrosion protection and hence by following standard manufacturing processes, Vernier Calipers can sustain for a life time.

- **Price:**

  Vernier calipers are very common, there are many suppliers available in the market. Therefore the prices are very competitive now and these are readily available in cheap prices as well.

DISADVANTAGES OF VERNIER CALIPER

- Good Vision is Needed:

  As quite evident, the Vernier scale of a Vernier caliper is significantly small component. With improper vision or improper angle of vision it is quite difficult to properly read or identify measurements. To avoid such mistakes normally good vision or a right light with magnifying glass would be recommended while taking readings.

- Learning A Vernier Caliper:

  All of us know that the Vernier scale is a specialized precision measuring tool; user should make an effort to learn how to read from a Vernier caliper before going to take measurements.

- Prospect Of Errors:

  While acquiring several numbers of measurements, user might end up committing error. To avoid this prospect of errors extra attentiveness is needed.

- Availability Of Alternates:

  Digital calipers are best alternate to Vernier calipers that can yield more accurate values with no prospect of errors as in manual Vernier Calipers

ADVANTAGES OF MICROMETER:

- More accurate than rules.
- Greater precision than calipers.
- No parallax error
- Relatively in expensive.
- End measurement

DISADVANTAGES OF MICROMETER:

- Short measuring range
- End measurement only.
- Limited wear area of anvil and spindle tip.
-

APPLCATIONS:

- It can be used to measure diameter of a wire, thickness of a thin metal sheet
- These instruments are used to check round work pieces accurately.
- It is also used to check wall thickness of the pipe.

VIVA-QUESTIONS:

- What is the least count of a Vernier caliper having 20divisions on Vernier scale, matching with 19 divisions of main sale?
- What type of micrometer is used for measuring longer internal length?
- How to maintain constant pressure in micrometer?
- What is the purpose of adjusting nuts in a micrometer?
- What is the range of dial bore gauge?
- What is the least count of digit vernier caliper?
- Explain briefly about the different types of micrometers?
- What is Micrometer?
- What is the Least Count of Vernier & Outside Micrometer?
- What are applications of Vernier & Outside Micrometer?
- What are the errors in Vernier & Outside Micrometer?
- Compare Vernier & Outside Micrometer.
- What are the precautions required during use of inside micrometer & dial Boreindicator.
- Which one is more precise when compared to inside micrometer & dial boreIndicator.
- What are the applications of inside micrometer & dial bore indicator?

EXPERIMENT NO. 3:

ANGLE MEASUREMENT USING BEVEL PROTACTOR & SINE BAR

AIM:

To measure the angle of the given wedge using Sine bar & Bevel Protractor

INSTRUMENTS USED:

1. Sine bar 2. Work piece 3. Dial Gauge 4. Slip gauges 5. Bevel Protractor.

SINE BAR:

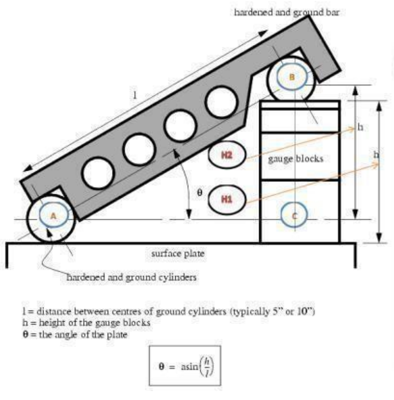
THEORY:

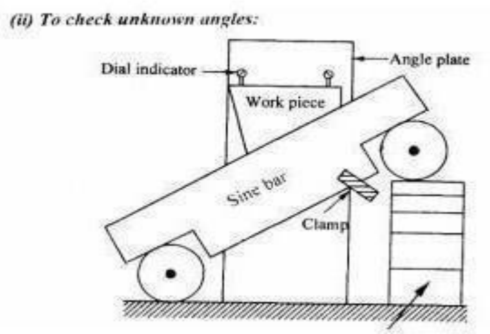
The sine principle uses the ratio of the length of two sides of a right triangle in deriving a given angle. The accuracy with which the sine principle can be put to use is dependent in practice, on some form of linear measurement. The sine bar in itself is not a complete measuring instrument. Sine bars in conjunction with slip gauges constitute a very good device for the precise measurement of angles. The arrangement is based on the fact that for any particular angle θ the sides of a right-angled triangle will have precise ratio, i.e,

$$\mathbf{Sin\theta = h/l}$$

If **h** and **l** could be measured accurately, θ can be obtained accurately. The value of h is built-up by slip gauges and value ‗l‘ is constant for a given sine bar.

Sine bars are used either to measure angles very accurately or for locating any work to a given angle within very close limits. Sine bars are made from high carbon, high chromium, corrosion resistant steel, hardened, ground and stabilized. Two cylinders of equal diameter are attached at the ends. The axes of these two cylinders are mutually parallel to each other and also parallel to and at equal distance from the upper surface of the sine bar. The distance between the axes of the two cylinders is exactly 100, 200and





.

PROCEDURE:

1. Place the work piece/wedge above the sine bar and make it horizontal with the base.
2. The dial gauge is then set at one end of the work moved along the upper surface of the component.
3. If there is any variation in parallelism of the upper surface of the component and the surface plate, it is indicated by the dial gauge.
4. The combination of the slip gauges is so adjusted that the upper surface is truly parallel with the surface plate.
5. Note down the values of the slip gauges.
6. Calculate the angle using the formula.

$$\theta = \sin^{-1}(h/l)$$

7. Repeat the procedure 3 or 4 times and take the average.

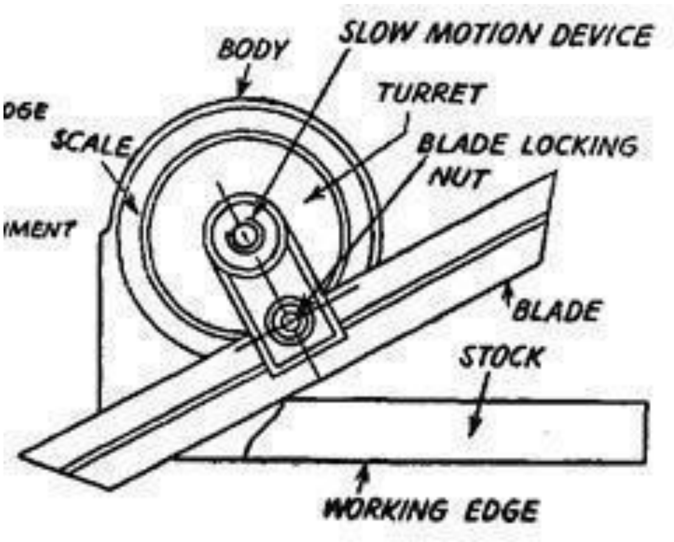
OBSERVATIONS:

S.No.	HEIGHT(h)	LENGTH(l)	ANGLE

BEVEL PROTRACTOR:

A universal bevel protractor is used to measure angles between two planes. This consists of stem, which is rigidly attached to main scale and a blade, which is attached to the Vernier scale and can be rotated to read angles. To improve the accessibility, the blade can also slide.

The least count is calculated by knowing the value of the smallest division on the main scale and number of divisions on the Vernier scale. It should be noted that the divisions on the main scale is in degrees and that the fractional divisions of degrees are minutes (i.e., with 60 minutes/degree, denoted). To measure angle between two planes, rest the stem on one of the planes (reference plane). Rotate the blade such that blade is flush with second plane. Readings are taken after ensuring that the stem and blade are in flush with the two planes. Lock the protractor at this point and note sown the readings.



OBSERVATIONS:

S.NO.	ANGLE MEASURED

PRECAUTIONS:

1. The sine bar should not be used for angle greater than 60 inconstruction is accentuated at this limit because any possible error
2. A compound angle should not be formed by mis-aligning of work piece with the sine bar. This can be avoided by attaching the sine bar and work against an angle plate.
3. As far as possible longer sine bar should be used since using longer sine bars reduces many errors.

RESULT:

1. The angle of the given specimen measured with the sine bar is
2. The angle of the given specimen measured with the Bevel Protractor is

ADVANTAGES:

- The bevel protractor is used to establish and test angles to very close tolerances. It reads to 5 minutes or $1/20^{o}$ and can be used completely through 360^{o}.
- For checking a V block
- For measuring Acute angle.

APPLICATIONS:

- The hypotenuse is a constant dimension— (100 mm or 10 inches in the examples shown).
- The height is obtained from the dimension between the bottom of one roller and the table's surface.
- The angle is calculated by using the sine rule. Some engineering and metalworking reference books contain tables showing the dimension required to obtain an angle from 0-90 degrees, incremented by 1-minute intervals.
- The two rollers must have equal diameter and be truecylinders.
- For checking inside face of bevel face of ground face.

VIVA - QUESTIONS:

- Name some angle measuring devices?
- What is the least count of mechanical Bevel Protractor?
- What is the least count of optical Bevel Protractor?
- What is a sine bar?
- What are the limitations of Sine bar?
- What is the difference between the sine bar and sine center?
- What is the use of V-block?
- How do you specify sine bar?

Experiment No. 4:

GEAR TOOTH VERNIER CALLIPER

AIM:

To measure the thickness and height of gear teeth at the pitch line or chordal thickness of teeth and the distance from the top of a tooth the chord using gear tooth caliper.

EQUIPMENT REQUIRED:

1. Gear tooth Vernier caliper
2. Gear of known module
3. Surface plate

THEORY:

Tooth thickness is the arc distance measured along the pitch circle from its intercept with one flank to its intercept with the other flank of the tooth.

p d N d 1

Module, m =(d/N) =(1/dP)

Where d = Pitch Circle Diameter(pcd)

N = Number of teeth on given gear dp

= Diametral Pitch

Diametral Pitch, dp = (N/d) = (N+2)/D

Where D = Outside Diameter of Gear

Theoretical Thickness, Wt = N m sin (90/N)

Chordal Height or depth, h = N m

% Error = $(W_t - W_m)/W_t \times 100$

Addendum is the radial distance from the tip of a tooth to the pitch circle.

In the most of the cases, it is sufficient to measure the chordal thickness i.e., the chord joining the intersection of the tooth profile with the pitch circle because it is difficult to measure length of the arc directly.

Tooth thickness caliper consists of a slide which moves vertically with the help of knob. The jaw moves horizontally with the help of know there by varying the gap between them. An adjustable tongue, each of which is adjusted independently by adjusting screw on graduated bars, measures the thickness of a tooth at pitch line and the addendum.

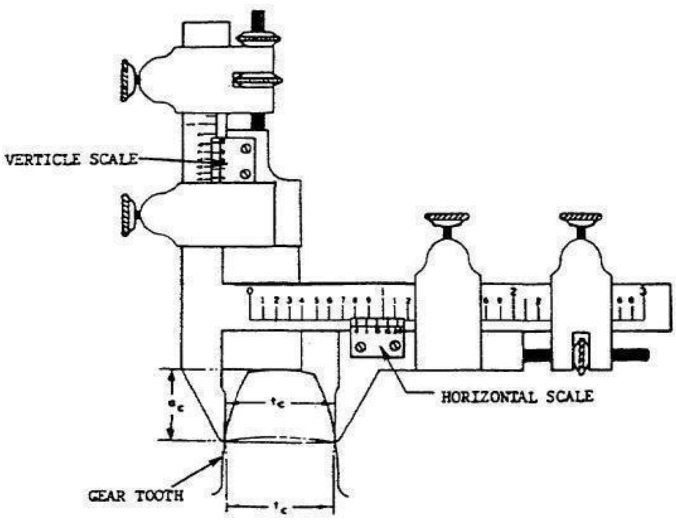
PROCEDURE:

1. The given gear caliper is held over the gear and the slide is moved down so that it touches the top of the gear tooth.
2. The jaws are made to have contact with the tooth on either side by adjusting the knob.
3. The reading on vertical scale i.e. height is noted down.
4. The reading on horizontal scale i.e. tooth thickness is noted down.
5. The above procedure is repeated for five times and readings are noted.

Least count of given caliper:

TOOTH THICKNESS

S.No.	M.S.R	V.S.R	TOTAL = MSR +(VSR x L.C.)



HEIGHT:

S.No.	M.S.R	V.S.R	TOTAL = MSR +(VSR X L.C)

RESULT:

The Height of the given specimen =_

The tooth thickness of the given specimen =

ADVANTAGES:

- The method and simple expensive.
- However, it needs different setting for a variation in number of teeth for a given pitch.
- Accuracy is limited by the least count of instrument.
- The wear during use is a concentrated on the two jaws.
- The caliper has to be calibrated at regular intervals to maintain the accuracy measurement.

APPLICATIONS:

- Can be used for measuring hobs, form and thread tools
- Adjusted independently by screws on the graduated bars
- Thickness of a tooth at the pitch line is measured by an adjustable jaw after the addendum is set by the adjustable tongue

VIVA QUESTIONS:

- What are the applications of Gear toothverniercaliper?
- How do we check the profile of a Gear tooth?
- Define various elements of agear?
- What is Chordal addendum?
- What is chordal thickness of gear tooth
- What are the various parts of gear tooth Vernier? v) Differentiate gear tooth Vernier from ordinary Vernier?
- What are the different types of gears?
- What are the various tests conducted on gears?
- What is the other parameter to be measured in gear by using other testing equipment?
- What is rolling gear test?
- What is the various quantitative test on gears?
- What is the use of gear tooth vernier caliper?
- Explain why chordal width of spur gear is an important dimension to measure?

EXPERIMENT NO. 5:

TOOL MAKER'S MICROSCOPE

AIM: To measure the pitch & angle of the screw thread.

APPARATUS: Tool makers microscope, screw thread specimen

THEORY:

Tool makers microscope is based on the principle of optics. The microscope consists of a heavy-duty hallow-duty hallow base, which accommodates the illuminating unit underneath, and above this on the top surface of the base, the work table carriage is supported on ball and controlled by micrometer screws. Projecting up from the rear of the base is a column, which carries the microscope unit and various interchangeable eyepieces. The chief applications of the tool room microscope are as follows

1. The determination of relative position of various points on work.
2. Measurement of angle by using a protractor eyepiece.
3. Comparison of thread forms with master profiles engraved in the eyepiece, measurement of pitch and effective diameter.

SPECIFICATION:

MAGNIFICATION : 30X (Standard)
OBJECTIVE :2X
EYEPIECE : W.F.15X with cross rectile
FIELD OFVIEW : 8mm. (approx)
WORKINGDISTANCE :80mm
OBSERVATIONTUBE : monocular inclined at 30degree
STAND : large and heavy base provide extra overall rigidity to the instrument

MEASUREMENT STAGE: 150X150.
Size travel up to 50mm in each direction, least count 6 minutes.

CONSTRUCITON OF MICROSCOPE

BASE:

The study base rest on three support two of which are adjustable for leveling the instrument. The base has built in all electrical transformers and their control panel and transmitted illuminator with green filter.

ARM:

The arm has a groove guide on which the microscope tube is vertically adjusted by rack and pinion system.

FOCUSSING MECHANISM:

The course focusing movement provided in the microscope tube separately. The coarse motion is knurled knob on both side of the tube and ha as the total travel of 200mm. Itsalso lock any position by lever, this movement is characterized by its exceptionally smooth and accurate precision. The vertical travel or measurement up to 10mm, thickness can be read by the depth dial gauge. The thickness is being measured with the difference of two different focusing of object. The least count of gauge is0.01.

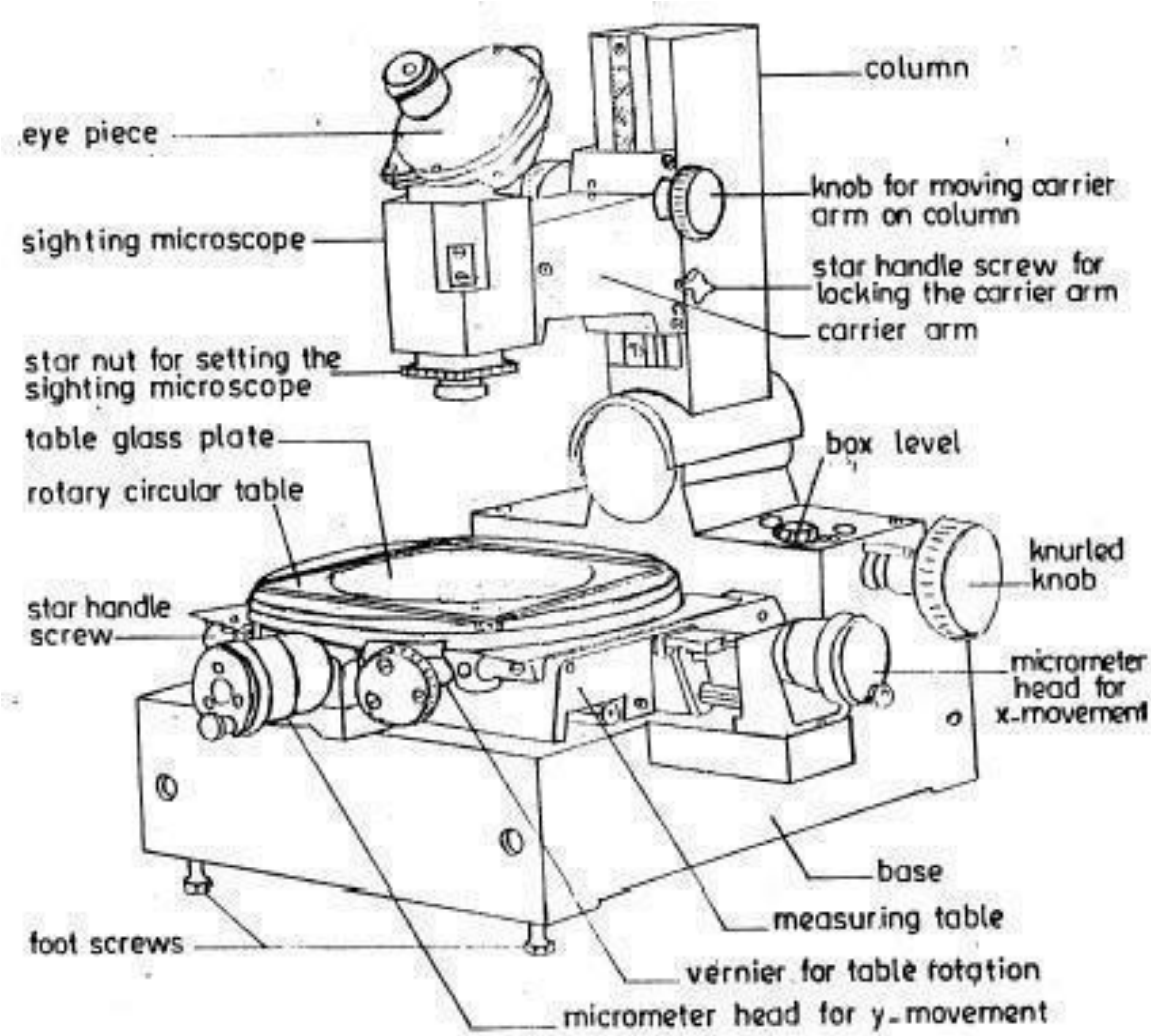


Fig. 1 Tool Makers Microscope

EYEPIECE PROTRACTOR

This unique protractor head graduated 0 to 360 degree with adjustable vernier reading to 6 minutes cross line incorporated in the protractor head rotating in the optical axis of the microscope the cross line graticule is replaceable with many other measuring graticules.

MEASURING STAGE

The stage plate is of 150 X 150 mm having very smooth and precise movements in both axis with special ball racers arrangements. The travel of the stage is 25mm. in both direction with precise imported micrometer head, least count 0.01 or 0.005mm. The stage has two T-slots for mounting accessories like rotary stage, center holding device attachment and V-block etc.

ROTARY STAGE

A rotating stage is fixed in T-slots of square plate having 360 degree graduations on its periphery with vernier reading to6 minute, and lock screw. All types of horizontal angular measurements can be done with this stage.

ILLUMINATING SYSTEM

Two possible range of illuminating system are provided with standard equipment to meet every application, operated through 6 volts solid state variable light control built in transformer.

1. Sub-stage transmitted light from a bottom source providing collimated green filter halogen light for viewing contours and transparent objects.
2. Surface incident illuminator for shadow free lighting, for high power examination of opaque objects.

PROCEDURE:

MEASUREMENT OF SCREW THREAD PITCH

1. The image of the thread profile is set so that some of the profile coincides with the cross hair as seen on the ground-glass screen.
2. The reading on thimble of the longitudinal micrometer screw is noted down.
3. Then the part is traversed by the micrometer screw until a corresponding point on the profile of the next thread coincides with the crosshairs.
4. The reading on thimble is again noted and the difference in two readings gives the actual pitch of the screw.

MEASUREMENT OF ANGLE OF THREAD

1. It is determined by rotating the screen until a line on the screen coincides with one flank of the thread profile

2. The angle of screen rotation is noted and then the screen is further rotated till the same line coincides with the other flank of thread. The difference in two angular readings gives the actual angel of thread on the screw.

PITCH OF THE THREAD

S. No.	Initial micrometer readings on thread pitch A(mm)	Final micrometer readings on thread pitch B(mm)	Pitch of the thread B-A (mm)

FLANK ANGLE OF THE THREAD:

S. No.	Initial flank angle A (Deg)	Final flank angle B (Deg)	Flank angle = B-A (Deg)

PRECAUTIONS:

1. The coincidence on the component & cross hairs must be carefully matched.
2. Eyepieces are to be handled carefully.
3. Don‘t expose eyes directly to the light source.

RESULT:

The pitch and flank angle of the given object is measured with toolmakers microscope are tabulated.

ADVANTAGES:

- As compared to the optical comparators, a tool maker ‘s microscope is preferred when the z-axis height information is required.
- The stage can be equipped with linear scales.
- They can easily adapt to both cameras CCTV's for photo documentation requirements.
- The toolmakers microscope offers a variety of optical techniques Moreover, it canuse optics, which offer higher magnification resolution for better measuring accuracy.
- It is ideal for measurements of hardness test indentations.

APPLICATIONS:

- **Determining relative positions**

Here, the microscope is used elative positions of different points by simply measuring the travel that is necessary for bringing a second point to the position that was formerly occupied by the first and so forth.

- **Measuring angles**

Using this microscope, it is possible to measure the angles by using the protractor eyepiece. This allows for the angles of the object to be viewed and determined. This is where the microscope is used to do comparison of the thread forms, measuring of the pitch and diameter. Here, the microscope achieves this using the master profiles engravings in the eyepiece.

- **Comparing with a scale**

This is where the images of the object are compared with the scale in the projection screen.

VIVA-QUESTIONS:

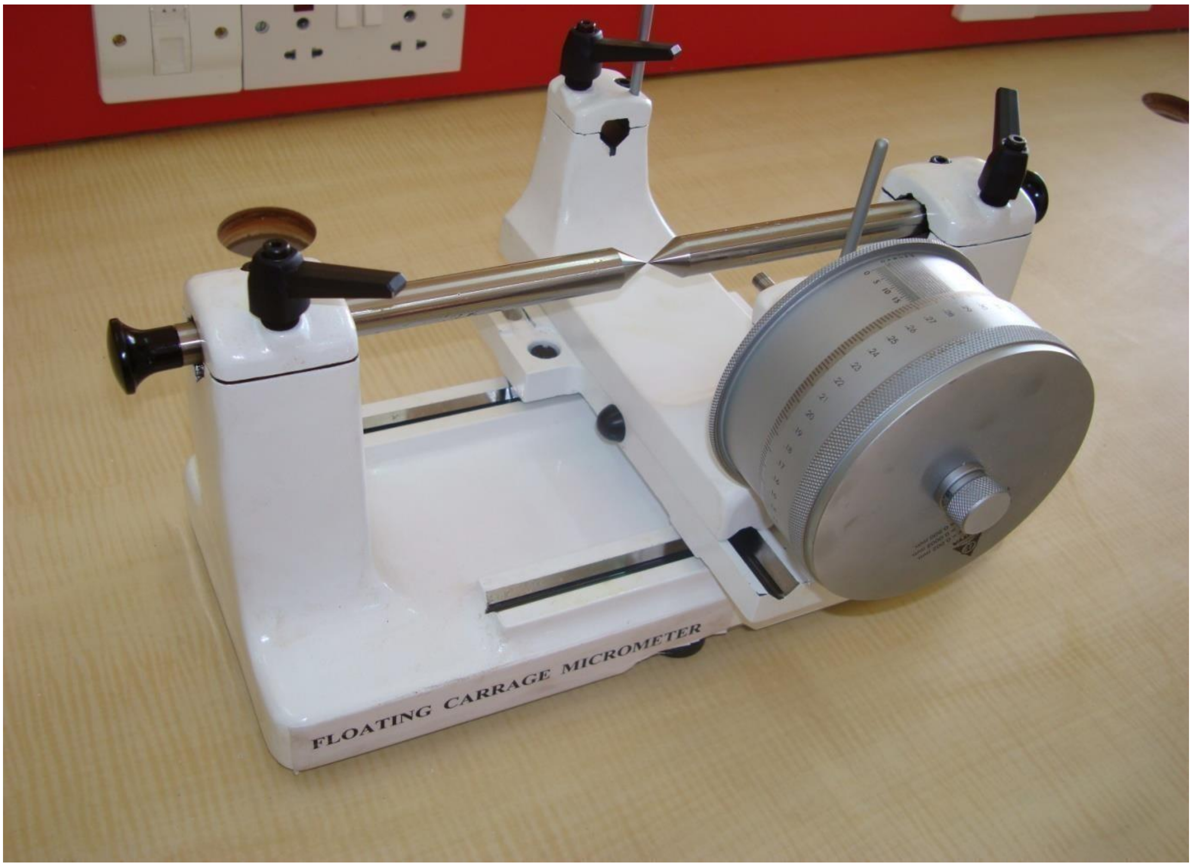
- What are the applications of Tool makers microscope?
- State the principle involved in Tool makers microscope?
- How to change the magnification in Tool makers microscope?

Experiment..N0.6

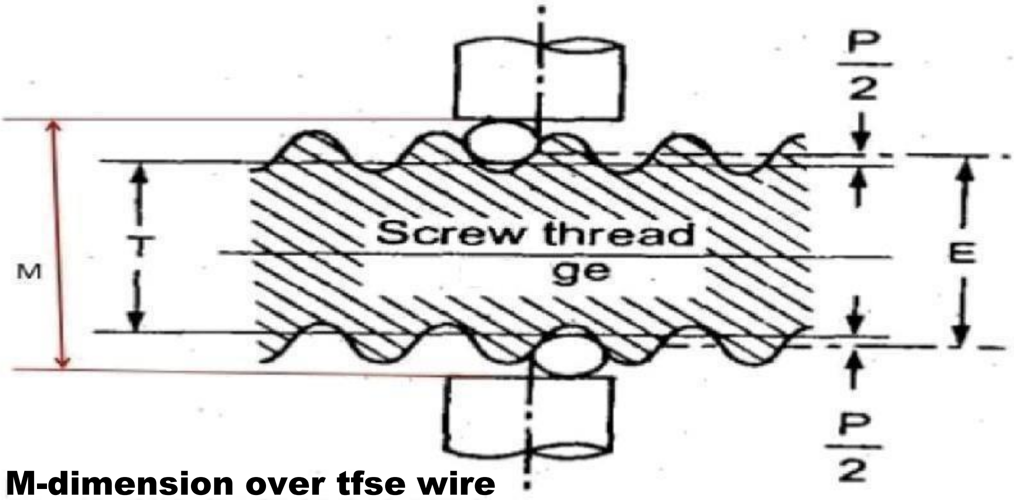
MEASUREMENT OF SCREW THREAD PARAMETERS USING TWO WIRE METHOD BY FLOATING CARRIAGE MICROMETER

Aim: To measure the screw thread parameters using two wire method by Floating carriage micrometer.

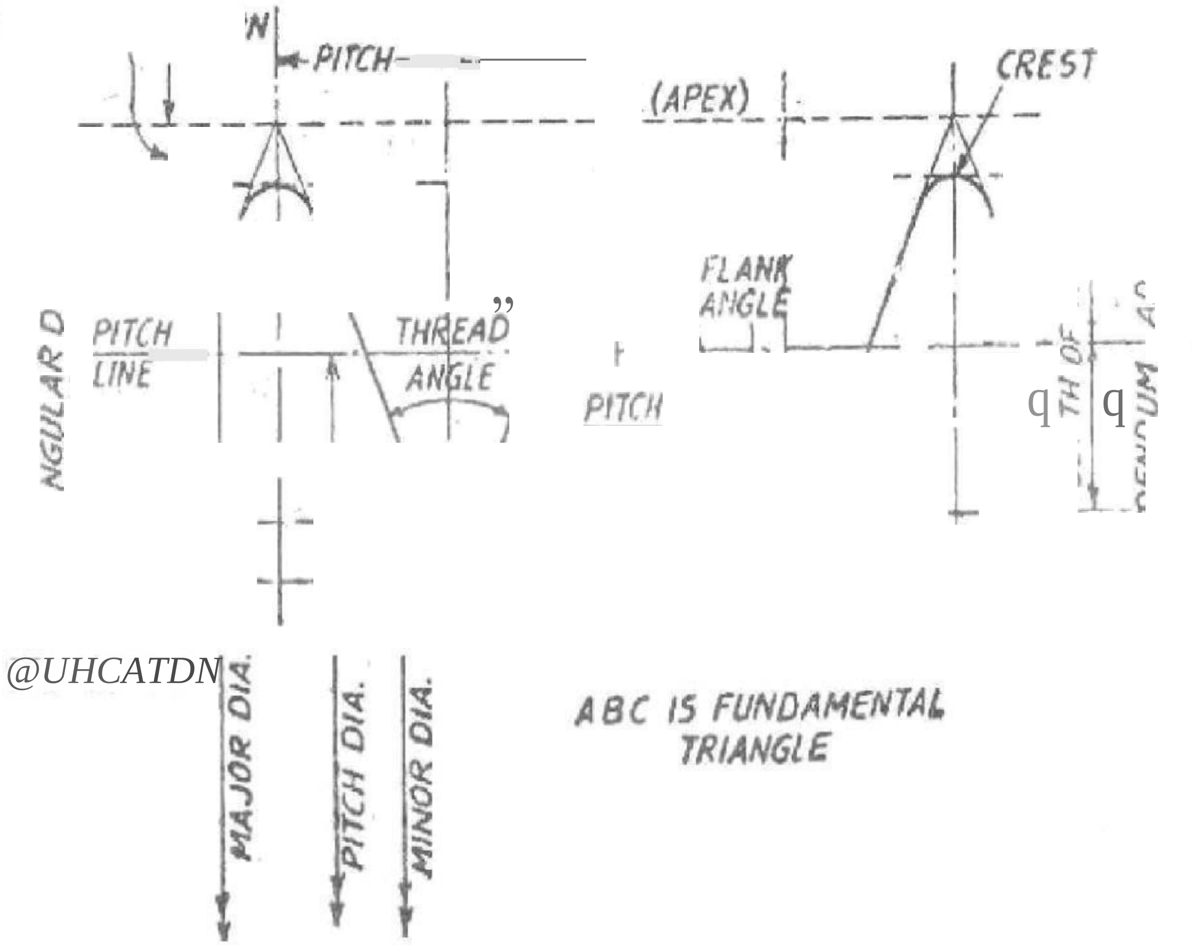
Apparatus: Micrometer, micrometer stand, a set of two wires, pitch gauge and Screw thread specimen.



Two wire method:



M-dimension over tfse wire



Screw Threads Terminology:

Screw thread. A screw thread is the helical ridge produced by forming a continuous helical groove of uniform section on the external or internal surface of a cylinder or cone. A screw thread formed on a cylinder is known as straight or parallel screw thread, while the one formed on a cone or frustum of a cone is known as tapered screw thread.

External thread. A thread formed on the outside of a work piece is called external thread e.g., on bolts or studs etc.

Internal thread. A thread formed on the inside of a work piece is called internal thread e.g. on a nut or female screw gauge.

Multiple-start screw thread. This is produced by forming two or more helical grooves, equally spaced and similarly formed in an axial section on a cylinder. This gives a _quick traverse_ without sacrificing core strength.

Axis of a thread. This is imaginary line running longitudinally through the Centre of the screw.

Hand (Right- or left-hand threads). Suppose a screw is held such that the observer is looking along the axis. If a point moves along the thread in clockwise direction and thus moves away from the observer, the thread is right hand; and if it moves towards the observer, the thread is left hand.

Form, of thread. This is the shape of the contour of one- complete thread as seen in axial section.

Crest of thread. This is defined as the prominent part of thread, whether it is external or internal.

Root of thread. This is defined as the bottom of the groove between the two flanks of the thread, whether it be external or internal.

Flanks of thread. These are straight edges which connect the crest with the root.

Angle of thread {Included angle). This is the angle between the flanks or slope of the thread measured in an axial plane.

Flank angle. The flank angles are the angles between individual flanks and the perpendicular to the axis of the thread which passes through the vertex of the fundamental triangle. The flank angle of a symmetrical thread is commonly termed as the half- angle of thread.

Pitch. The pitch of a thread is the distance, measured parallel to the axis of the thread, between corresponding points on adjacent thread forms in the same axial plane and on the same side of axis. The basic pitch is equal to the lead divided by the number of threads starts. On drawings of thread sections, the pitch is shown as the distance from the Centre of one thread crest to the centre of the next, and this representation is correct for single start as well as multi-start threads.

Lead. Lead is the axial distance moved by the threaded part, when it is given one complete revolution about its axis with respect to a fixed mating thread. It is necessary to distinguish between measurements of lead from measurement of pitch, as uniformity of pitch measurement does not assure uniformity of lead. Variations in either lead or pitch cause the functional or virtual diameter of thread to differ from the pitch diameter.

Procedure:

1. Fix the given screw thread specimen to the arrangement block.
2. Measure the pitch of the given thread using pitch gauges and also note downthe angle of the thread based on Metric or With Worth.
3. Measure the maximum diameter of the screw thread using micrometer.
4. Calculate the best wire to be used by using the given equation.
5. Consider the available wires and fix the two wires to one end on micrometer Anvil and one wire towards another anvil.
6. Measure the distance over the wire properly by using micrometer.
7. Calculate the effective diameter of the screw thread.
8. Find out the error in effective diameter of the screw thread.

Observations:

1. Least Count of the Micrometer= mm.
2. Initial error in the micrometer= mm.
3. Pitch of the thread p= mm.
4. Best size of the wire used d= mm.

Results:

The following parameters are found as follows;

1. Major Diameter= mm
2. Minor Diameter= mm
3. Effective Diameter= mm.

ADVANTAGES:

- Very accurate, assuming correct flank angle Can be used on all external threads Suitable for machine set-up and process control.
- Inspects full thread profile and pitch Can be used with a minimum of training Assuming correct useof both GO and NO-GO gaugesthe component can be judged ‖good‖ or‖bad
- Measures the total thread geometry (diameters and pitch).
- When set up easy to use. Fixtures for both external and internal threads.
- Suitable for machine set-up and process control

DISADVANTAGES:

- Only suitable for external threads Requires a calculation to find the correct measurement result Measuring wires must be bought to suit the relevant micrometer spindle diameter N.B. there are 3 standard micrometer spindle diameters – Ø8mm (5/16‖), Ø6,5 and Ø6,35 mm (1/4‖) ―Only‖ measures thread pitch diameter.
- Only reveals if the component is ‖good‖ or ‖bad‖ – not the relationship to the tolerance Time consuming when setting up the machine and performing process control Difficult/expensive to calibrate Manufacturing tolerances and wear on the gauges usually give less tolerance on the actual components to be inspected Can only be used for the specific thread and tolerance stated on the gauge.

- Relatively expensive as it can only be used for the designated thread.
- Requires a reference component for correct setup.
- One wrong dimension on the threaded component can give a false indication i.e. an incorrect pitch will give a false reading as will an incorrect flank angle.

APPLICATIONS:

- Certify set plug gages and working thread plug gages
- Monitor the wear on working thread plug gages
- Monitor and control pitch diameter variation during thread fabrication
- Use in conjunction with Go- and No-Go ring gages to control thread sizes to the most demanding specification
- Determine out of roundness and taper that may exist in threaded parts
- Eliminate the cost and time involved in using outside calibration services
- Reducemeasurementtimetoafractionoftimenormallytakingusingthetraditional three-wire method.

VIVA-QUESTIONS:

- What is the least count of dial indicator?
- Name some angle measuring devices?
- Why do we use Feeler gauges?
- What are slip gauges and why do we use them?
- What are slip gauges and why do we use them?
- Explain zero error and zero correction in case of micrometers?
- What are the precautions to be taken while using slip gauges?