I

Name _____

Roll No. _____ Year 20____20____

Exam Seat No. _____

MECHANICAL GROUP | SEMESTER - III | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

MECHANICAL ENGINEERING MATERIALS (22343)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

for

Mechanical Engineering Materials

(22343)

Semester-III

(ME)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on June, 2018)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms. ……..…… Roll No. ……..…., of Third Semester of Diploma in ……..…… of Institute, ……..…….……..… (Code: ……...) has completed the term work satisfactorily in course **Mechanical Engineering Materials (22343)** for the academic year 20…….. to 20…….. as prescribed in the curriculum.

Place: …… Enrollment No:.……

Date: …… Exam. Seat No: ……

Subject Teacher **Head of the Department** **Principal**

Seal of Institution

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This practical manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the students the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

With the advances made in the field of material science, millions of materials are now available to cater to various needs of mankind. These needs and service conditions dictate the properties to be developed in the materials. Therefore the subject Mechanical Engineering Materials has attracted a lot of attention. Materials like ferrous and nonferrous metals, polymers, ceramics and composites are widely used in variety of engineering applications. This course deals with these materials along with advance materials, their metallurgical considerations, heat treatment processes, structure-property relationship and applications. This course will enable diploma engineering students to identify variety of material and their selection for various applications.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course

Following POs and PSO are expected to be achieved through the practicals of the course.

PO 1. **Basic knowledge :** Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems.

PO 2. **Discipline knowledge:** Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems.

PO 4. **Engineering tools:** Apply relevant mechanical technologies and tools with an understanding of the limitations.

PO 8. **Individual and team work:** Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PO 10. **Life-long learning:** Engage in independent and life-long learning activities in the context of technological changes also in the mechanical engineering and allied industry.

Program Specific Outcomes (PSOs):-

PSO 1: Modern Software Usage: Use latest mechanical related softwares for simple design, drafting, manufacturing, maintenance and documentation of mechanical components and proceses.

PSO 2: Maintenance and selection of machines, equipment, instruments: Maintain and select appropriate machine, equipment and instrument in the field of Mechanical Engineering.

PSO 3: Manage Mechanical Process: Manage the mechanical processes by selection and scheduling right type of machinery, equipment, substrates, quality control techniques, operational parameters and softwares for a particular mechanical process or job for economy of operations.

List of Industry Relevant Skills

The following industry relevant skills of the competency '**Use relevant mechanical engineering materials in different applications** ' are expected to be developed in you by undertaking the practical of this laboratory manual.

1. Use relevant hardness measuring instruments of machine components
2. Select the relevant measuring instruments for Heat treatment
3. Measure the hardness of ferrous and nonferrous material.
4. Measure the strength of plastics and rubber

Practical- Course Outcome matrix

Course Outcomes (COs)

a. Identify properties of materials.
b. Select relevant ferrous materials for mechanical components.
c. Select relevant cast iron for the engineering application.
d. Use non-ferrous metals for mechanical components.
e. Suggest relevant advanced materials for mechanical components.
f. Select relevant heat treatment process

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.	CO f.
1.	Prepare specimen of a given material for microscopic examination.	√	-	-	-	-	-
2.	Use metallurgical microscope to interpret micro structure of steels and alloy steels on standard specimen.	√	-	-	-	-	-
3.	Use Brinell hardness tester to determine the hardness of a given sample.	√	-	-	-	-	-
4.	Use Rockwell Hardness tester to determine the hardness of given sample.	√	-	-	-	-	-
5.	Use relevant hardness tester to determine the hardness of mild steel before and after heat treatment.	√	-	-	-	-	-
6.	Use relevant hardness tester to determine the hardness of alloy steel before and after heat treatment.	-	√	-	-	-	-
7.	Use Metallurgical microscope to interpret micro structure of cast iron on standard specimen.	-	√	-	-	-	-
8.	Use Metallurgical microscope to interpret microstructure of aluminum on standard specimen.	-	-	√	-	-	-
9.	Use relevant hardness tester to determine the hardness of copper.	-	-	-	√	-	-
10.	Use relevant peel tester to determine the adhesive strength of cellophane tape and, duct tape on a smooth surface.	-	-	-	√	-	-
11.	Perform flame test to identify different types of plastics.	-	-	-	-	√	-
12.	Use High-temperature oven or electrical current to Identify behavior of the shape-memory alloy as a function with regards to temperature.	-	-	-	-	√	-

13.	Use relevant peel tester to determine the adhesive strength of scotch tape, electrical tape and masking tape on a smooth surface.	-	-	-	-	√	-
14.	Use muffle /box type furnace to determine the effect of • oil • water • brine as quenching media on the hardness of mild steel	-	-	-	-	-	√

Guidelines to Teachers

1. Teacher need to ensure that a dated log book for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to submit for assessment to the teacher in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters(if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a dated log book for the whole semester, apart from this laboratory manual which s/he has to submit for assessment to the teacher in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, Technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practicals.

Content Page

List of Practicals and Progressive Assessment Sheet

S. No	Practical Outcome	Page No.	Date of performance	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
12.	Use High-temperature oven or electrical current to identify behavior of the shape-memory alloy as a function with regards to temperature.	88					
13.	Use relevant peel tester to determine the adhesive strength of scotch tape, electrical tape and masking tape on a smooth surface.	95					
14.	Use muffle /box type furnace to determine the effect of • oil • water • brine as quenching media on the hardness of mild steel	102					
Total							

Note: To be transferred to Proforma of CIAAN-2017.

Practical No. 01: Specimen Preparation for Microscopic Examination

I Practical Significance

Sample preparation is an essential part of microscopy and there are many techniques that can be used. Incorrect techniques in preparing a sample may result in altering the true microstructure and will most likely lead to erroneous conclusions. The basic sample preparation process consists of sectioning, mounting, course & fine grinding, and polishing.

II Relevant Program Outcomes (POs):

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of cutting machine, polishing machine, optical microscope
2. Check the correctness of specimen preparation.

IV Relevant Course Outcomes (from course details)

(a) Identify properties of materials.

V Practical Outcome

Use Slitting/cutting Machine, Polishing Machine and Grinding machine to prepare specimen of a given material for microscopic examination.

VI Relevant Affective domain related Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices

VII Minimum Theoretical Background

Specimen preparation

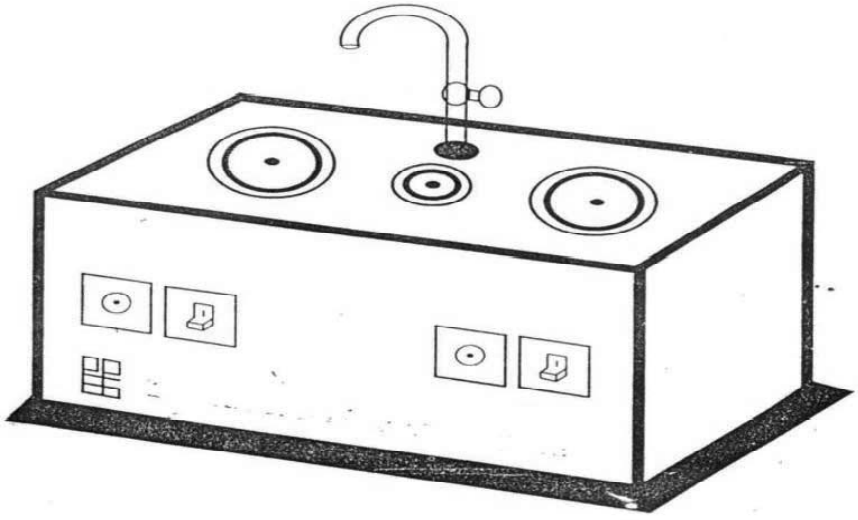
1. Grinding

Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool. The purpose of the grinding step is to remove damage from cutting, planarize the specimen(s), and to remove material approaching the area of interest**.** Grinding removes saw marks and levels and cleans the specimen.

2. Polishing

In metallography and metallurgy, polishing is used to create a flat, defect-free surface for examination of a metal's microstructure under a microscope. Polishing is the process of creating a smooth and shiny surface by rubbing it or using a chemical action, leaving a surface with a significant specular reflection. Polishing is the most important step in preparing a specimen for microstructural analysis. It is the step which is required to completely eliminate previous damage. Surface Polishing removes the artifacts of grinding but very little stock.

VIII Experimental set-up



Disc polishing machine

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Given specimen	Carbon/ Alloy steel rod or bar of 25 mm dia or 25mm x25mm c/s area	1 piece of 25 mm thickness per student	
2	Slitting Machine	Slitting width- standard 300 mm or extensible, Slitting blade, Slitting each width at least 15 mm	01	

3	Polishing Machine Grinding/polishing disc	diameter: 200mm. Rotation speed: 0-600 rpm	01	
4	Aluminum oxide abrasive solution	Commercial grade	1 bottle per 10 students	
5	Emery papers	(80,120,240,400,600,1200) Grades	1 set of Each for 4 students	

X Precautions (if any)

1) Polishing should be slow, smooth and flat.
2) Uniform pressure is applied throughout the polishing.
3) When polishing the specimen, hold it with both hands, apply a moderate amount of pressure, and don't let it go. The rough polishing stages (5-25 microns) should take between 1 and 2 minutes each. If you let go of the specimen it may fly, harm you or others in the laboratory and become damaged forcing you to start over again with coarse grinding - hold it tight and be careful.
4) Do not contaminate the polishing wheel; cover the wheel when not in use.
5) Do not touch the specimen surface after polishing.

XI Procedure

1. Cut the sample on slitting machine from the bar/rod as per the dimensions
2. Remove the burrs using file or coarse grinding paper.
3. Grind the specimen on emery papers starting from coarse(400) to fine grade (1200)
4. Clean your specimen and hands thoroughly before polishing.
5. Wear safety goggles when using the polishers.
6. Polish the specimen beginning with the 25-micron, nylon cloth polishing station.
7. Turn the water on adjusting to less than one drop per second.
8. Apply a small amount of the aluminium oxide abrasive solution to the polishing cloth.
9. Wash and dry both the specimen and your hands thoroughly, then rinse the specimen.
10. Repeat steps 6 through 9 for the 5-micron stage.
11. Proceed to the final polishing stage (1 micron).
12. The final polishing stage (1-micron) should take between 1/2 and 1 minute

XII Resources Used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations

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XVI Results

1. Chamfered edges of the sample
2. Mirror like surface of the sample

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Briefly (one concise sentence each) describe the steps involved in the preparation of a metallographic sample:
   - Sectioning
   - Mounting
   - Coarse Grinding
   - Fine Grinding
   - Polishing
2. Explain the need of washing and drying of metallographic samples before proceeding from one grinding or polishing operation to the next?
3. Explain the correlation of grade number of the emery paper with its nature
4. Suggest the method for polishing small size sample which cannot be hold properly in the hand
5. State the precautions to be taken to preserve the polished sample for future use.
6. List the various commercial brands of emery papers.
7. Describe the different ways of specifying the emery papers.

[Space for Answers]

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XX References / Suggestions for further Reading

a. https://youtu.be/AwM1dOsWsoo?t=77
b. https://youtu.be/Cl0nBBu-gzA?t=53
c. https://youtu.be/fc8zrgYJCJw?t=75
d. https://youtu.be/UuHofNW40Yw?t=63

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (10Marks)		**40%**
1	Preparation of experimental set up	10%
2	Cutting of specimen using slitting machine or hack saw	10%
3	Grinding and Polishing of specimen	20%
Product Related (15Marks)		**60%**
4	Prepared specimen	30%
5	Interpretation of result	10%
6	Conclusions	10%
7	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. …….
2. …….
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.02: Microstructure of Steels

I Practical Significance

The microstructure of steel can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance. These properties in turn govern the application of these materials in industrial practice. The effects of most industrial processes applied to metals to control their properties can be explained by studying their microstructures.

II Relevant Program Outcomes (POs) :-

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1- Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of Metallurgical Microscope
2. Identification of phases of microstructure

IV Relevant Course Outcomes (from course details)

(a)Identify properties of materials.

(b) Select relevant ferrous materials for mechanical components.

V Practical Outcome

Use metallurgical microscope to interpret micro structure of carbon steels and alloy steels

VI Relevant Affective domain related Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

VII Minimum Theoretical Background

Structures which are coarse enough to be differentiated by the naked eye or under low magnifications are termed 'macrostructures'. Those which require high magnification to be visible are termed 'microstructures'. Microscopes are required for the examination of the microstructure of the metals. The function of a microscope is to transform an object into an image, which is generally magnified to varying degree. Metals and alloys are polycrystalline, that is, they are composed of crystals commonly referred to as grains. The size, shape, and configuration of the grains within a metal or an alloy are a function of the way in which the metal was produced and used. The metallographic examination of specimens allows the metallographer to observe and record the crystalline structures and to interpret from them the history of manufacture and use of the material.

Etching:

In order to make the grain boundaries visible, after polishing the metal specimens are usually etched. Etching is the selective attack by a chemical reagent that reveals the micro-structural detail of the polished mount. Before etching, the polished specimen is thoroughly washed in running water. Then, the etching is done either by,

(i) Immersing the polished surface of the specimen in the etching reagent or by

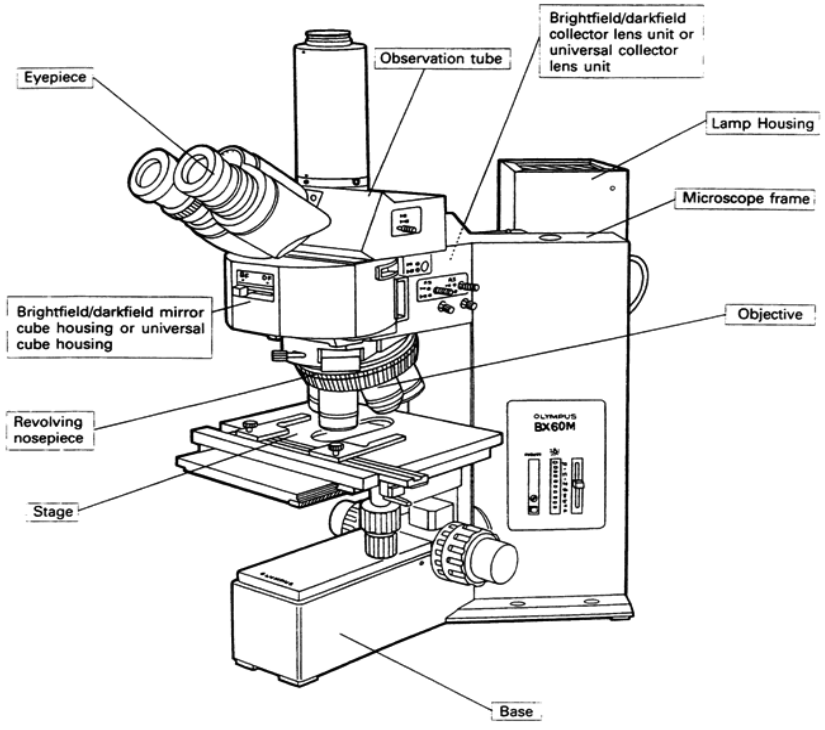
(ii) Rubbing the polished surface gently with a cotton swab wetted with the etching reagent.

After etching, the specimen is again washed thoroughly and dried. Now, the specimen can be studied under the microscope.

Metals	Etching Reagent	Composition	Remarks
Iron and steel	Nital	1 to 5% Nitric Acid 95 to 99 Alcohol	Carbon steels darkens pearlite, reveals ferrite boundaries; general use for high speed steels; Time: 1 to 60 sec.
	Picral	4g Picric Acid 100ml Alcohol	Carbon and Low alloy steels, heat treated or not. Time: 5 to 120 sec.
	Ferric Chloride& Hydrochloric Acid	5g $FeCl_3$ 50g HCl 100ml H_20	Reveals structures of austenite and stainless steels

VIII Experimental set-up

Optical Microscope



Optical Microscope Construction

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Optical Microscope	Metallurgical reflected light Microscope 6V, 30W halogen Light,200x magnification,191x126x100 mm specimen stage ,Size With 100 mm travel	05	
2	Standard Specimen of plain carbon steel and alloy steel	Rectangular shape 25 mm x 25 c/s area or circular shape 25 mm diameter or as per the availability Low, medium, high carbon steel, Ferritic, Austenitic and Martensitic Stainless steel, HSS, Spring steel	5 specimen of each type	

X Precautions (if any)

1. Only screw head should be rotated and the sleeve should not be rotated to avoid excess pressure.
2. The screw should be always rotated in one direction to avoid backslash error.

XI Procedure

1. Turn the lowest-power objective lens into place.
2. Turn the stage height focusing control to position the specimen about half a centimeter under the objective lens.
3. Look through the eyepieces and use the focusing controls (coarse and fine stage height controls) to bring the specimen into appropriate focus.
4. Scan the specimen surface by moving the stage using the stage position controls and select the areas that may warrant more complete study at higher magnification.
5. Turn the higher-power objective into place.
6. Adjust the stage height using the fine control until the specimen comes into sharp focus.
7. Put a drop of oil on specimen surface usually is needed at higher magnification (greater than X2000) to help with focusing.

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Observations

S. No	The magnification used	Important phases noted	Shape	Size	Color	Distribution of phases
1						
2						
3						

XVI Results

For each feature, one normally records the following characteristics:

1. Shape
2. Size
3. Color (in plane polarized light or with crossed polars)
4. Distribution of phases

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define Microscopy?
2. State the principle of Metallurgical Microscope?
3. List different etching agents used for specimen preparations?
4. Describe features of microstructures obtained in each case
5. Examine the four requisite samples and photograph each at the optimal magnification (if a camera is not available then sketch each of the microstructures).
6. Briefly describe the salient features of the eutectoid specimens that you have examined. How many phases and constituents are present in each?
7. Based on the observed microstructure of the steel sample, can you determine the carbon content of the steel? If yes, then briefly explain how to know the carbon content.
8. Describe the microstructure of low carbon steel?
9. Describe the microstructure of alloy steel?

10. Describe the microstructure of medium carbon steel?

[Space for Answers]

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XX References / Suggestions for further Reading

a) https://www.youtube.com/watch?v=fc8zrgYJCJw
b) https://www.youtube.com/watch?v=UuHofNW40Yw
c) https://www.youtube.com/watch?v=d4_xSRQxDxs
d) https://www.youtube.com/watch?v=zCznMbj2Yn4
e) https://www.youtube.com/watch?v=ljTEG-B-kGc

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	10%
2	Etching the specimen with suitable etchant	25%
3	Observation of the microstructure of the specimen at different magnification using microscope	25%
Product related (10 Marks)		**40%**
4	Follow Safety measures	10%
5	Answer experiment related questions	10%
6	Submit journal report on time	10%
7	Follow Housekeeping	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 03: Hardness Testing Using Brinell Hardness Tester

I Practical Significance

The hardness tests can provide information from which many important mechanical properties can be derived. Since the hardness test can be conducted easily and quickly, they are very popular in industry. These are used to control processing and for inspection and acceptance of materials and components.

II Relevant Program Outcomes (POs) :

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of Brinell hardness testing machine, optical microscope
2. Check the correctness of specimen for hardness testing

IV Relevant Course Outcomes

(a) Identify properties of materials

V Practical Outcome

Use Brinell hardness tester to determine hardness of a given sample.

VI Relevant Affective domain unrelated Outcome(s)

a) Follow safety practices.
b) Practice good housekeeping.
c) Demonstrate working as a leader/a team member.
d) Maintain tools and equipment.
e) Follow ethical Practices

VII Minimum Theoretical Background

The method of hardness testing was introduced by J.A. Brinell in 1900. In this test, a standard hardened steel ball is indented into the surface of the specimen by a gradually applied load which is maintained on the specimen for definite time (usually 10 or 15 sec). Ball of 10 mm, 5 mm, and 2.5 mm are generally used. The diameter of the impression or indentation is measured by microscope and the Brinell hardness number (B.H.N.) is found out by following formula.

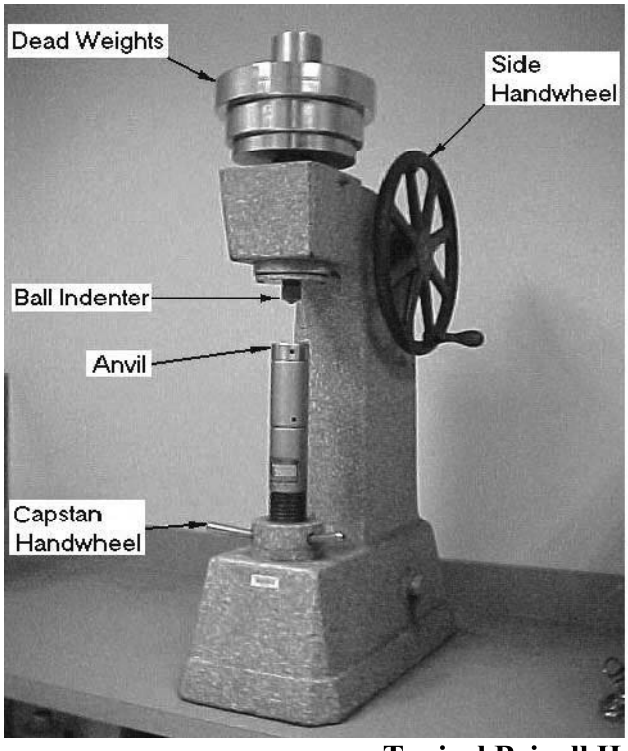
Brinell Hardness Number (B.H.N.) = Total load / surface area of indentation

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

Where, F is the load applied, D is diameter of ball, d is diameter of impression and h= depth of indentation = $(D - \sqrt{(D^2 - d^2)}/ 2$

This Brinell Hardness Test is used to determine the hardness number of hard, moderately hard, and soft material E.g. Brass, Bronze, Aluminum, Gold, Copper, etc. Very hard material and brittle material cannot be tested by Brinell hardness tester.

VIII Experimental set-up



Typical Brinell Hardness Tester

IX Resources required

Sr. No.	Instrument /Components	Specification	Quantity	Remark
1	Conventional/Digital Brinell Hardness Machine	FIE Make, Hardness range HBW<125 Test loads from 500 to 3000 kgf in steps of 250kgf; The height X Throat is 380 X 200 mm; Indentation measurement by Brinell Microscope of 25 X Magnification; Special Test fixtures for odd jobs / production testing can be supplied (Optional); Computerized Brinell Impression measurement system (Optional); Manual / Optical /Computerized type Brinell Hardness testing machine; Accuracy conform to IS:2281-2005 and BS:240	2	
2	Set of standard specimen	Mild steel, Brass, Bronze, Copper, Aluminium	Each One	

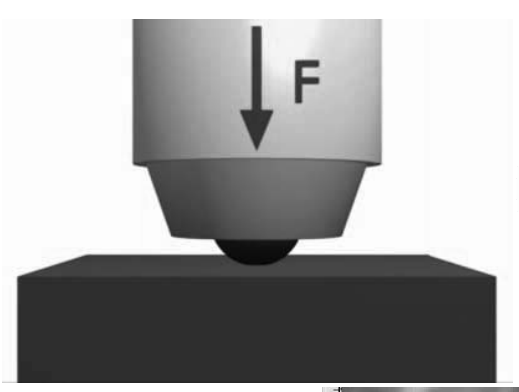
X Precautions (if any)

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 on which the Brinell impression is to be made should be sufficiently smooth and clean.

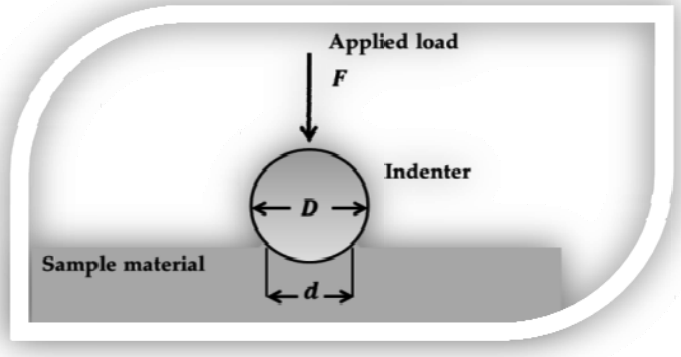
XI Procedure

1. The face of the specimen is lightly grind and rubbed with fine emery paper if required.
2. Select the proper test table based on the size and shape of the specimen and place it on main screw or elevating screw.
3. Select the diameter of the indenter as 10mm or 5 mm based on the thickness of the specimen and place it in 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 the specimen 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 from 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 Brinell microscope and find the Brinell hardness number using formula.
13. Repeat the above procedure for three to four times.



Indentation image



XII Resources Used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Room temperature –

S.N.	Test specimen material	Dia. of indenter D mm	Applied load Kgf (F)	Diameter of indentation (d) mm			Average diameter (d)mm	Brinell Hardness Number
				1	2	3		
1								
2								
3								

Sample Calculation –

XVI Results

The Brinell hardness number of the give sample is -------

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the difference between Hardness & Hardenability?
2. Describe the surface conditions necessary for Brinell hardness testing.
3. Very hard materials cannot be tested in Brinell hardness testing machine. State the reason
4. List the different types of indenters used in hardness testing?
5. Thickness of the test piece must not be less than 8 times the depth of impression. Justify
6. List the materials which cannot be tested by Brinell hardness tester
7. Can cylindrical samples be tested on Brinell hardness tester?
8. State the reason for using ball indentors of different diameter for Brinell hardness testing
9. Can the sample after testing be used for the desired application? Justify

[Space for Answers]

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XX References / Suggestions for further Reading

1. https://youtu.be/6I2yMEVLclc?t=96
2. https://youtu.be/RJXJpeH78iU?t=3
3. https://youtu.be/Az4QF5uIew8?t=17
4. https://youtu.be/8Jx7sSNGsfw?t=19
5. https://youtu.be/9Bb884w5fEE?t=41

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**60%**
1	Preparation of experimental set up , Selection of indentor and weight	20%
2	Following procedure	15%
3	Measurement of diameter	15%
4	Cleanliness	5%
5	Safety precautions	5%
Product Related (10 Marks)		**40%**
6	Calculation of BHN	10%
7	Interpretation of result	10%
8	Conclusions	10%
9	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 04: Hardness Testing Using Rockwell Hardness Tester

I Practical Significance

In the industry, it has become practice to understand hardness as the indentation hardness only, unless otherwise specified. The Rockwell hardness test is probably the most widely used method of hardness testing. It is developed with the depth of penetration as the criterion for the hardness of the metal. This concept was proposed in 1908 by Ludwig at Vienna.

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of Rockwell hardness testing machine, optical microscope
2. Check the correctness of specimen for hardness testing

IV Relevant Course Outcomes

(a) Identify properties of materials

V Practical Outcome

Use Rockwell hardness tester to determine hardness of a given sample.

VI Relevant Affective domain unrelated Outcome(s)

a) Follow safety practices.
b) Practice good housekeeping.
c) Demonstrate working as a leader/a team member.
d) Maintain tools and equipment.
e) Follow ethical Practices

VII Minimum Theoretical Background

Rockwell hardness test differs from Brinell hardness test in that the hardness is determined from the depth of indentation made by the indenter under a constant load. Various types of indenters may be used in Rockwell hardness tests: diamond indenter and steel-ball indenters of diameter 1/16, 1/8, 1/4, or 1/2 inch. In this test, the indenter is pressed into the specimen surface under an initial minor (light) load followed by a

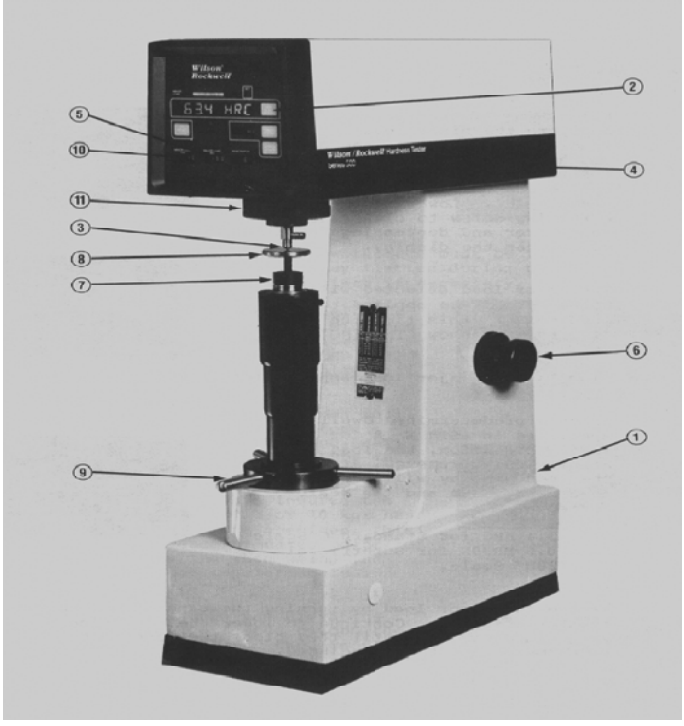
major (heavy) load. The additional depth of indentation made by the indenter under the major load beyond that by the minor load is measured and converted to a hardness number. The hardness number is inversely related to the depth of indentation. In regular Rockwell hardness tests, the minor load is always 10 kg while the major load can be 60, 100, or 150 kg. A letter is assigned to each scale that employs a particular combination of indenter and major load. A hardness number is suffixed by first the letter H (for hardness), then the letter R (for Rockwell), and finally the letter that indicates the scale used. For example, a value of 45 on the Rockwell C scale is expressed as 45 HRC.

Rockwell hardness tester gives the direct reading of hardness number on a dial provided with the machine. The specimen may be cylinder, cube, thick or thin metallic sheets.

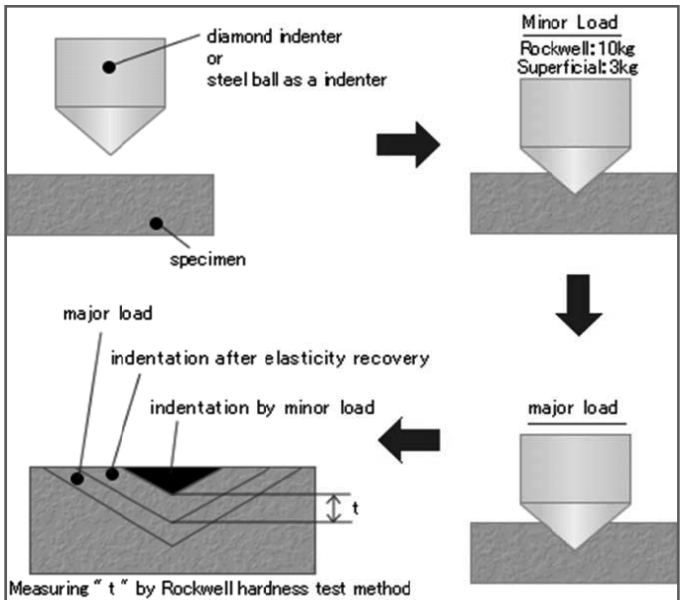
Type of specimen	Type of Indentor	Scale	Total load(P) Kg-F
Hard Metals	Diamond cone	C (Black graduations)	150
Soft Metals	Ball (1/16”)	B (Red graduations)	100

Indentor Types

VIII Experimental set-up



1. Power switch
2. Test scale scroll key
3. Indenter
4. Indenter display
5. Major load (kg) display
6. Weight selector dial
7. Anvil
8. Specimen
9. Capstan hand wheel
10. Minor load (kg) display



Rockwell Hardness Tester

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Rockwell Hardness Testing Machine	10 kgf minor load and major loads; are 60,100,150kgf.; with Rockwell hardness scales HRA, HRB, HRC. Different types of indentors (Diamond / Ball); Test height x Throat is - 215 x 132 mm; Extra test height and throat of 295 x 148 mm, Machines strictly conforms to IS:1586-2000	2	
2	Digital Rockwell hardness tester	Easy-to-use Electronics Console Hi/Lo Tolerance Settings, Adjustable Time @ Load Average Test Group Results 2-9; Test Result Memory Capacity 5000 results, RS232 Output,- Average Range.	2	
3	Set of standard specimen	Hardened steel, Mild steel, Brass, Copper, Aluminium	2	

X Precautions (if any)

1. The surface on which the Rockwell impression is to be made should be flat and sufficiently smooth.
2. Specimen should be cleanand free from scale, pits, and foreign materials.

3. The bottom surface also should be free from scale, dirt, or other foreign substances that might crush or flow under the test pressure and so affect the results.
4. Apply the load slowly and gradually on the sample
5. Distance between old impression and location for new impression should be 3D (three times the ball diameter)
6. The thickness of the test piece must not be less than 8 times the depth of impression

XI Procedure

1. Turn power switch located in lower rear panel "ON".
2. Select desired scale by means of the "TEST SCALE SCROLL". This key may be depressed for each scale advancement or held in for rapid scrolling.
3. Select and install the proper indenter, as indicated in the "PENETRATOR" display.
4. Select the proper major load, as indicated in the "MAJOR LOAD kg" display, by means of the weight selector dial.
5. Place the specimen on the anvil.
6. Raise specimen into contact with the indenter by turning capstan hand wheel clockwise slowly. The bar LEDs (red) will light up and the read display will show "MINOR LD".
7. Continue to slowly turn the capstan hand wheel. Stop the hand wheel when the bar LEDs reach the "SET" zone. The major load will automatically be applied and then removed. The read display will show "TESTING" and then the numerical value and the scale tested.
8. Remove the minor load by turning the capstan hand wheel counter-clockwise. Continue to lower the specimen until it clears the indenter. The test is concluded.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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……

XIV Precautions followed

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……
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XV Observations and Calculations

Room temperature –

S.N.	Material	Thickness	Scale	Type of Indenter	Minor Load	Major Load	Measured Hardness			Average Rockwell Hardness
					kgf	kgf	1	2	3	
1										
2										
3										

Sample calculation –

XVI Results

The Rockwell hardness number of the give material is **-------**

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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(**Hint)** The given sample can be used for high/medium/low hardness application.

XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the purpose of applying the minor load in case of Rockwell Hardness test?
2. State the different types of indenters used in hardness testing?
3. Explain surface condition requirement for Rockwell hardness testing with justification.
4. State the factors which affect the hardness measurement?
5. State the reason for taking at least three readings for hardness testing.
6. State the other methods of hardness measurement.
7. Differentiate other hardness measurement methods with Rockwell method.
8. State the conditions in which hardness measurement by Rockwell method may not be preferred.
9. Can temperature of the surrounding affect hardness of the material?
10. State the course of action to be taken with justification if there is considerable difference between the three readings of hardness of the same sample.

[Space for Answers]

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XX References / Suggestions for further Reading

a) https://youtu.be/NlWVmp_q_XE?t=10
b) https://youtu.be/KptkaeXiIs0?t=8
c) https://youtu.be/R3NUpHKviRU?t=4
d) https://youtu.be/G2JGNlIvNC4?list=PLHeMUbM1Zwsc8E3xaq8fu5kqOszaBQtHK&t=9
e) https://youtu.be/cYzAw9zZbR8?t=113

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (15Marks)		**60%**
1	Preparation of experimental set up	20%
2	Selection of scale, indentor and major weight	15%
3	Following procedure	15%
4	Cleanliness	5%
5	Safety precautions	5%
Product Related (10Marks)		**40%**
6	Calculation of RHN	10%
7	Interpretation of result	10%
8	Conclusions	10%
9	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 05: Hardness Testing of Mild Steel Before and After Heat Treatment

I Practical Significance

Hardness testing provides useful information, which can be correlated to tensile strength, wear resistance, ductility, and other physical characteristics. Hardness testing is therefore useful for monitoring quality control and for the materials selection process.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, martempering, and austempering.

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Specimen identification skills.
2. Specimen mounting skills.
3. Use box furnace to give different heat treatment.
4. Use hardness tester to measure hardness

IV Relevant Course Outcomes

(a) Identify properties of materials.
(b) Select relevant heat treatment process.
(c) Select relevant ferrous materials for mechanical components.

V Practical Outcome

Use Rockwell hardness tester to determine hardness of a given sample.

VI Relevant Affective domain related Outcome(s)

a) Follow safety practices.
b) Practice good housekeeping.
c) Demonstrate working as a leader/a team member.
d) Maintain tools and equipment.
e) Follow ethical Practices

VII Minimum Theoretical Background

Ferrous materials can be heated to above transformation temperature and can be heat treated to obtain different structure. The different heat treatment processes are based on heating the material to certain temperature and employing different cooling rates. In this process, heating temperature and rate of cooling adopted plays an important role.

The different processes are:

1. Annealing
2. Stress-relief annealing.
3. Process annealing.
4. Spheroidising.
5. Full annealing.
6. Normalizing
7. Hardening
8. Tempering

Annealing:

Annealing primarily is the process of heating a metal which is in a metastable or distorted structural state, to a temperature which will remove the instability or distortion and then cooling it to the room temperature so that the structure is stable and/or strain free.

Purpose of Annealing:

1. Removal of residual stress.
2. Refining and homogenizing the structure and to give a coarse pearlite structure.
3. Improving machinability.
4. Improving cold working characteristics for facilitating further cold work.
5. Producing desired microstructure.
6. Removing residual stresses.
7. Improving mechanical, physical, electrical and magnetic properties.
8. Reducing hardness.

Normalizing:

This process involves heating the metal above the transformation temperature up to 900º C and cooling from that temperature adopting the required rate of cooling. This process involves:

- Heating the metal to around 900º C so that the metal transforms completely into austenite.
- Holding at that temperature for some times (3minutes / mm of thickness)
- Cooling at a rate of 80º C to 90º C per hour up to 700ºC
- Then air – cooled from 700º C to room temperature.

Purpose of Normalizing:

1. Refining the grain structure and giving a fine pearlite structure.
2. Producing a uniform structure.
3. Achieving the required strength and ductility in a steel that is too soft and ductile for machining.
4. Improving structures in welds.
5. In general, improving engineering properties of steels.

Hardening: (By Quenching)

Hardening is performed on metals to obtain desired hardness and structure. It involves:

- Heating the metal above transformation temperature, around 900ºC
- Holding at that temperature for 15 to 30 minutes per 25mm of cross-section.

- Quenching it immediately in a suitable cold medium (brine solution, Water, oil etc.)

Hardness obtained will depend upon the Composition of the material, nature and properties of quenching medium and quenching temperature.

Properties obtained by hardening are:

- Desired hardness can be obtained.
- Strength of material is increased.
- Wear resistance is increased.
- Martensite structure is obtained.

Tempering:

Hardening of metal produces Martensite structure with some retained austenite. The martensite structure makes the metal very hard and brittle. The retained austenite is unstable and it will change with time. This transformation of retained austenite even at room temperature leads to distortion of metal. Due to these factors the hardened metal cannot be used as it is. Hence tempering is carried out on the metals.

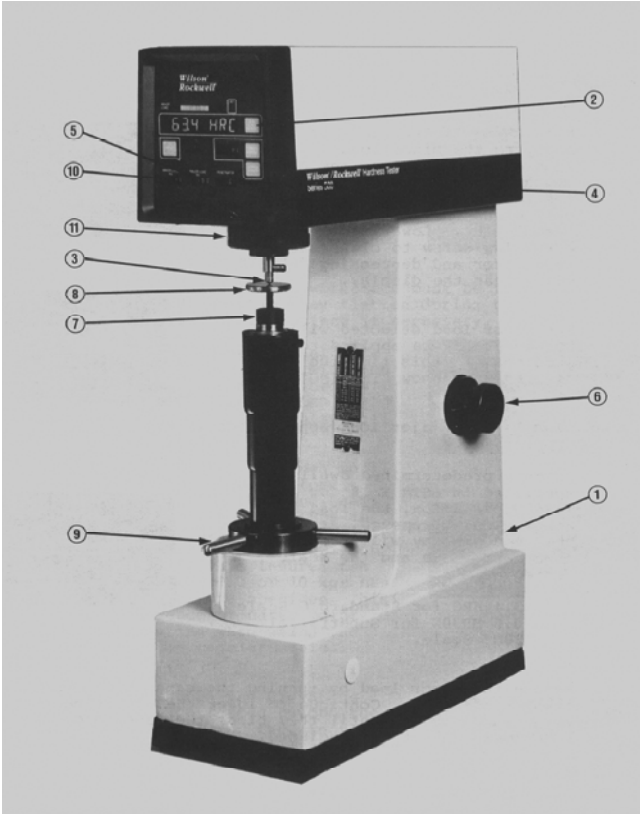
Tempering treatment involves:

Heating the metal just above Martensite structure temperature (50º C), holding it at that temperature for some time and then cooling either rapidly or slowly. The purpose of tempering is to remove brittleness and improve ductility in the material.

The Properties obtained after Tempering are:

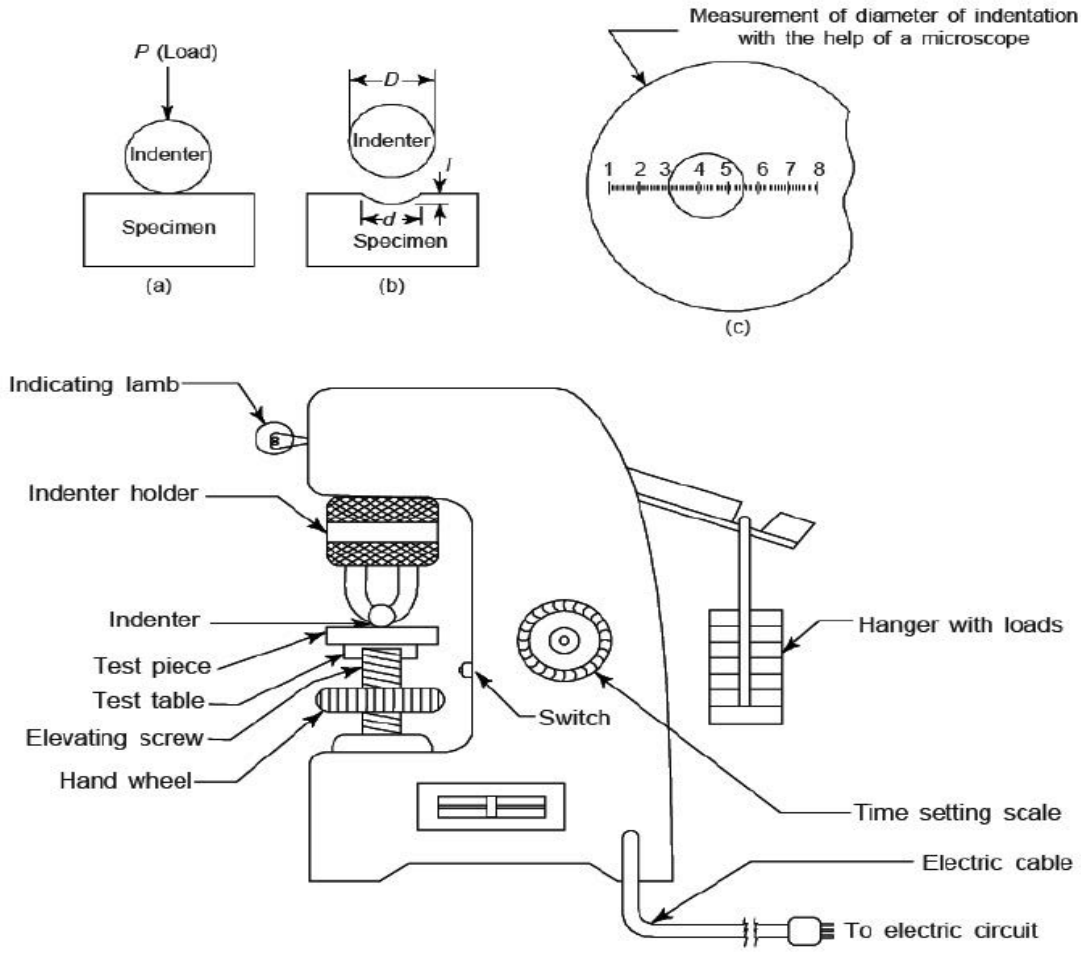
1. Improvement in ductility and toughness.
2. Slight reduction in hardness.
3. Increase in tensile strength.
4. Reduction in internal stress.

VIII Experimental set-up

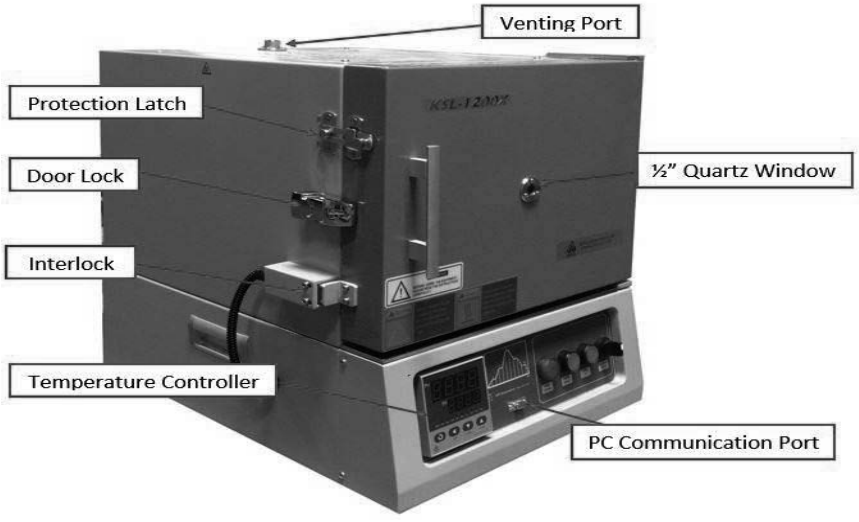


1. Power switch
2. Test scale scroll key
3. Indenter
4. Indenter display
5. Major load (kg) display
6. Weight selector dial
7. Anvil
8. Specimen
9. Capstan hand wheel
10. Minor load (kg) display

Rockwell Hardness Tester



Brinell hardness testing machine



Box Furnace

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remarks
1.	Brinell Hardness tester	Ball Indenter of diameter 2.5mm and 5mm,Maximum application of load =250 Kgf, Ability to determine hardness up to =1411 BHN	01	
2.	Rockwell Hardness tester	Diamond cone indenter, ball indenter. Ability to determine hardness up to = 100 RHN, Maximum application of load = 150 Kgf	01	
3.	Laboratory box furnaces	1200°c	02	
4.	Mild steel Specimen (without heat treatment)	Thickness :- Standard	01	
5.	Mild steel Specimen (with heat treatment)	Thickness:- Standard	01	

X Precautions (if any)

Rockwell hardness tester

1. The surface on which the Rockwell impression is to be made should be flat and sufficiently smooth
2. Specimen should be cleanand free from scale, pits, and foreign materials.
3. The bottom surface also should be free from scale, dirt, or other foreign substances that might crush or flow under the test pressure and so affect the results.
4. Apply the load slowly and gradually on the sample
5. Distance between old impression and location for new impression should be 3D (three times the ball diameter)
6. The thickness of the test piece must not be less than 8 times the depth of impression

Laboratory box furnaces

1. Use tongs to insert or remove the specimens from the furnace.
2. Use insulating gloves to open or close the doors to the furnaces.
3. Either cool the specimens immediately after removal from the furnace or place in a designated area for slow cooling. Hot specimens should not be left in the open where may be accidentally touched.
4. The furnaces should be turned off when not in use.
5. If specimens are left in a furnace and the area is abandoned by the student, a sign must be left with a name and phone number and time for removal.

6. Quenching samples in oil can cause the oil to ignite. Be prepared to cover the container after immersion.
7. Use baskets or tongs for quenching in oil or water.

XI Procedure

Hardness Tester

1. Turn power switch located in lower rear panel "ON".
2. Select desired scale by means of the "TEST SCALE SCROLL". This key may be depressed for each scale advancement or held in for rapid scrolling.
3. Select and install the proper indenter, as indicated in the "PENETRATOR" display.
4. Select the proper major load, as indicated in the "MAJOR LOAD kg" display, by means of the weight selector dial.
5. Place the specimen on the anvil.
6. Raise specimen into contact with the indenter by turning capstan hand wheel clockwise slowly. The bar LEDs (red) will light up and the read display will show "MINOR LD".
7. Continue to slowly turn the capstan hand wheel. Stop the hand wheel when the bar LEDs reach the "SET" zone. The major load will automatically be applied and then removed. The read display will show "TESTING" and then the numerical value and the scale tested.
8. Remove the minor load by turning the capstan hand wheel counter-clockwise. Continue to lower the specimen until it clears the indenter. The test is concluded.

Heat treatment

1. First, the samples should be checked for hardness.
2. Then, keep them in furnace at 900°C for ½ an hour.
3. Afterwards, one sample is cooled to room temperature in air while other is quench hardened followed by again keeping it in furnace but now at 200-250°C.
4. Then, this sample is also air cooled.
5. As such, one sample is normalized and the other is tempered. Now, the samples are grinded and polished to obtain a flat surface and hardness of both the samples is checked again.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Brinell Hardness Measurement

SR No	Specimen	Indenter Diameter (D) mm	Total Load(P) Kgf	Diameter of Indentation (d) mm			Avg. Diameter d_{avg}	BHN
				1	2	3		
1	Mild steel Specimen (without heat treatment)							
2	Mild steel Specimen (with heat treatment)							

Rockwell Hardness Measurement

SR No	Specimen	Type of Indenter	Rockwell Hardness Number(RHN)			Avg. RHN
			1	2	3	
1	Mild steel Specimen (without heat treatment)					
2	Mild steel Specimen (with heat treatment)					

Calculations

For Brinell Hardness-

Brinell Hardness Number (BHN) $= \frac{2P}{\pi D[D-\sqrt{D^2-d^2}]}$

XVI Results

1. The Rockwell hardness number of mild steel before heat treatment is ……
2. The Rockwell hardness number of mild steel after heat treatment is …….
3. The Brinell Hardness Number before Heat Treatment ……
4. The Brinell Hardness Number after Heat Treatment ……

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Give the composition of mild steel.
2. State effect of constituting elements on the properties of mild steel.
3. Draw iron-carbon diagram. Showing important phases.
4. State the effect of heat treatment on the properties of mild steel.
5. State various applications of mild steel.
6. State the limitations of mild steel.
7. Suggest various methods to improve properties of mild steel with justification.
8. List 5 applications with justification where mild steel is not a good choice.

[Space for Answers]

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XX References / Suggestions for further Reading

1. https://youtu.be/_yonqoGymzE?t=381
2. https://youtu.be/kLbbR_cpBnk?t=48
3. https://youtu.be/J8r6wRvskxU?t=14

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (15Marks)		**60%**
1	Preparation of experimental set up	20%
2	Selection of scale, indentor and major weight	15%
3	Following procedure	15%
4	Cleanliness	5%
5	Safety precautions	5%
Product Related (10Marks)		**40%**
6	Calculation of hardness	10%
7	Interpretation of result	10%
8	Conclusions	10%
9	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.6: Hardness Testing of Alloy Steel before and after Heat Treatment

I Practical Significance

Hardness Testing provides useful information, which can be correlated to tensile strength, wear resistance, ductility, and other physical characteristics. Hardness testing is therefore useful for monitoring quality control and for the materials selection process. 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, martempering, and austempering.

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Specimen identification skills.
2. Specimen mounting skills.
3. Use box furnace to give different heat treatment.
4. Use hardness tester to measure hardness

IV Relevant Course Outcomes

(a) Identify properties of materials
(b) Select relevant heat treatment process
(c) Select relevant ferrous materials for mechanical components

V Practical Outcome

Use relevant hardness tester to determine hardness of a given sample of alloy steel before and after heat treatment.

VI Relevant Affective domain related Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.

d. Maintain tools and equipment.
e. Follow ethical Practices.

VII Minimum Theoretical Background

Ferrous materials can be heated to above transformation temperature and can be heat treated to obtain different structure. The different heat treatment processes are based on heating the material to certain temperature and employing different cooling rates. In this process, heating temperature and rate of cooling adopted plays an important role.

The different processes are:

1. Annealing
2. Stress-relief annealing.
3. Process annealing.
4. Spheroidising.
5. Full annealing.
6. Normalizing
7. Hardening
8. Tempering

Annealing:

Annealing primarily is the process of heating a metal which is in a metastable or distorted structural state, to a temperature which will remove the instability or distortion and then cooling it to the room temperature so that the structure is stable and/or strain free.

Purpose of Annealing:

1. Removal of residual stress.
2. Refining and homogenizing the structure and to give a coarse pearlite structure.
3. Improving machinability.
4. Improving cold working characteristics for facilitating further cold work.
5. Producing desired microstructure.
6. Removing residual stresses.
7. Improving mechanical, physical, electrical and magnetic properties.
8. Reducing hardness.

Normalizing:

This process involves heating the metal above the transformation temperature up to 900º C and cooling from that temperature adopting the required rate of cooling.

This process involves:

- Heating the metal to around 900º C so that the metal transforms completely into austenite.
- Holding at that temperature for some times (3minutes / mm of thickness)
- Cooling at a rate of 80º C to 90º C per hour up to 700ºC
- Then air – cooled from 700º C to room temperature.

Purpose of Normalizing:

1. Refining the grain structure and giving a fine pearlite structure.
2. Producing a uniform structure.
3. Achieving the required strength and ductility in a steel that is too soft and ductile for machining.
4. Improving structures in welds.
5. In general, improving engineering properties of steels.

Hardening: (By Quenching)

Hardening is performed on metals to obtain desired hardness and structure. It involves:

- Heating the metal above transformation temperature, around 900ºC
- Holding at that temperature for 15 to 30 minutes per 25mm of cross-section.
- Quenching it immediately in a suitable cold medium (brine solution, Water, oil etc.)

Hardness obtained will depend upon the composition of the material, nature and properties of quenching medium and quenching temperature.

Properties obtained by hardening are:

- Desired hardness can be obtained.
- Strength of material is increased.
- Wear resistance is increased.
- Martensite structure is obtained.

Tempering:

Hardening of metal produces martensite structure with some retained austenite. The martensite structure makes the metal very hard and brittle. The retained austenite is unstable and it will change with time. This transformation of retained austenite even at room temperature leads to distortion of metal. Due to these factors the hardened metal cannot be used as it is. Hence tempering is carried out on the metals.

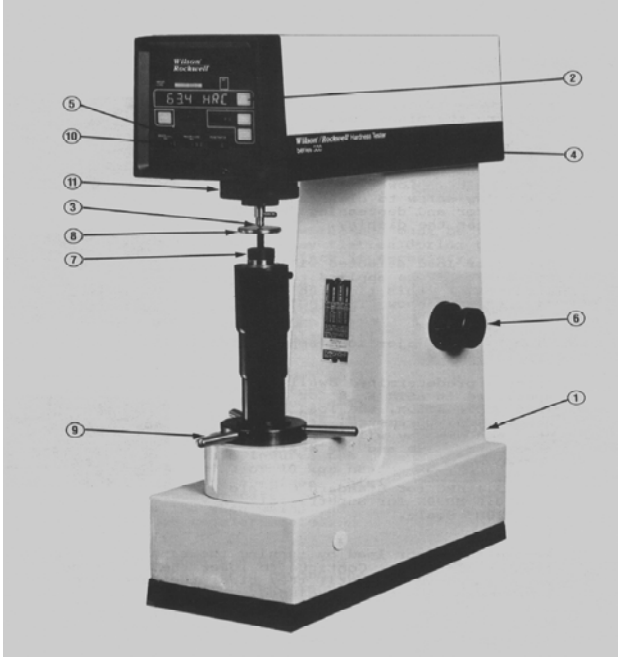
Tempering treatment involves:

Heating the metal just above Martensite structure temperature (50 O C), holding it at that temperature for some time and then cooling either rapidly or slowly. The purpose of tempering is to remove brittleness and improve ductility in the material.

The Properties obtained after Tempering are:

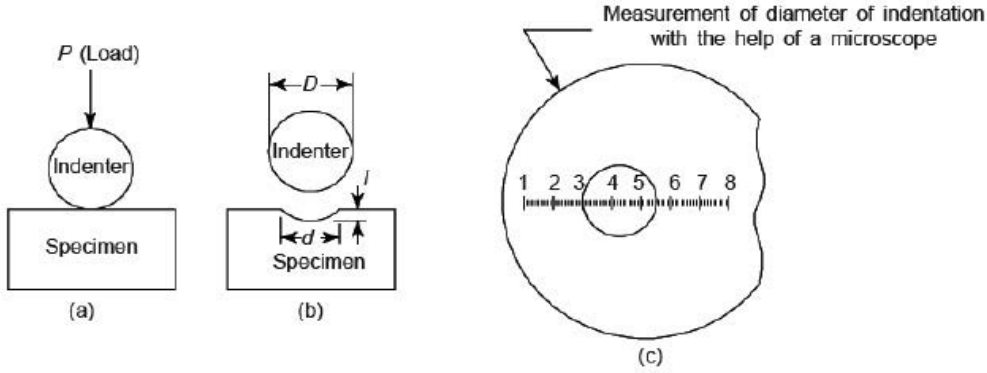
1. Improvement in ductility and toughness.
2. Slight reduction in hardness.
3. Increase in tensile strength.
4. Reduction in internal stress.

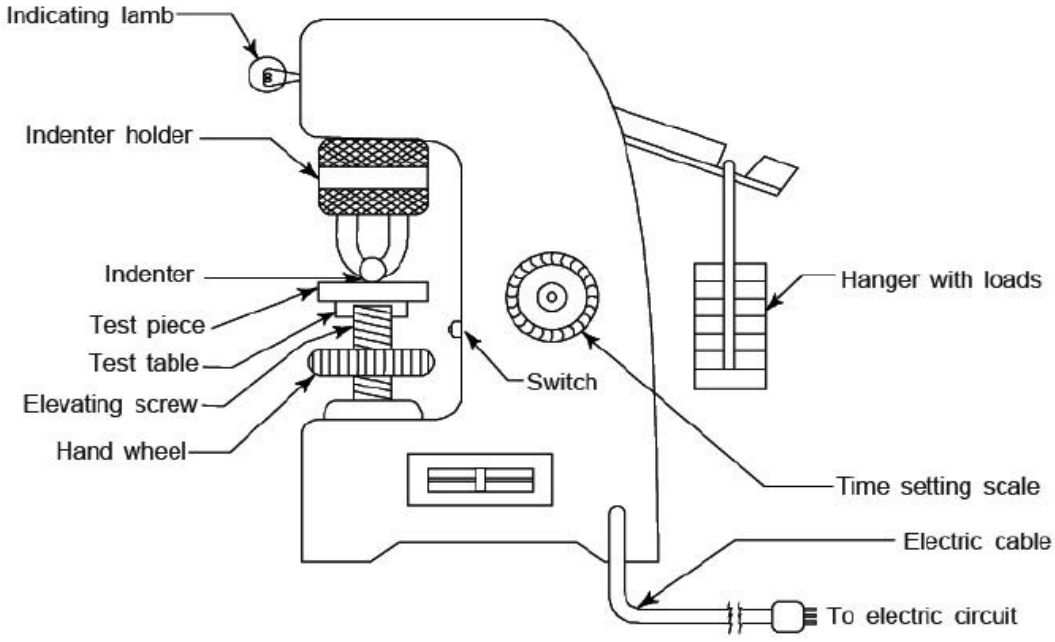
VIII Experimental setup



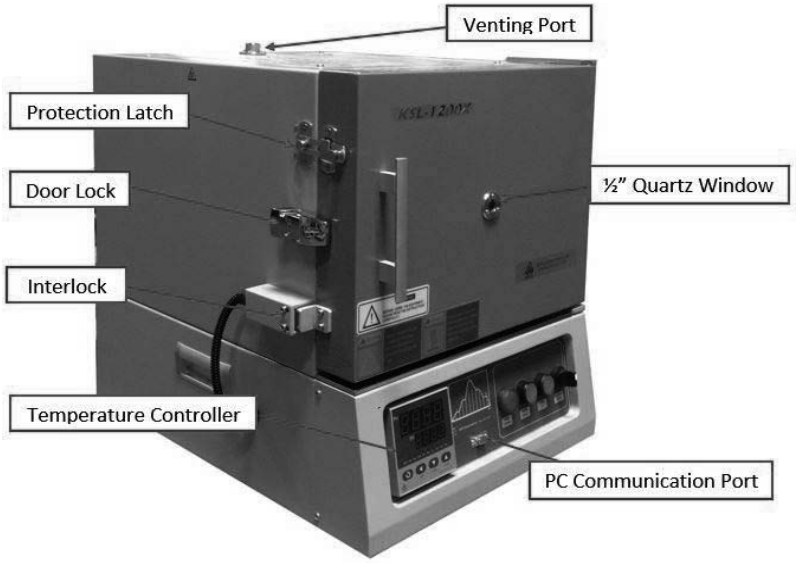
1. Power switch
2. Test scale scroll key
3. Indenter
4. Indenter display
5. Major load (kg) display
6. Weight selector dial
7. Anvil
8. Specimen
9. Capstan hand wheel
10. Minor load (kg) display

Rockwell Hardness Tester





Brinell hardness testing machine



Box furnace

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remarks
1.	Brinell Hardness tester	Ball Indenter of diameter 2.5mm and 5mm,Maximum application of load =250 Kgf, Ability to determine hardness up to =1411 BHN	01	
2.	Rockwell Hardness tester	Diamond cone indenter, ball indenter. Ability to determine hardness up to = 100 RHN, Maximum application of load = 150 Kgf	01	
3.	Laboratory box furnaces	1200°c	02	
4.	Alloy steel Specimen (without heat treatment)	Standard	01	
5.	Alloy steel Specimen (with heat treatment)	Standard	01	

X Precautions

1. Use tongs to insert or remove the specimens from the furnace.
2. Use insulating gloves to open or close the doors to the furnaces.
3. Either cool the specimens immediately after removal from the furnace or place in a designated area for slow cooling. Hot specimens should not be left in the open where may be accidentally touched.
4. The furnaces should be turned off when not in use.
5. If specimens are left in a furnace and the area is abandoned by the student, a sign must be left with a name and phone number and time for removal.
6. Quenching samples in oil can cause the oil to ignite. Be prepared to cover the container after immersion.
7. Use baskets or tongs for quenching in oil or water.

XI Procedure

1. First, the samples should be checked for hardness.
2. Then, keep them in furnace at 900°C for ½ an hour.
3. Afterwards, one sample is cooled to room temperature in air while other is

quench hardened followed by again keeping it in furnace but now at 200-250°C.

4. Then, this sample is also air cooled.
5. As such, one sample is normalized and the other is tempered. Now, the samples are grinded and polished to obtain a flat surface and hardness of both the samples is checked again.

For Brinell Test

1. Keep the loading and unloading lever at unloading position.
2. Select the suitable indenter & weights according to the scale.
3. Place the Alloy Steel (without Hardening) specimen on testing table anvil.
4. Turn the hand wheel to raise a job until it makes contact with indenter.
5. When the longer pointer of the dial gauge reaches steady position.
6. Remove the job from the platform and note down the diameter of the Indentation using Brinell microscope.
7. Similarly repeat the step for Alloy Steel (with Hardening) specimen

For Rockwell hardening Test

a. Keep the loading and unloading lever at unloading position.
b. Select the suitable indenter & weights according to the scale.
c. Place the specimen on testing table anvil.
d. Turn the hand wheel to raise a job until it makes contact with indenter.
e. When the longer pointer of the dial gauge reaches steady position take back the lever to the unloading position.
f. Turn back the hand wheel and remove the job.

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations:

a. Brinell Hardness Measurement

Sr No	Specimen	Indenter Diameter (D) mm	Total Load(P) Kgf	Diameter of Indentation (d) mm			Avg. Diameter d_{avg}	BHN
				1	2	3		
1	Alloy steel Specimen (without Hardening)							
2	Alloy steel Specimen (with Hardening)							

b. For Rockwell Hardness

SR No	Specimen	Type of Indenter	Rockwell Hardness Number(RHN)			Avg. RHN
			1	2	3	
1	Alloy steel Specimen (without Hardening)					
2	Alloy steel Specimen (with Hardening)					

Calculations

For Brinell Hardness-

Brinell Hardness Number (BHN) $= \frac{2P}{\pi D[D-\sqrt{D^2-d^2}]}$

XVI Results

1. The Rockwell hardness number of alloy steel before heat treatment is ……..
2. The Rockwell hardness number of alloy steel after heat treatment is ……..
3. The Brinell Hardness Number Before heat treatment is ……..
4. The Brinell Hardness Number after heat treatment is ……

XVII Interpretation of results

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XVIII Conclusions & Recommendation

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XIX Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Define heat treatment?
2. State the different types of heat treatment?
3. Enumerate the need for heat treatment of steel?
4. List different types of hardness testing methods?
5. Define BHN?
6. Differentiate between hardenability and hardness?
7. State the different types of indenters used in hardness testing?
8. State the factors which affect the hardness of steels?
9. State the reason for the minor load applied before applying the major load?
10. Derive the formula to calculate BHN.
11. Which steel sample was harder, the air-cooled or water quenched? Why was it harder?
12. Which steel alloy was harder? Why was it harder?
13. How did the different cooling rate affect the microstructure of the steel? Do these microstructures agree with what would be predicted from the TTT diagrams?
14. What did reheating do to the microstructure and properties of steels? Why?
15. Why are the steels heat treated?
16. If one of the specimens of the same kind of steel is normalized and the other is annealed, which will show more strength and why?
17. Out of the normalized and annealed samples, which one is more machinable and why?
18. How does the hardness vary with cooling rate?

[Space for Answers]

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XX References / Suggestions for further Reading

a. https://youtu.be/AwM1dOsWsoo?t=77
b. https://youtu.be/Cl0nBBu-gzA?t=53
c. https://youtu.be/fc8zrgYJCJw?t=75
d. https://youtu.be/UuHofNW40Yw?t=63

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Selection of scale, indenter and major weight	15%
3	Following procedure	15%
4	Cleanliness	5%
5	Safety precautions	5%
Product related (10 Marks)		**40%**
6	Calculation of hardness	10%
7	Interpretation of result	10%
8	Conclusions	10%
9	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 07: Metallographic Analysis of Cast Iron

I Practical Significance

Metallographic analysis is a valuable tool. By properly documenting the initial specimen condition and the further microstructural analysis, metallography provides a powerful quality control as well as an invaluable investigative tool.Metallurgical analysis (metallography) of the microstructure provides the Material Scientist or Metallurgist information about phase structure, grain size, solidification structure, casting voids, etc. Optical microscopy is sufficient for general purpose examination. For advanced examination research laboratories often use electron microscopes (SEM and TEM), x-ray and electron diffractometers or possibly other scanning devices.The effects of most industrial processes applied to metals to control their properties can be explained by studying their microstructures.

II Relevant Program Outcomes (POs)

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1- Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of Optical Microscope
2. Identification of Phases of microstructure

IV Relevant Course Outcomes

(a) Identify properties of materials.
(b) Select relevant cast ironfor mechanical components.

V Practical Outcome

Use metallurgical microscope to interpret micro structure of cast irons.

VI Relevant Affective domain related Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

VII Minimum Theoretical Background

Cast iron is an alloy of iron and carbon where the carbon content lies in a range between 2.1 and 6.67 wt%. .Cast iron is of following types

1. Grey cast iron
2. Nodular (ductile) cast iron
3. White cast iron
4. Malleable cast iron

Proper preparation of metallographic specimens requires that a rigid step-by-step process be followed. In sequence, the steps include sectioning, mounting, coarse grinding, fine grinding, polishing, etching and microscopic examination.

Sectioning is cutting the small piece of specimen from metal for examination.

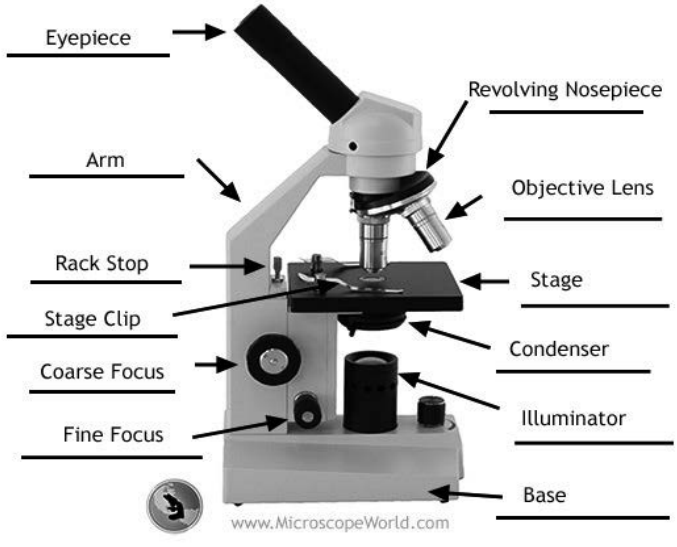
Grinding is an abrasive machining process that uses a grinding wheel as the cutting tool.

Polishing is the process of creating a smooth and shiny surface by rubbing it or using a chemical action, leaving a surface with a significant specular reflection.

Etchant	Composition	Application	Conditions
Vilella's Reagent	45 ml Glycerol 15 ml Nitric acid 30 ml Hydrochloric acid	Stainless steel, carbon steel, cast iron	Seconds to minutes

Bright Field (B.F.) illumination is the most common illumination technique for metallographic analysis. The light path for B.F. illumination is from the source, through the objective, reflected off the surface and returning through the objective and back to the eyepiece or camera. This type of illumination produces a bright background for flat surfaces with the non-flat features (pores, edges, etched grain boundaries) being darker as light is reflected back at an angle.

VIII Experimental set-up



Metallurgical Microscope

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Optical Microscope	Metallurgical Reflected light Microscope 6V, 30W, halogen Light,200x magnification, 191x126x100 mm specimen stage, size with 100 mm travel	05	
2	Standard cast iron Specimen	Rectangular shape 25 mm x 25 c/s area or circular shape of 25 mm diameter or as per the availability White cast iron,Gray cast iron,Malleable cast iron,Ductile cast iron	5 specimen	

X Precautions (if any)

1. All specimens are cut to a suitable size, and the smaller specimens mounted in thermo-plastic resin in a mould.
2. Sanding is done using successive grades of waxed emery paper, finishing at grade 000.
3. Polishing is done on a polishing machine, using a paste of magnesium oxide on selvyt cloth.
4. Etching is carried out with the reagent Nital, 4% Nitric Acid in Alcohol.

XI Procedure

1. Polish the specimen by using (80,120,240,400,600) grade emery papers. Subject the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive. Clean the specimen with alcohol and wash it under the stream of flowing water
2. After washing, the specimen is dried. After drying apply the suitable etching agent for 30 to 50 sec.
3. After etching wash the specimen under stream of flowing water.
4. Dry the specimen with the help of air drier.
5. Place the specimen for metallurgical studies.
6. Draw the microstructure and analyze the properties.

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations (Draw microstructure & state properties)

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XVI Results

For each feature, one normally records the following characteristics:

1. Shape
2. Size
3. Color (in plane polarized light or with crossed polars)
4. Distribution

XVII Interpretation of results

S. No	The magnification used	Important phases noted	Shape	Size	Color	Distribution
1						
2						
3						

XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Based on the observed microstructure of the cast iron sample, can you determine the carbon content of the cast iron? If yes, then briefly explain how you can determine the carbon content.
2. State the type of cast iron is more ductile in comparison to others?
3. On the basis of microstructure, explain why gray cast iron is brittle and weak in tension?
4. Is it possible to produce malleable cast iron in pieces having large cross sectional dimensions? Explain the reason.
5. Compare gray and malleable cast irons with respect to (a) Microstructure and (b) Mechanical characteristics.

[Space for Answers]

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XX References / Suggestions for further Reading

a. https://www.youtube.com/watch?v=are5impxItM
b. https://www.youtube.com/watch?v=LznZz38OUCk
c. https://www.youtube.com/watch?v=_UtPvltK38w
d. https://www.youtube.com/watch?v=b2PCJ5s-iyk
e. https://www.youtube.com/watch?v=Jx_ZjY-u2rk

***Note :** please verify whether the above resources have a license which permits its free use.

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**70%**
1	Preparation of experimental set up	10
2	Etching the specimen with suitable etchant	30
3	Observation of the microstructure of the specimen at different magnification using microscope	30
Product related (10 Marks)		**30%**
4	Follow Safety measures	10
5	Answer experiment related questions	10
6	Submit journal report on time	5
7	Follow Housekeeping	5
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.08: Metallographic Analysis of Aluminum

I Practical Significance

The examination of microstructure is one of the principal means of evaluating alloys and products to determine the effects of various fabrication and thermal treatments and to analyse the cause of failure. Main microstructural changes occur during freezing, homogenisation, hot or cold working, annealing, etc. In general, the metallography of aluminium and its alloys represent a great variety of chemical compositions and thus a wide range of hardness and different mechanical properties. One specific alloy can contain several microstructural features, like matrix, second phases, dispersoids, grains, sub grains and thus grain boundaries or sub boundaries according to the type of the alloy and its thermal or thermo mechanical history. However, some methods of sample preparation and observation are quite general and apply to all aluminium alloys.

II Relevant Program Outcomes (POs)

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1- Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of Optical Microscope
2. Identification of Phases of microstructureof given Aluminum sample
3. Select appropriate Aluminum for relevant application

IV Relevant Course Outcomes

(a) Identify properties of materials.
(b) Use non-ferrous metals for mechanical components.

V Practical Outcome

Use metallurgical microscope to interpret micro structure of aluminum.

VI Relevant Affective domain related Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.

e. Follow ethical Practices.

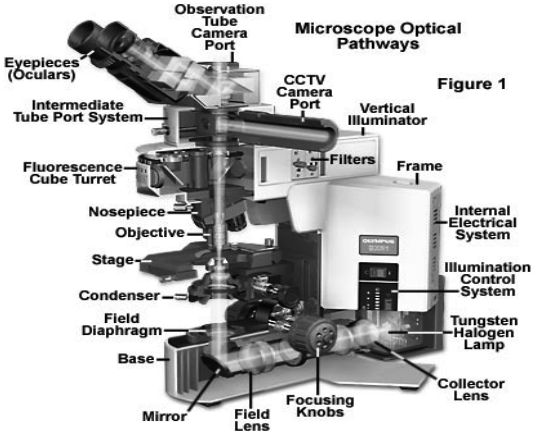
VII Minimum Theoretical Background

Metallography is the general study of metals and their behavior, with particular reference to their microstructure and macrostructure. Microstructure is the characteristic appearance and physical arrangement of metal molecules as observed with a microscope. Preparation of specimen is necessary to study its microstructure. The metallurgical microscope makes use of the principle of reflection of light from the specimen to obtain the final image of the metal structure.

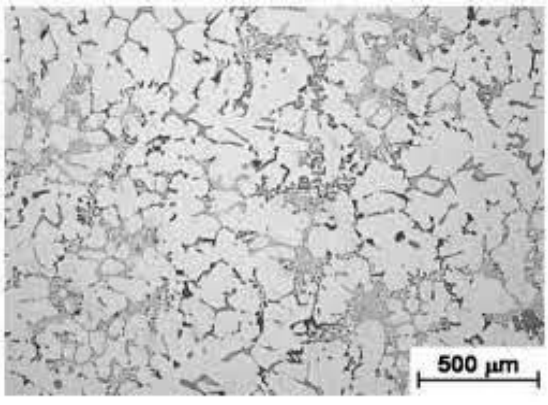
Nonferrous metals and alloys contain elements other than iron as a main constituent. They exhibit different properties compared to ferrous metals and alloys. Hence their application also differs from ferrous metals. Aluminum is a soft, silvery metal with a face-centered cubic crystal structure. Aluminum, like chromium, niobium and titanium, is very corrosion resistant and a thin, transparent oxide film will form on a freshly polished surface. This film is responsible for its good corrosion resistance, but also makes etching difficult. Aluminum alloys contain a rather high content of intermetallic precipitates. Aluminum and its alloys are low in strength and hardness.

Etchant	Composition	Application	Conditions
***Kellers*Reagent**	Distilled water 190 ml Nitric acid 5 ml Hydrochloric acid 3 ml Hydrofluoric acid2 ml	For most aluminum and aluminum alloys	10-30 second immersion Use fresh eagent for each immersion
	Methanol 25 ml Hydrochloric acid 25 ml Nitric acid 25 ml Hydrofluoric acid 1 drop	Pure aluminum, aluminum-magnesium, and aluminum-magnesium-silicon alloys	10-60 seconds
Krolls Reagent	Distilled water 92 ml Nitric acid 6 ml Hydrofluoric acid 2 ml	Aluminum-copper alloys	15 seconds

VIII Experimental set-up



Metallurgical Microscope



Microstructure of Aluminium

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Optical Microscope	Metallurgical Reflected light Microscope 6V, 30W halogen Light, 200X magnification, 191x126x100 mm specimen stage ,Size with 100 mm travel	05	
2	Standard specimen of Aluminum	Rectangular shape 25 mm x 25 c/s area or circular shape 25 mm diameter or as per the availability	5 specimen of each type	

X Precautions (if any)

1. All specimens are cut to a suitable size, and the smaller specimens mounted in thermo-plastic resin in a mould.
2. Sanding is done using successive grades of waxed emery paper finishing at grade 000.
3. Polishing is done on a polishing machine, using a paste of magnesium oxide on selvyt cloth.
4. Uniform pressure is applied throughout the polishing
5. Etching is carried out with the reagent Nital, 4% Nitric Acid in Alcohol.

XI Procedure

1. Polish the specimen by using (80,120,240,400,600) or (1/0, 2/0,3/0,4/0,) grade emery papers. Polish the given specimen to mirror like finish by using disc polishing machine and with suitable abrasive. Clean the specimen with alcohol and wash it under the stream of flowing water
2. After washing the specimen is dried. After drying, apply the suitable etching agent for 30 to 50 sec.
3. After etching wash the specimen under stream of flowing water.
4. Dry the specimen with the help of air drier.
5. Place the specimen for metallurgical studies.
6. Draw the microstructure and analyze the properties

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Table 1: microstructure observations

S. No	The magnification used	Important phases noted	Shape	Size	Color	Distribution
1						
2						
3						

XVI Results

For each feature, one normally records the following characteristics:

1. Shape
2. Size
3. Color (in plane polarized light or with crossed polars)
4. Distribution

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the specifications of grinding and polishing machines?
2. Define lapping? Which degree of accuracy can be achieved in metals by polishing?
3. Grinding performed before polishing? Justify
4. State the need for polishing on four grades of emery paper?
5. State the reason for specimen rotated by 90°, while changing from one grade of emery paper to another?
6. Dry polishing done before wet polishing? Give reason
7. State the purpose of wet polishing after dry polishing?
8. Alumina powder used in wet polishing? Give reason
9. State the purpose of etching?
10. Name the etchants use for etching Mild steel, Aluminium and Copper.
11. State the principle of working of metallurgical microscope
12. Draw neatly the microstructure of all the samples as observed under optical microscope. State the machines materials and etchants used. Write the optimum time required to obtain a reasonably good microstructure.
13. Describe Microscopy?
14. It is necessary to mount the specimen before grinding and polishing? Justify
15. List the different etching agents used for specimen preparations?
16. Draw the microstructure of pure Aluminum.

[Space for Answers]

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XX References / Suggestions for further Reading

a. https://www.youtube.com/watch?v=are5impxItM
b. https://www.youtube.com/watch?v=LcXnWh_2Zxk
c. https://www.youtube.com/watch?v=fc8zrgYJCJw
d. https://www.youtube.com/watch?v=LznZz38OUCk

***Note :** please verify whether the above resources have a license which permits its free use.

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20
2	Etching the specimen with suitable etchant	20
3	Observation of the microstructure of the specimen at different magnification using microscope	20
Product related (10 Marks)		**40%**
4	Follow Safety measures	10
5	Answer experiment related questions	10
6	Submit journal report on time	10
7	Follow Housekeeping	10
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.9: Determination of the Hardness of Copper

I Practical Significance

Hardness Testing provides useful information, which can be correlated to tensile strength, wear resistance, ductility, and other physical characteristics. Hardness testing is therefore useful for monitoring quality control and for the materials selection process.

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Specimen identification skills.
2. Specimen mounting skills.
3. Use hardness tester to measure hardness.

IV Relevant Course Outcomes

(a) Identify properties of materials

(b) Use non-ferrous metals for mechanical components

V Practical Outcome

Use relevant hardness tester to determine hardness of a Copper.

VI Relevant Affective domain related Outcome(s)

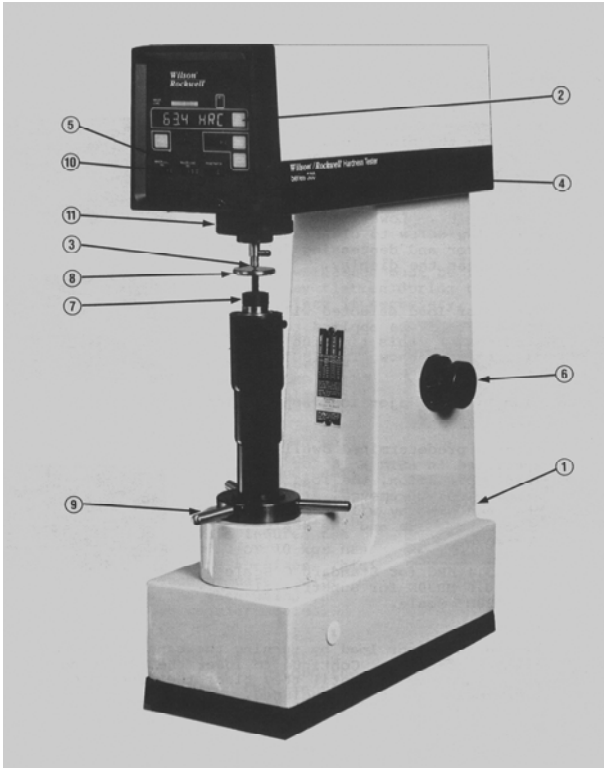
a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/team member.
d. Maintain tools and equipments.
e. Follow ethical practices.

VII Minimum Theoretical Background

Hardness of a material is generally defined as resistance to the permanent indentation under static and dynamic load. When a material is required to use under direct static or dynamic loads, only indentation hardness test will be useful to find out resistance to indentation. The Rockwell hardness test procedure of copper covers thirty different

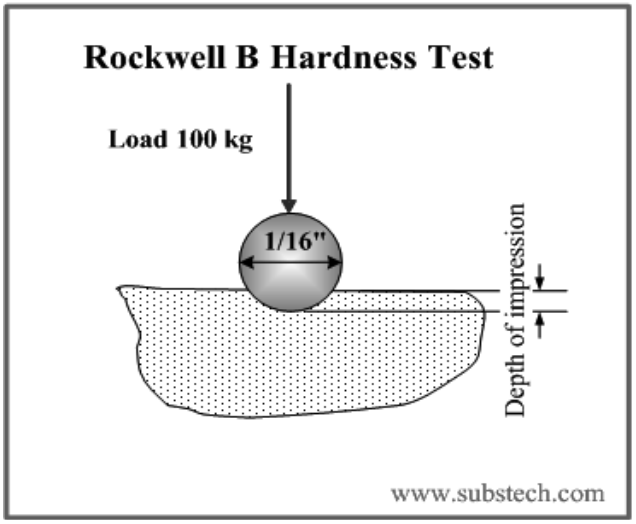
tests (scales) with various loads and indenter configurations. The most common Rockwell scales, B and C, are used for copper alloys only when the part thickness is greater than 0.04 inch (1 mm).

VIII Experimental setup

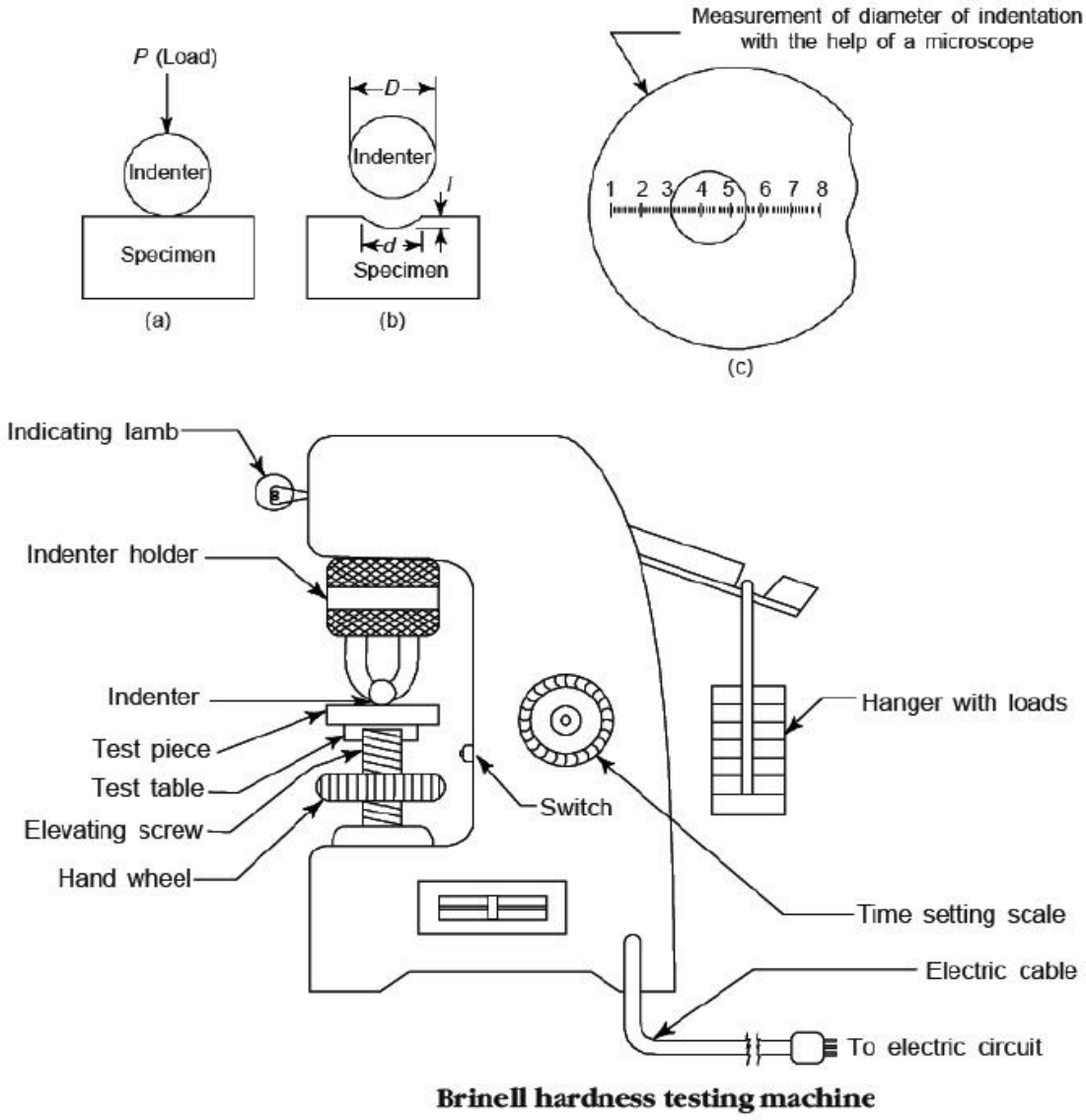


1. Power switch
2. Test scale scroll key
3. Indenter
4. Indenter display
5. Major load (kg) display
6. Weight selector dial
7. Anvil
8. Specimen
9. Capstan hand wheel
10. Minor load (kg) display

Rockwell Hardness Tester



Indentation



Brinell hardness testing machine

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remarks
1.	Brinell hardness tester	Ball Indenter of diameter 2.5mm and 5mm,Maximum application of load =250 Kgf, Ability to determine hardness up to =1411 BHN	01	
2.	Rockwell hardness tester	Diamond cone indenter, ball indenter. Ability to determine hardness up to = 100 RHN, Maximum application of load = 150 Kgf	01	
3.	Copper Specimen		02	

X Precautions

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1. Do not apply excessive load on specimen. Use 50.0 kg load for hardness testing of soft alloys using Brinell hardness tester.
2. Select the appropriate scale if using Rockwell hardness tester
3. Ensure clean and well positioned indenter and anvil
4. The test sample should have clean, dry, smooth and oxide-free surface
5. The surface should be flat and perpendicular to the indenter
6. Specimen thickness should be 10 times higher than the depth of the indenter
7. The spacing between the indentations should be 3 to 5 times of the indentation diameter
8. Loading speed should be standardized.

XI Procedure

For Rockwell hardening Test

a. Keep the loading and unloading lever at unloading position.
b. Select the suitable indenter and weights according to the scale.
c. Place the specimen on testing table anvil.
d. Turn the hand wheel to raise a job until it makes contact with indenter.
e. When the longer pointer of the dial gauge reaches steady position take back the lever to the unloading position.
f. Turn back the hand wheel and remove the job.

For Brinell Test

1. Keep the loading and unloading lever at unloading position.
2. Select the suitable indenter and weights according to the scale.
3. Place the specimen on testing table anvil.
4. Turn the hand wheel to raise a job until it makes contact with indenter.
5. When the longer pointer of the dial gauge reaches steady position.
6. Remove the job from the platform and note down the diameter of the Indentation using Brinell microscope.
7. Similarly repeat the step for multiple readings

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations:

c. Brinell Hardness Measurement

SR No	Specimen	Indenter Diameter (D) mm	Total Load(P) Kgf	Diameter of Indentation (d) mm			Avg. Diameter d_{avg}	BHN
				1	2	3		
1	Copper	Ball (1/16")						

d. For Rockwell Hardness

SR No	Specimen	Type of Indenter	Scale	Total Load(P) Kgf	Rockwell Hardness Number(RHN)			Avg. RHN
					1	2	3	
1	Copper							

Calculations

For Brinell Hardness-

Brinell Hardness Number (BHN) $= \frac{2P}{\pi D[D-\sqrt{D^2-d^2}]}$

The formulas used for calculating Rockwell Hardness values are as follows:

For regular Rockwell Hardness using spheroconical "Brale" Indenter

HR[Scale] = 100 - h/0.002

Where Scale is A, C, D and h is the depth penetrated in mm.
For regular Rockwell Hardness using a steel ball

HR[Scale] = 130 - h/0.002

where Scale is B, E, F, G etc. and h is in mm

XVI Results

The hardness of copper is ------- 1) BHN_____ 2) RHN_____

XVII Interpretation of results

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XVIII Conclusions & Recommendation

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XIX Practical related Questions

1. Define Hardness.
2. State the applications of Rockwell Hardness A – Scale, B-Scale, C-Scale.
3. Name the type of indentor used in the three different scales of ‘Rockwell Hardness Test’.
4. List the different types of hardness testing methods.
5. State the size of the ball to be used in ‘Ball Indentor’ of ‘Rockwell Hardness Test’.
6. State the diameters of the different balls used in ‘Brinell Hardness Test’.
7. State the selection of load in ‘Brinell Hardness Test’.
8. State the selection of load in ‘Rockwell Hardness Test’.

[Space for Answers]

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XX References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=i1x-vJ85sBA
2. https://www.youtube.com/watch?v=ysInnHOoouc
3. https://www.youtube.com/watch?v=NlWVmp_q_XE
4. https://www.youtube.com/watch?v=RJXJpeH78iU
5. https://www.youtube.com/watch?v=G2JGNlIvNC4

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of hardness tester	20
2	Mounting of specimen	20
3	Hardness testing	20
Product related (10 Marks)		**40%**
4	Specimen tested	10
5	Interpretation of result	10
6	Conclusions	10
7	Practical related questions	10
	Total (25Marks)	**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.10: Use Relevant Peel Tester to Determine the Adhesive Strength of Cellophane Tape and Duct Tape on a Smooth Surface.

I Practical Significance

Adhesives are all around us. They come in the form of tapes, wall/window/floor decals, and glues. Millions of dollars each year are invested in purchasing these products as well as doing research to design more efficient products. The strength of these adhesives determines their use. Stronger adhesives such as duct tape leave a residue and are very difficult to remove from most surfaces. Weaker adhesives such as wall decals must be strong enough to stay on the wall but must be able to be easily removed. The strength of theses adhesives is measured by doing a peel test. A peel test measures the force required to remove the adhesive from the surface.

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of peel tester
2. Check adhesive strength of cellophane tape and duct tape.

IV Relevant Course Outcomes

(a) Identify properties of materials.

(b) Suggest relevant advanced materials for mechanical components.

V Practical Outcome

Use peel tester to check adhesive strength of cellophane tape and duct tape.

VI Relevant Affective domain related Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices

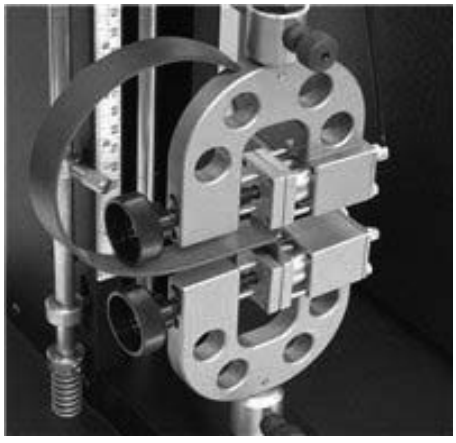
VII Minimum Theoretical Background

Peel adhesion is defined as the force needed to "peel" an adhesive tape from any given surface, whether flexible, smooth, or rigid. This "peel" force is always and only measured across the width of the taped substrate, making it the more difficult separating force to resist. It is important to understand the peel adhesion factor, as it can serve as a guide for choosing the right tape for the application. Some of the common types of tapes are cellophane tape, duct tape, scotch tape, electrical tape and masking tape.

Duct tape is one of the most versatile tapes and they can be used for many applications like holding carpets in place, repairing hoses, binding books and even holding together parts of a broken window. They are normally used in places where long-lasting, flexible and strong adhesive is required.

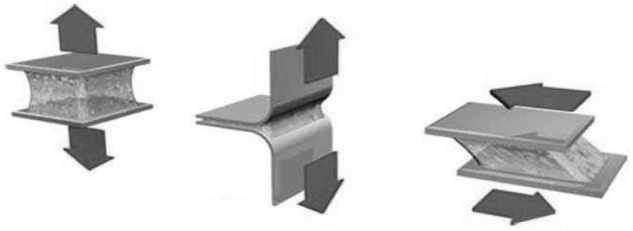
Peel adhesion is a very important consideration for both kinds of adhesive applications, temporary and permanent. For a temporary application, the peel adhesion needs to maintain an optimal balance between maintaining proper adhesion and allowing ease of removal.

VIII Experimental set-up



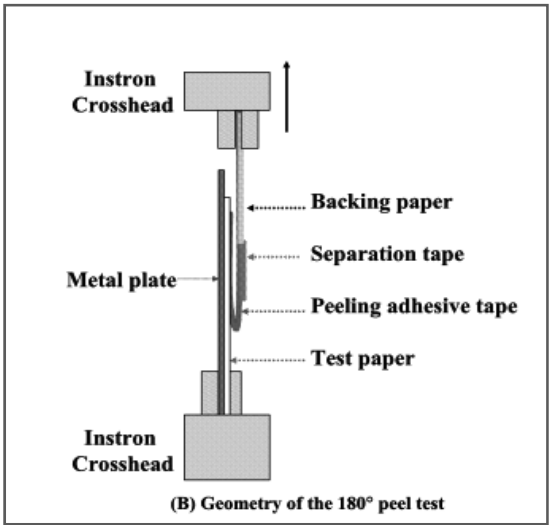
Peel Tester

Adhesive Tape



Perform Peel Test to determine the Strength of Adhesives

http://www.testing-instruments.com/blog/perform-peel-test-to-determine-the-strength-of-adhesives/



(B) Geometry of the 180° peel test

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Digital Peel Tester	Load capacity: Up to 5 kg No. of load cell: One Cross Travel: Up to 250 mm Speed: 300 mm/minute Direct display: Peak load Paint: Powder coated Power: 230 Volts, 50 Hz, single phase	01	
2	Peeling Strength Tester	Capacity Range 0~200 N (30 N, 50 N and 100 N are optional) Accuracy 1% of reading value Resolution 0.01N Test Speed 50, 100, 150, 200, 250, 300, 500 mm/min Specimen Width ≤30 mm Stroke 500 mm	01	

3	Cellophane Tape	Type: Adhesive Tape Length: 6 m	1 in group of 5	
4	Duct Tape	Tape Length: 10-20 m, 40-50 m, 0-10 m, >50 m, 30-40 m, 20-30 m Tape Width: >100 mm, 80-100 mm, 0-20 mm, 20-40 mm, 60-80 mm, 40-60	1 in group of 5	

X Precautions (if any)

1. Use peel tester carefully
2. Apply tapes on test plate properly

XI Procedure

1. Adhere the specimen to the testing plate.
2. Fold an end of the specimen to create a tab parallel to the plate.
3. Secure the end of the plate farthest away from the tab to the moving grip.
4. Secure the tab to the static grip.
5. Move the plate and begin peeling the tape at a 180 degree angle at the specified rate.
6. Record the average force required for peeling.

Or

1. Prepare at least 10 specimens according to the guidelines in the specification. A specimen consists of a flexible adhesive capable of folding back and peeling at a 180 degree angle as well as a substrate material to bond the adhesive to. The substrate object may be wood, textile, metal, or rubber. Samples must be conditioned according to the standard between preparation and testing.
2. Bond approximately six inches of the adhesive to the substrate material. Fold back the free end of the tape or sealant to a 180 degree angle.
3. Attach the free end of the substrate material to the vice grip on the testing machine's crosshead section. Keeping at least one inch of separation between the substrate material and the free end of the adhesive, secure the free part of the adhesive to the second vice grip.
4. Ensuring that the sample is in the plane of the vice grips, zero the materials testing machine. Move the crosshead at the specified rate until at least half of the bonded section has been peeled.
5. Record the average load. Repeat this test at least 10 times for each adhesive type.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			

XIII Actual Procedure Followed

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XIV Precautions Followed

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XV Observations and Calculations

Name of tape	Load (N)	Thickness (t) mm	Width (b) mm	Avg Peel Strength N/mm^2

Calculation: Peel Strength = Load/ Area under Load

XVI Results

1. Adhesive strength of Cellophane is ------
2. Adhesive strength of duct tape is ------

XVII Interpretation of results

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XVIII Conclusions & Recommendation

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XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. List the uses of duct tape?
2. Name the five brands of cellophane tape in market.
3. Name the five different commercial brands of tapes in the market.
4. Define the term 'Peel Strength'
5. Name any five different adhesive tapes used in industrial applications with their specifications.
6. Explain whether the process that makes adhesive tape sticky is physical or chemical?
7. Is the tape conductive?

[Space for Answers]

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XX References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=wLRptWkhlyY
2. https://www.youtube.com/watch?v=lwA_TGnJyUI
3. https://www.youtube.com/watch?v=6SbwBiN5YIs
4. https://www.youtube.com/watch?v=XQq5xCmXRyA
5. https://www.youtube.com/watch?v=xMn6HqrTVI8
6. https://www.youtube.com/watch?v=kTRk42hzxI8

XXI Assessment Scheme

Performance indicators		Weightage
Process related (10 Marks)		**40%**
1	Preparation of experimental set up	10%
2	Mounting of tapes	10%
3	Testing of tapes	20%
Product related (15 Marks)		**60%**
4	Prepared tape specimen	30%
5	Interpretation of result	10%
6	Conclusions	10%
7	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Practical No.11: Perform Flame test to Identify Different Types of Plastics

I Practical Significance

When working with plastics there is often a need to identify which particular plastic material has been used for a given product. This is essential to get an idea of the cost and likely properties of the product.

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of flame test setup
2. Observation skill

IV Relevant Course Outcomes

(a) Identify properties of materials.

V Practical Outcome

Perform flame test to identify different types of plastics.

VI Relevant Affective domain unrelated Outcome(s)

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices

VII Minimum Theoretical Background

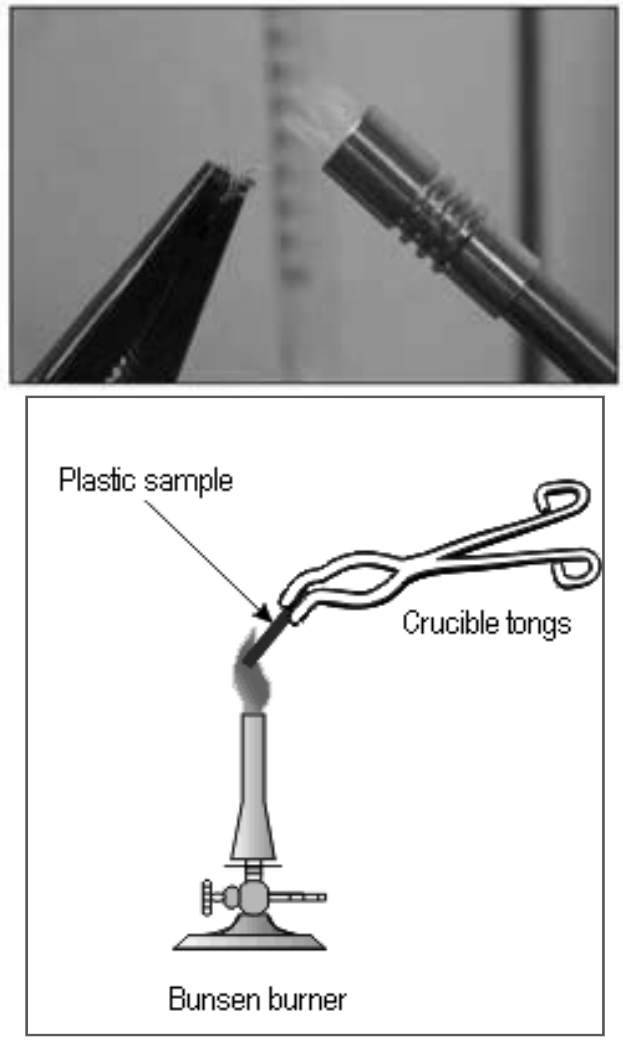
A polymer is the basic long chain molecule and is a pure molecule. Polymers are most often modified or compounded with additives (including colours) to form useful materials. The compounded product is generally termed as plastic.

The polymer based materials are classified as "thermoplastic materials" and "thermosetting materials". Thermoplastic materials can be melted many times and

will harden on cooling to return to their normal state. Applying heat will soften them again.

Thermosetting materials can be shaped and hardened once only. Applying heat will not soften the material but will burn or char it.

VIII Experimental set-up



Flame test

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Given specimen of plastics	1 to 2cm strip of each sample	1 in group of 5 students	
2	Tong,Bunsen Burner , Beakers	As per availability	1	

X Precautions (if any)

1. Flame testing should be performed within a well-ventilated hood.
2. Arrangement of water near the site of test should be made.

XI Procedure

1. Take different samples of plastics and label them A,B,C.
2. Take sample A and clamp it in the tong.
3. Place the sample on burner flame.
4. Observe the burning of sample.
5. Note the whether samples are being softened or decomposed.
6. Repeat the procedure with other samples.
7. Record the observations.

Or

The size of the sample should be about 2 x4 cm.

1. Reduce the flame on the Bunsen burner or torch to a minimum. With the forceps, hold the sample over the flame. The sample will demonstrate a specific behavior as it melts or burns. The color of the flame may be (A) yellow, (B) orange, (C) orange and yellow, or (D) orange and blue. The consistency of any melted drops also can help identify the type of plastic. Recorded responses are (E) melts, (F) drips, and/or (G) shrinks.
2. Remove the sample from the flame before it is consumed, noting the flammability of the plastic. Recorded responses are (a) continues to burn or (b) self-extinguishing.
3. The residues left after the sample is burned are (c) charred or (d) clear.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual procedure followed

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XIV Precautions Followed

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XV Observations

Table 1: Identification of Flame colour and Type of polymer

Polymer specimen	Flame Color	Type of polymer	Remarks

XVI Results

1. Different color of flames
2. Knowing the unknown samples

XVII Interpretation of results

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XVIII Conclusions

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XIX Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

a) State the major sources of raw materials for the manufacture of plastics?
b) Name the different tests other than flame test for identification of plastics.
c) Explain which plastics are harmful to environment
d) Explain which plastics are harmless to environment.
e) List the major characteristics of plastics?
f) Are Plastics eco-friendly? Explain
g) Plastics used in packaging? Give reason
h) Suggest the different methods to recycle the plastics.

[Space for Answers]

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XX References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=asHNidtj6dc
2. https://www.youtube.com/watch?v=_jYs-kv2tVY
3. https://www.youtube.com/watch?v=3fNujTRvpDI
4. https://www.youtube.com/watch?v=4EEwldmZg8g
5. https://www.youtube.com/watch?v=M4D1GSgRka8
6. https://www.youtube.com/watch?v=lYmLy5I0hDQ

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (15Marks)		**40%**
1	Preparation of experimental set up	10%
2	Burning of plastic specimen	10%
3	Observation of flame	20%
Product Related (10Marks)		**60%**
4	Prepared specimen	30%
5	Interpretation of result	10%
6	Conclusions	10%
7	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 12: Identify Behavior of the Shape-Memory Alloy as a Function with Regards to Temperature

I Practical Significance

Shape memory alloys (SMAs) are the special materials that have the ability to return to a predetermined shape when heated. When this alloy is in below transformation temperature it undergoes low yield strength and will deform easily into any new shape which it will retain, if this alloy is heated above its transformation temperature it changes its crystal lattice structure which returns to its real shape

II Relevant Program Outcomes (POs) and PSO

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

a. Identification of shape memory effect

IV Relevant Course Outcomes

(a) Suggest relevant advanced materials for mechanical components.

V Practical Outcome

Use High-temperature oven or electrical power source to be able to turn a wire into a desired shape.

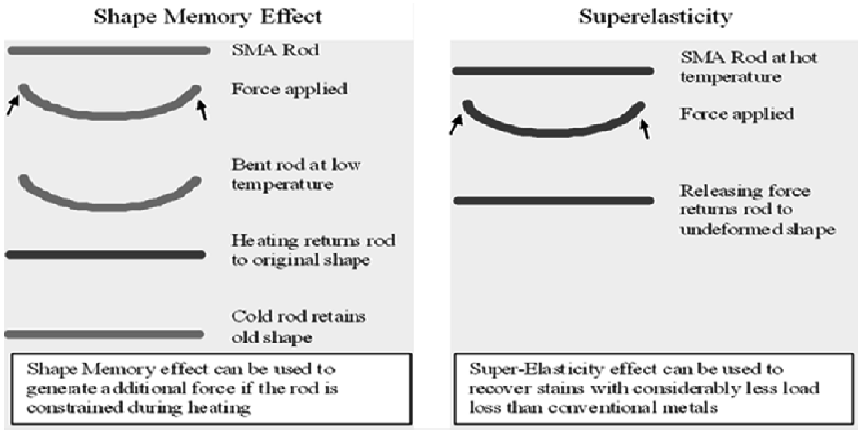
VI Relevant affective domain related Outcome(s)

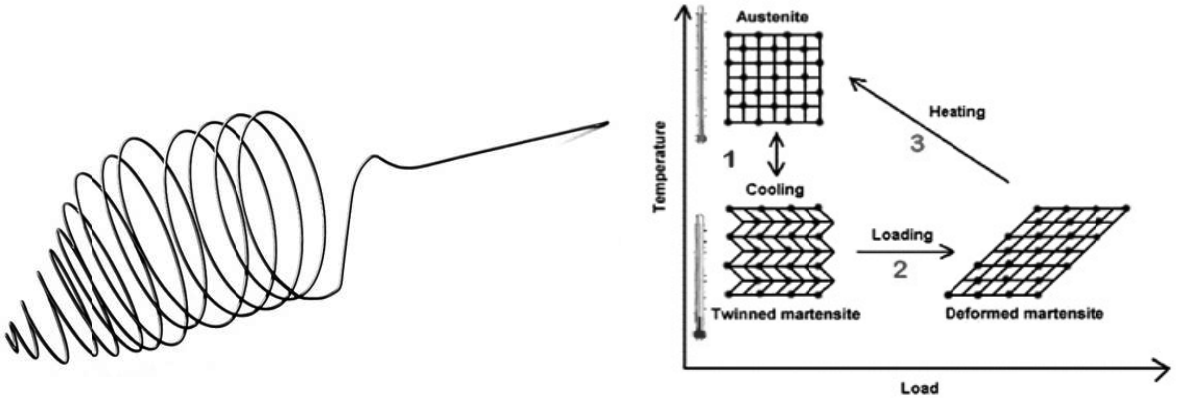
a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices

VII Minimum Theoretical Background

"Shape Memory" describes the effect of restoring the original shape of a plastically deformed sample by heating it. Shape memory effect is one of the unique property which a part returns to the actual shape during heating, after being deformed. In other words it is the ability of the material to regain from after plastic deformation by thermal processing.

VIII Experimental set-up





Shape Memory Effect mechanism

Example of Shape

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Shape memory alloy wire	min10 mm of nitinol wire of available dia. min 10 mm of steel wire		
2	Glass beaker	Suitable size		
3	Heat Source (High-temperature oven or electrical current)	a power source capable of at least 5 Amperes and 20 Volts will be necessary		
4	High temperature gloves/tongs	Suitable type		

X Precautions (if any)

1. Use protective equipment such as tongs or high temperature gloves when handling hot items, and beware of electric shock.

XI Procedure

1. Fill the beaker with water.
2. Place the beaker on the hot plate and turn to ‘High’. The water should be heated to just below boiling.
3. Bend the nitinol wire to a desired shape.
4. Place the nitinol wire in the hot water.
5. The nitinol wire should immediately return to its original shape
6. Remove the nitinol wire from the beaker using the pliers and show it to the students.
7. Repeat steps 3-6, trying different shapes and amounts of deformation.
8. Repeat steps 3-6 with the steel wire.

XII Resources Used

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual Procedure Followed

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XIV Precautions Followed

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XV Observations

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XVI Results

1. Heated wire
2. Cooled wire

XVII Interpretation of results

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XVIII Conclusions & Recommendation

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XIX Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the difference between shape memory and super elasticity on a macroscopic level and on a microscopic level?
2. The nitinol wire change shape, but not the steel wire?Justify
3. State the uses can you think of for materials that have this special behavior?
4. Explain the difference in super-elasticity and the shape memory effect. How are both achieved?

5. Name the forms of SMA have the same physical appearance?
6. State Practical applications for shape memory alloys.
7. Explain the effect when a metal is heated above its transformation temperature? How can this effect be reversed?
8. State the effect of the structure of a SMA during transition?

[Space for Answers]

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XX References / Suggestions for further Reading

a. https://www.youtube.com/watch?v=xhykVMFDULk
b. https://youtu.be/AwM1dOsWsoo?t=77
c. https://www.youtube.com/watch?v=QYp9rIJRM8s
d. https://www.youtube.com/watch?v=4Yi4epJ83EE
e. https://www.youtube.com/watch?v=1rrPv5AlVXg
f. https://www.youtube.com/watch?v=wKoc7-APFsk
g. https://www.youtube.com/watch?v=fsBHF_j2FJ4

XXI Assessment Scheme

Performance Indicators		Weightage
Process Related (15Marks)		**40%**
1	Preparation of experimental set up	10%
2	Observe the shape before Heating the specimen wire	10%
3	Observe the shape during Heating	10%
4	Observe the shape after Cooing the specimen wire	10
Product Related (10Marks)		**60%**
5	Hot and cooled wire	30%
6	Interpretation of result	10%
7	Conclusions	10%
8	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.13: Use Relevant Peel Tester to Determine the Adhesive Strength of Scotch Tape, Electrical Tape and Masking Tape on a Smooth Surface.

I Practical Significance-

Adhesives are all around us. They come in the form of tapes, wall/window/floor decals, and glues. The strength of these adhesives determines their use. Stronger adhesives such as duct tape leave a residue and are very difficult to remove from most surfaces. Weaker adhesives such as wall decals must be strong enough to stay on the wall but must be able to be easily removed. The strength of theses adhesives is measured by doing a peel test. A peel test measures the force required to remove the adhesive from the surface.

II Relevant Program Outcomes (POs)

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1-Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Skills

This practical is expected to develop the following skills for the industry identified competency "Use relevant mechanical engineering materials in different applications.'

1. Select relevant peel tester

IV Relevant Course Outcome(s)

1. Use non-ferrous metals for mechanical components.

V Practical Outcome

1. Use relevant peel tester to determine the adhesive strength of scotch tape, electrical tape and masking tape on a smooth surface.

VI Relevant Affective Domain Unrelated Outcomes

a. Follow safe practices
b. Practice good housekeeping
c. Demonstrate working as a leader/a team member
d. Maintain tools and equipment
e. Follow ethical practices

VII Minimum Theoretical Background

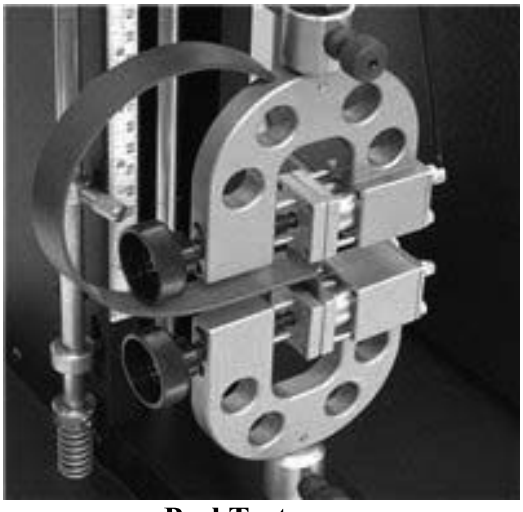
Peel adhesion is defined as the force needed to "peel" an adhesive tape from any given surface, whether flexible, smooth, or rigid. This "peel" force is always and only measured across the width of the taped substrate, making it the more difficult separating force to resist. It is important to understand the peel adhesion factor, as it can serve as a guide for choosing the right tape for the application. Some of the common types of tapes are cellophane tape, duct tape, scotch tape, electrical tape and masking tape.

Duct tape is one of the most versatile tapes and they can be used for many applications like holding carpets in place, repairing hoses, binding books and even holding together parts of a broken window. They are normally used in places where long-lasting, flexible and strong adhesive is required.

Electrical tape is normally used in homes or automobiles to insulate electrical wiring. In homes, they are normally used for installing electrical fixtures such as lights and fans. Their purpose is to insulate wire joints and terminate exposed live wires to prevent short circuits or electrocution in case someone accidentally touches the exposed wire.

The most common type of tape found in all homes is the transparent scotch tape and the cellophane tape. These are multipurpose tapes and they are used to gift-wrap presents, stick paper together and to seal plastic bags.
Peel adhesion is a very important consideration for both kinds of adhesive applications, temporary and permanent. For a temporary application, the peel adhesion needs to maintain an optimal balance between maintaining proper adhesion and allowing ease of removal.

VIII Experimental setup



Peel Tester

Adhesive Tape

IX Resources Required

S. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Digital Peel Tester	Load capacity: Up to 50 kg No. of load cell: One Cross Travel: Up to 250 mm Speed: 300 mm/minute Direct display: Peak load Paint: Powder coated Power: 230 Volts, 50 Hz, single phase	1
2	Peeling Strength Tester	Capacity Range 0~200 N (30 N, 50 N and 100 N are optional) Accuracy 1% of reading value Resolution 0.01N Test Speed 50, 100, 150, 200, 250, 300, 500 mm/min Specimen Width ≤30 mm Stroke 500 mm	1
3	Electric Tape	0.18mm thickness, Plasticized PVC backing, Rubber based adhesive	1 reel
4	Masking Tape	Backing – Crape paper Thickness – 0,14 mm Adhesive -rubber	1
5	Masking Tape	Backing – Polyester film Thickness – 0.06 mm Adhesive - Silicon	1

X Precautions to be Followed

1. Use peel tester carefully
2. Take precaution while applying tapes on test plate

XI Procedure

1) Adhere the specimen to the testing plate.
2) Fold an end of the specimen to create a tab parallel to the plate.
3) Secure the end of the plate furthest away from the tab to the moving grip.
4) Secure the tab to the static grip.
5) Move the plate and begin peeling the tape at a 180 degree angle at the specified rate.
6) Record the average force required for peeling

XII Resources Used

S. No.	Name of Resource	Broad Specifications		Quantity	Remarks (If any)
		Make	Details		
A.					
B.					
C.					

XIII Actual Procedure Followed

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XIV Precautions Followed

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XV Observations and Calculations

Observations and Measurements

Name of tape	Load (N)	Thickness (t) mm	Width (b) mm	Avg Peel Strength N/mm^2

Calculation

Peel Strength = Load/ Area under Load

XVI Results

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XVII Interpretation of Results

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XVIII Conclusions

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XIX Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) Define the term 'Peel Strength'
2) Name any five different adhesive tapes used in industrial applications with their specifications.

[Space for Answers]

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XX References / Suggestions for Further Reading

- https://www.youtube.com/watch?v=6XyrePiyreQ
- https://www.youtube.com/watch?v=I1SWCqNnE7c

Similar resources are available on internet. The students should be encouraged to search and see these resources.

XXI Assessment Scheme

Performance indicators		Weightage
Process related (10 Marks)		**40%**
1	Preparation of experimental set up	10%
2	Mounting of tapes	10%
3	Testing of tapes	20%
Product related (15 Marks)		**60%**
4	Prepared tape specimen	30%
5	Interpretation of result	10%
6	Conclusions	10%
7	Practical related questions	10%
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……

Marks Obtained			Dated signature of Teacher
Process Related(10)	**Product Related(15)**	**Total (25)**	

Experiment No. 14: Determination of the Effect of Quenching Media on the Hardness of Mild Steel

I Practical Significance

Hardening is the commonly used heat treatment process to obtain desired hardness and structure. It involves heating the steel above transformation temperature, holding at that temperature and quenching it immediately in a suitable cold medium such as water, brine solution, oil, molten salt and air. The rapidity with which heat is removed by the quenching medium governs the hardness obtained and distortion of steel. Therefore selection of proper quenching medium is important to obtain desired results.

II Relevant Program Outcomes (POs)

PO 1- **Basic knowledge** : Apply knowledge of basic mathematics, sciences and basic engineering to solve the broad-based mechanical engineering problems

PO 2- **Discipline knowledge**:- Apply mechanical engineering knowledge to solve broad-based mechanical engineering related problems.

PO 3-**Experiments and practice**:- Plan to perform experiments and practices to use the results to solve broad-based mechanical engineering problems

PO 4- **Engineering tools** :- Apply relevant mechanical technologies and tools with an understanding of the limitations

PO 8- **Individual and team work**:- Function effectively as a leader and team member in diverse/ multidisciplinary teams.

PSO 1- Manage mechanical engineering processes by selecting and scheduling relevant equipment, substrates, quality control techniques, operational parameters and software.

III Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency **'Use relevant mechanical engineering materials in different applications'**

1. Use of Muffle/ Box furnace
2. Select suitable quenching medium for the desired results.
3. Use of Rockwell hardness testing machine

IV Relevant Course Outcomes (from course details)

a. Identify properties of materials.
b. Select relevant ferrous materials for mechanical components.
c. Select relevant heat treatment process.

V Practical Outcome

Use muffle /box type furnace and hardness tester to determine the effect of cooling medium on hardness of steel

VI Relevant Affective domain related Outcome(s)

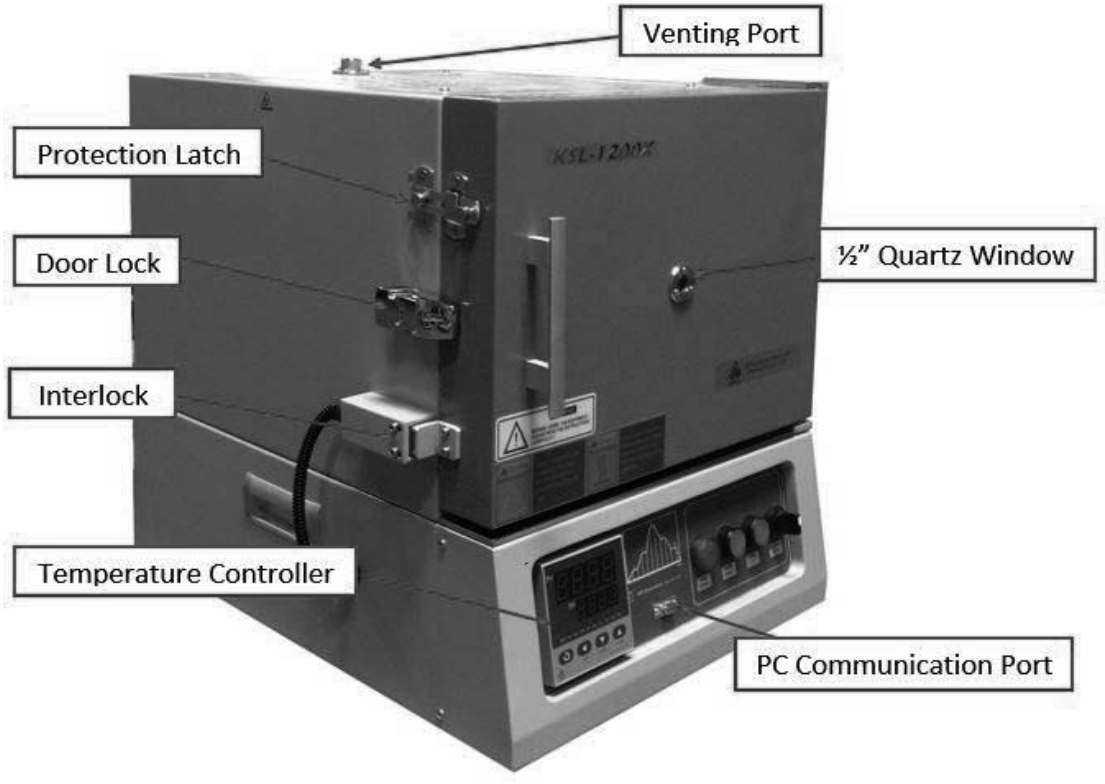
a. Handling furnace carefully.
b. Handling hardness tester carefully

VII Minimum Theoretical Background

Plain carbon steels are widely used for many industrial applications and manufacturing on account of their low cost and easy fabrication. They are classified on the basis of their carbon content as their major alloying element is carbon. Hardness and other mechanical properties of plain carbon steels increase with the rise in concentration of carbon dissolved in austenite prior to quenching during hardening heat treatment, which may be due to transformation of austenite into martensite. Therefore, the mechanical strength of medium carbon steels can be improved by quenching in appropriate medium. Comparisons of different quenchants in the heat-treatment processes of steels are of great usefulness in order to achieve desired hardness, strength or toughness, and to minimize the possibility of the occurrence of quench cracks due to the evolution of residual stresses. The choice of effective quenching medium following heat treatment is critical to ensuring the achievement of the desired mechanical properties; hence, the selection of a quenchant depends on the quench sensitivity of a particular grade of steel and on the severity of the quench medium.

There are three stages of quenching. The first is the vapor blanket, in which vapor film surrounding the component acts as an insulating blanket reducing the heat flow from the component subjected to quenching. The second stage is known as the nucleate boiling stage, where the vapor film collapses and high heat extraction rates are achieved. The third stage, known as the convective cooling stage, begins when the temperature of the metal surface is reduced below the boiling point of the quenching liquid; the cooling rate is low during this stage. Quenching is performed to prevent ferrite or pearlite transformation and allow bainitic or martensitic transformation.

VIII Experimental set-up



Box furnace

IX Resources required

S. No.	Instrument /Components	Specification	Quantity	Remark
1	Laboratory box furnaces	1200°c	02	
2	Digital Rockwell hardness tester-Easy-to-use Electronics Console	Hi/Lo Tolerance Settings, Adjustable Time @ Load Average Test Group Results 2-9; Test Result Memory Capacity 5000 results, RS232 Output,- Average Range.	02	

X Precautions (if any)

1. For quenching, the sample should be immediately transferred from the furnace to the water/oil bath.
2. The quenching media should be agitated.
3. The specimen should be well grinded and polished before measuring hardness.
4. Hardness should be checked in cold state.

XI Procedure

1. Put all the samples in the furnace and heat it for the selected temperature.
2. Hold the samples in the furnace for given soaking period.
3. Select any two cooling medium for quenching.
4. Take out the samples one by one and immerse it in quenching mediums.
5. As sample gets cooled, its faces are ground and polished to get an even surface.
6. Check hardness and plot graph, if desired.

Selection of heat treatment conditions

	Heating temperature	Socking time	Quenching media
	880°C, 920°C, 960°C	1 hour	Water, Brine, Oil or Air

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Table 1: Measurement of hardness from test

Sr. No	Specimen	Indentor Diameter(D) in mm	Total load(P) Kg-F	Diameter of Indentation(d) in mm			Average dia	RHN
				1	2	3		
1								
2								
3								

Table 2: Measurement of effect of quenching on hardness

Material	Initial Hardness (RHB)	Hardness after quenching			
		Quenching Medium			
		Water	Brine	Oil	Air

Calculations :

Calculate Hardness after quenching treatment:=

XVI Results

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The effect of different oil-quenching temperatures on the properties and structures of steel.

XVII Interpretation of results

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XVIII Conclusions and Recommendations (if any)

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XIX Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State the importance of cooling rate?
2. Plot a graph of different hardness values in Rc scale for various heat treated low carbon steel specimen
3. Plot a graph 'Hardness vs. tempering temperature for constant tempering time of 1 hour'.
4. Plot a graph 'Hardness vs. tempering temperature for constant tempering time of 1 ½ hour'.

5. Plot a graph 'Hardness vs. tempering temperature for constant tempering time of 2 hour'.
6. When austempering steel, after the 30 minutes in the 400°C bath the specimen is removed from the bath and can be either quenched in water or allowed to air cool at room temperature. Will these two procedures produce different results? Explain.
7. Discuss the relationship between heat treatment and the resulting hardness values obtained in this experiment.
8. State the effect of water contamination affect the performance of quench oil?
9. State the effect of oxidation of oil on quench oil performance?
10. State bath agitation affect quenching?
11. State the effect of salt concentration in brine?
12. Some heat treated components develop cracks? Give reason
13. State the reason for stresses develop during quenching?
14. State distortion of quenched component due to?
15. Is there a way of calculating the required cooling rate for a given component?
16. Is there a simplified approach for guiding in the selection of proper quenchant?

[Space for Answers]

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XX References / Suggestions for further Reading

a. https://www.wikihow.com/Harden-Steel
b. https://www.youtube.com/watch?v=QQ051Zie8pk
c. https://www.youtube.com/watch?v=Gmqkuc-n_IU
d. https://www.youtube.com/watch?v=U1patVgm8C0
e. https://www.youtube.com/watch?v=U-DesKKNi9g
f. https://www.youtube.com/watch?v=hw4Rl0uG7ok
g. https://www.youtube.com/watch?v=gPKkgmDoEoU
h. https://www.youtube.com/watch?v=bkxVLi3ezwA
i. https://www.youtube.com/watch?v=ulfCxDsVTWo

XXI Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Hardening of specimen	20
2	Quenching of specimen	20
3	Hardness measurement of specimen	20
Product related (10 Marks)		**40%**
4	Hardened specimen	20
5	Quenched specimen	20
Total (25Marks)		**100 %**

Names of Student Team Members

1. ……..
2. ……..
3. …….

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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