# PRACTICAL WORKBOOK
## MY-101: INTRODUCTION TO METALLURGICAL ENGINEERING

**Name:** ______________________

**Roll No:** ______________________

**Batch:** ______________________

**Year:** ______________________

**Department** ______________________

**DEPARTMENT OF METALLURGICAL ENGINEERING**
**NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY**

# PRACTICAL WORKBOOK

## MY-101: INTRODUCTION TO METALLURGICAL ENGINEERING

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**This is to certify that this practical book contains eleven practical and______pages. All practical are prepared as per contents of course.**

**Approved By:**

**Chairman**

**DEPARTMENT OF METALLURGICAL ENGINEERING**
**NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY,**

# CERTIFICATE

It is Certified that Mr. / Miss ____________________________________________

Student of class ________________________________ Batch __________________

Bearing Roll No. __________________________________________ has completed

his/her course work in the subject of ______________________________________

as prescribed and approved by Board of Review of Materials and Metallurgical Engineering Department.

His/Her performance is reflected by index/contents of his/her practical workbook. This overall performance of the student is Excellent/Very Good/Good (satisfactory)/Not Satisfactory

___________________

**Course Teacher**

# MY-101: INTRODUCTION TO METALLURGICAL ENGINEERING

*List of Practical*


| S No. | EXPERIMENTS | Page No. |
|---|---|---|
| 01 | Safety in Laboratories | 05 |
| 02 | Tools of Metallurgist; MYD laboratories. | 07 |
| | **Identification of Materials** | |
| 03 | Identification of various engineering materials on the basis of density. | 09 |
| 04 | Identification of iron ores on basis of their color and response to magnetism. | 13 |
| | **Learning Metallography** | |
| 05 | Sectioning or Cutting of metallic samples | 15 |
| 06 | Hot mounting of Materials | 17 |
| 07 | Cold mounting of Materials | 20 |
| 08 | Grinding and Polishing of metallic samples | 22 |
| 09 | Preparation and application of Etchant for Ferrous materials alloys | 25 |
| 10 | Examination of microstructure using Optical Microscope | 27 |
| | **Some Analytical Tools** | |
| 11 | Hardness Testing Techniques for Ferrous materials | 30 |

# EXPERIMENT No. 01

## Object

Safety in Laboratories

## Safety Precautions

1. Keep the work area clean. Wipe up oil and grease spills immediately to prevent injuries caused by slipping and falling. Keep paths to exits clear.
2. Wear lab coat at all times while in sample preparation lab.
3. Wear safety glasses and gloves during grinding and polishing, and during etching.
4. Etching can only be done under supervision.
5. Do not wear gloves in the microscopes room.
6. Always carry out etching in a fume cupboard.
7. While etching, always use tongs to handle the specimen.
8. Etchant splashes on the skin or eyes must be washed with copious amounts of water.
9. Mount specimen in vises, anvils, and clamps securely in abrasive cutter equipment
10. Use proper tools. Always use the proper-sized tools and equipment for the job.
11. Obtain the instructor's permission. Use equipment only with the instructor’s permission.
12. The instructor must be aware of all laboratory activities and will know if the equipment is in safe working order
13. Wear proper clothing. Wear clothing that is not loose or bulky and wear hard-toed shoes with non-skid soles
14. Restrain long hair. Restrain excessively long hair with a band or cap to keep hair from getting entangled in machines.
15. Know emergency procedures. In the event of an emergency, all students involved in or observing the emergency should call for help immediately as well as assist in correcting the situation. You should know the location of fire extinguishers and fire blankets and how to use them. You should also know the approved procedure for exiting the laboratory.
16. Report all injuries or accidents to the instructor immediately, no matter how slight. The instructor will secure medical help.
17. Avoid horseplay and loud talk. Loud talking as well as pushing, running, and scuffling that can cause serious accidents. Keep your mind on your work.
18. Turn off all equipment before leaving work area. Before leaving the laboratory or work station, make certain the equipment is properly shut off.

## Questions

1. What safety practices are used in your shop to promote general safety?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

2. What personal safety protection devices or clothing must you wear while working in the shop?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

3. List down the importance of safety in the industry?

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

# EXPERIMENT No. 02

## Object

Tools of Metallurgist; MYD laboratories.

## Theory

**Metallurgy** is a study of Material sciences that studies the physical and chemical behavior of metallic elements, their inter-metallic compounds, and their compounds, which are called alloys. It is also the technology of metals: the way in which science is applied to their practical use. Metallurgy is commonly used in the craft of metalworking.

In simpler words the study of behavior of metals and their compounds is known as metallurgy.

## Procedure

Name all the equipments present in the laboratory and write down purposes in the table given below:

## Observation

| EQUIPMENT | PURPOSE |
|---|---|
| | |
| | |
| | |
| | |
| | |
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| | |
| | |

| | |
|---|---|
| | |
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| | |
| | |
| | |

# Questions

2. Define metallurgy?

______________________________________________

______________________________________________

______________________________________________

4. How many types of optical microscope are present in laboratory?

______________________________________________

______________________________________________

______________________________________________

5. Responsibilities of a Metallurgical Engineer in the industry?

______________________________________________

______________________________________________

______________________________________________

# EXPERIMENT No. 03

## Object

Identification of various engineering materials on the basis of density

## Apparatus

Weight balance, Vernier Caliper, Assorted Specimen

## Theory

The density of a material is defined as the mass per unit volume of the material. Density can be expressed as follows:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Its unit is grams per centimeters cube ($g/cm^3$). Metals, as a category, have higher density than plastic however; some metals are denser than others. Therefore, materials can be categorized on the basis of density.

## Procedure

First we take the mass of specimen by using weight balance. Measure the dimension of the specimen by using vernier caliper. Using the dimension, determine the volume of the specimen by using the formulas

Volume (cylinder) = $\pi r^2 h$

Volume (rectangular) = Length * Width * Height

Volume (cone) = $1/3\ \pi r^2$ * height

Volume (sphere) = $4/3\ \pi r$

**1. Compare the observed density of each specimen with standard density.**

**Table: 01** **DENSITY OF MATERIALS**

| MATERIAL | DENSITY ($gm/cm^3$) |
|---|---|
| Aluminum | 2.7 |
| Copper | 8.8 |
| Steel | 7.85 |
| Polymers (Elastomers) | 0.98 |
| Ceramics (Concrete) | 2.4 |
| Composite Material (Wood) | 0.46-0.50 |

**Table:02 STANDARD DENSITY FOR VARIOUS ENGINEERING MATERIALS AT 20 $^0$C**

| No. | Materials | (gm/cm$^3$) |
|---|---|---|
| 01. | Aluminum Alloys | 2.6 to 2.9 |
| 02 | Copper alloys | 7.5 to 9.o |
| 03 | Lead alloys | 8.9 to 11.3 |
| 04 | Magnesium alloys | 1.9 |
| 05 | Nickel alloys | 7.8 to 9.2 |
| 06 | Titanium alloys | 4.3 to 5.1 |
| 07 | Zinc alloys | 5.2 to 7.2 |
| 08 | Carbon & low alloy Steels | 7.8 |
| 09 | High alloy Steels | 7.8 to 8.1 |
| 10 | Engineering Ceramics | 2.2 to 3.9 |
| 11 | Glasses | 2 to 3 |
| 12 | Thermoplastics | 0.9 to 1.6 |
| 13 | Polymer Foams | 0.04 to 0.7 |
| 14 | Engineering Composites | 1.4 to 2 |
| 15 | Concrete | 2.4 to 2.5 |
| 16 | Wood | 0.4 to 1.8 |
| 17 | Polyester (Thermoset) | 1.04 to 1.46 |

**2. Now identify the materials on the basis of density**

Materials may also be identified by appearance to some extent when in pure form

**Table: 03 COLOUR IDENTIFICATION**

| MATERIALS | COLOUR |
|---|---|
| Aluminum | White |
| Copper | Reddish |
| Iron | Grey |
| Zinc | Bluish |
| Tin | Silvery |

## Calculation

| | | |
|---|---|---|
| Volume (specimen one) | = | ______________________ |
| | = | ______________________ |
| | = | ______________________ |
| Volume (specimen two) | = | ______________________ |
| | = | ______________________ |
| | = | ______________________ |
| Volume (specimen three) | = | ______________________ |
| | = | ______________________ |
| | = | ______________________ |
| Density of specimen one | = | ______________________ |
| | = | ______________________ |
| Density of specimen two | = | ______________________ |
| | = | ______________________ |
| Density of specimen three | = | ______________________ |
| | = | ______________________ |

## Observation

| No. | Specimen | Mass | Volume | Density |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

## Result

Specimen one has identified as ___________

Specimen two has identified as ___________

Specimen three has identified as ___________

## Questions

1. The density of a material is defined as the_______________of the material.

2. The theoretical density of a metal can also be calculated using the properties of the___________________

3. The unit of density in S.I system______________, C.G.S system___________, F.P.S system_______________.

4. The density of Aluminum is______________

5. The density of Copper is_________________

6. The density of Stainless Steel is___________

# EXPERIMENT No. 04

## Object
Identification of iron ores on the basis of colour and response to magnetism.

## Apparatus
Iron ores

## Theory
**IRON**

Iron is a metallic element with atomic number 26 and atomic weight 56. it is symbol is Fe which comes from a Latin word “ferrum”. When it is pure it has a dark slivery grey colour. It is a very reactive element and oxidizes (rusts) very easily. Iron constitutes about 4.6% of earth’s crust and hence it is one of the most widely distributed an abundant element in the nature. The naturally occurring materials containing iron are known as minerals of iron. The minerals deposits from which iron is extracted are known as iron ores.

**CLASSIFICATION OF IRON ORES**

The ores of iron are classed according to the iron mineral which is predominant. They are in the order of theoretical percentage of iron present in the mineral.

**MAGNETITES (Black Ores) $Fe_3O_4$**

These iron ores contain 40% to 70% of iron. They are very hard and strongly magnetic. Magnetites also occur in a mixture with silica (35-37 iron and upto 60%silica) and are then known as “ferruginous quartzites”. Ferruginous quartzites call for special methods of dressing perpartion prior to smelting. The colour of magnetite is dark gray to black and a specifc gravity 5.16 to 5.18. The magnetic property is important for it primary exploration by magnetic method and makes possible the megnetic separation of magnetite from gangue materials to produce a high quality concentrate. Magnetite occurs in igneous, metamorphic and sedimentary rocks.

**HEMATITES (Red Ores) $Fe_2O_3$**

These iron ores contain 45% to 65% of iron. Hematite is easily reduceable to metallic form and iron from. It can be produced at a lower cost. It usually contains little phosphorous and sulphur. Usually, hydrated hematites contain 25% to 50% of iron. The colour of hematite ore are from steel gray to dull or bright red. The specific gravity is 5.26. Its common varieties are termed crystalline; specular, martite, earthy, maghemite, and compact.

**LIMONITES (Brown Ores) $Fe_2O_3.H_2O$**

These iron ores contain57.14% of iron with a 25.3% of water combination. Limonites are porous minerals. Limonites is the name commonly given to hydrous iron oxides that is a mixture of the cyoethite Hfe $O_2$ (Hydrous iron oxide) or lepidocrocite FeOCOH. It has a specific gravity in the range of 3.6 – 4.0, is commonly yellow or brown to nearly black in colour and is compact in early occurrence. It is a secondary mineral, formed commonly by weathering and occurs in association with other iron oxides and in sedimentary rocks

**SIDERITE (White Ores) $FeCO_3$**
It has a chemical compound of $FeCO_3$ (Iron Carbonate). The ore contains 48.20% of iron, 37.99% of $CO_2$, and 13.81% oxygen. The specific gravity is 3.83 and its colour varies from white to greenish gray and brown. It's commonly contained variable amount of Ca, Mg, Cr, Mn. Sidrite varries from dense, fine grained and compact to crystalline. That ore are sometimes termed as spatrie iron ore or black band ore.

**LIMENITE ($FeTiO_3$)**
It has a chemical compound of $FeTiO_3$ (iron titanium oxide) contains to 36.82% iron, 31.7% titanium and 31.63% oxygen. This is commonly considered as iron titanate. It is often associated in small amount with magnetite.

**Response of IRON ORES TO Magnetism**
Magnetite is a mineral and one of the main iron ores. It is attracted to a magnet and can be magnetized to become a permanent magnet itself. With the exception of extremely rare native iron deposits, it is the most magnetic of all the naturally occurring minerals on Earth. Naturally magnetized pieces of magnetite, called lodestone, will attract small pieces of iron, which is how ancient peoples first discovered the property of magnetism.
Limonite attains magnetic properties when heated, and has an opaque appearance. The chemical formula of this ore is α-FeO (OH). Limonite is yellow to yellowish brown; reddish brown to brown in colour. Hematite is an iron ore that contains iron in the form of $Fe_2O_3$. It is a significant source of iron extraction. Hematite is a mineral that is paramagnetic. As a result, it can be drawn to an external magnetic field. Siderite ($FeCO_3$) is a brownish translucent mineral crystallizing in the same hexagonal lattice as calcite. Siderite is antiferromagnetic with a Néel temperature ($T_N$) of about 38 K.

## Procedure
Identify the name and the properties of the sample of given iron ore by looking at its colour and physical properties.

**Colour**

______________________________________________

**Physical Properties**

______________________________________________

______________________________________________

______________________________________________

## Conclusion:

______________________________________________

______________________________________________

# EXPERIMENT No. 05

## Object

Sectioning or Cutting of metallic samples.

## Apparatus

Abrasive cutter machine, Samples.

## Theory

The first step in preparing a specimen for metallographic or micro structural analysis is to locate the area of interest. Most metallographic samples need to be cut to the area of interest and for easy handling Sectioning or cutting is the most common technique for obtaining this area of interest. The sectioning part is where the sample is cut or "sectioned" off from the main material source. One of the most important aspects of sectioning is to not alter the microstructure or damage fracture features when cutting a specimen.

Sectioning can be categorized into two areas: Abrasive Cutting and Precision Wafer Cutting. In metallographic sample preparation, mostly abrasive cut-off machines are used for sectioning of work pieces for microscopic examination and other material investigations. This technique uses low-speed cut-off wheels in cases where the heat created by standard abrasive cutters must be avoided. Optimum cooling is just as important for the sectioning result as precise movement. It is important to keep the sample cool with lubricant or coolant. The damage to the specimen during sectioning depends on the material being sectioned, the nature of the cutting device, the cutting speed, feed rate, and the amount and type of coolant used. Common cooling media consist of a mixture of a boric and amino acid-free corrosion protection agent with water. An appropriate concentrate is diluted with water in a ratio of e. g. 1:30. A cut-off wheel consists of abrasive grains (such as Aluminum Oxide or Silicon Carbide), bonded together with rubber or other materials in the form of a thin wheel. Abrasive cutting is primarily used for ductile materials. Examples include metals, plastics, polymer matrix composites, metal matrix composites, etc. Proper blade selection is required to minimize burning and heat generation during cutting which degrades both the specimen surface as well as the blade cutting efficiency. Lubrication during abrasive cutting is required to minimize damage and to remove the cutting debris. It should have a relatively high flash point because of the sparks produced during abrasive sectioning.

Proper sectioning is required to minimize damage, which may alter the microstructure and produce false metallographic characterization. Proper cutting requires the correct selection of abrasive type, bonding and size, as well as proper cutting speed, load and coolant.

## Procedure

- Select the appropriate abrasive blade.
- Secure specimen - improper clamping may result in blade and specimen damage
- Check coolant level and replace when low or excessively dirty.
- Since abrasives blades breakdown or wear out during cutting they produce a significant amount of debris.

- Allow blade to reach its operating speed before beginning the cut.
- A steady force or light pulsing action will produce the best cuts and minimize blade wear characteristics as well as the maintain sample integrity (no burning).

**Result**

The metallic sample is successfully sectioned to the area of interest.

**Questions**

1. The purpose of cutting is to____________________________________.
2. Different types of cutting methods are______________________________.
3. Coolant used in the experiment is___________________________________.
4. Composition of cutting blade used in the experiment is______________.
5. Safety required during sectioning is______________________________.
6. The material used in the experiment is ____________________________.

# EXPERIMENT No. 06

## Object

To carry out hot mounting of given specimens using Mounting Press Machine.

## Apparatus

Mounting press specimen, bakelite, funnel, measuring spoon, and mould release wax.

## Theory

The mounting press machine is an Automatic Mounting Press shown in Fig. 1. The primary purpose of mounting is for convenience is handling specimens of difficult shapes or sizes during the subsequent steps of preparation and examination. A secondary purpose is to protect and preserve extreme edges of surfaces defects during preparation. Thickness of the mount should be sufficient to enable the operator to hold the mount firmly during grinding and polishing thereby to prevent a rocking motion and to maintain a flat surface.Circular mounts are commonly 1 to 2 in. in diameter and are the most easily handled. Different types of mounting methods are available e.g. clamp mounting, compression mounting, cold mounting etc. we use compression mounting method in experiment using automatic hydraulic mounting press.

Compression mounting, the most common mounting method involves molding around the specimen by heat pressure. Molding materials used are bakelite, aniline formaldehyde compound resins, and acrylic, Lucite resins etc. bakelite and aniline formaldehyde compound resins are thermosetting, and acrylic and Lucite resins are thermoplastic. For making transparent mold we may use Lucite. Both thermosetting and thermoplastic materials require head and pressure during the molding cycle, but after curing, mounts made of thermosetting materials may be ejected from the mold at maximum temperature. Thermoplastic materials remain molten at the molding temperature and must cold under pressure before ejection. Mounting presses quipped with molding tools and a heater is necessary compression mounting. The cylinder is nearly filled with molding material in powder form, and the plunger is inserted into open end of the cylinder. A cylinder heater is placed around the mold assembly, which has been exerted and maintained on the plunger to compress the molding material until it and the mold assembly has been heated to the proper temperature, the finished mount may be ejected from the mould by forcing the plunger entirely through the mould cylinder.


**(Fig.1) MOUNTING PRESS MACHINE**

## Procedure

1. The inner ram pressure I supplied by hydraulic pressure. To activate the ram, the "Ram Up" and "Ram Down" buttons on the control panel are used.
2. Raise the ram until the top below the edge of mold assembly.
3. Apply mold release inside the mold chamber. When using either spray of liquid silicone mold release.
4. Raise the ram from flush with the top of the assembly.
5. Place the specimen onto the lower ram and lower is using the ram down button until fully down.
6. Apply enough mounting material to cover the mount, as well extra material on top, so the top ram does not make contact with the part.
7. If using the duple Xing spacer to produce two mounts in one cycle, place the spacer on top of the mounting material covering the first sample.
8. Swing the top ram/die over the mold chamber. The ram is spring loaded for ease of removal when unloading the chamber. Push down on the bayonet handles and turns it clock wise to lock the lid until stops hard against the bayonet.
9. Press the button "RUN" to the menu screen, select the menu and press "Run" again to begin the cycle.

10. This cycle will automatically raise the ram into the top and begin heating the mold.
11. Do not touch the molds while it I heating or cooling, as it may cause a painful burn.
12. During the cycle, an illuminated LED on the display panel will indicate operation of a cycle (Cycle On), and whichever cycle is operating: Pre-Heat, Heat or Cool.
13. When the cycle is complete, an alarm will sound as a series beeps. The mold will lower automatically enough to loosen and rotate bayonet open. Loosen the bayonet by turning the top handle, counterclockwise, until it is unlocked. It might be necessary to lower the ram a little more to loosen the bayonet, which can be done by pressing the "Ram Down" button.
14. List the top ram up and swing it away around to the rear where it may rest on the heat sink until it is ready to be used again. The sample may be removed at this time.

## Result

Small specimen is successfully mounted in thermosetting plastic and bakelite.

## Questions

7. The purpose of mounting is to________________________________________.
8. Different types of mounting methods are________________________________.
9. Mounting press used in the experiment is________________________________.
10. Mounting material used in the experiment is_____________________________.
11. The mounting temperature for thermo setting plastic is____________________.
12. For making transparent mount we use________________as mounting material.
13. Diameter of the mount made in the experiment is________________________.
14. Mounting force is used in the experiment is ____________________________.

# EXPERIMENT No. 07

**Object**

To carry out the cold mounting of a given specimens using Cold Casting Method.

**Apparatus**

Weigh Machine, Hardener, Resin, Mixing Cup and Sample.

**Theory**

Cold Casting is a term used to describe the process of mixing metal powder with a resin to create castings that give the appearance of solid metal. After sectioning, material samples are usually mounted. They are typically embedded in synthetic material. This procedure ensures that the sample is held securely for a subsequent mechanical preparation. The primary purpose of mounting is for convenience is handling specimens of difficult shapes or sizes during the subsequent steps of preparation and examination. A secondary purpose is to protect and preserve extreme edges of surfaces defects during preparation. Thicknessof the mount should be sufficient to enable the operator to hold the mount firmly during grinding and polishing thereby to prevent a rocking motion and to maintain a flat surface. Circular mounts are commonly 1 to 2 in. in diameter and are the most easily handled.

During the cold mounting process, the mounting resin is mixed with a hardener. The mixture is subsequently poured into an embedding mould which contains the sample. Then polymerization takes place. Different types of resins are used for cold mounting such as epoxy resin, polyester and acrylic resin etc.

Epoxy resins are suitable for mounting of all types of materials and are especially recommended for vacuum impregnation. Epoxies have the lowest shrinkage of all cold- mounting resins. The curing time is relatively long, but adhesion to most materials is excellent. They polymerize through a chemical reaction after being mixed in the correct proportions. Thehardened epoxy is duroplastic, and not affected by moderate heat or chemicals. Epoxy systems consist of two components: a resin and a curing agent/hardener. Properties such as low vapor pressure, transparency, good adhesion, low viscosity, and no shrinkage are all specific to epoxies.

**Procedure:**

- The specimen must be cleaned prior to mounting in order to improve adhesion of the mounting medium to the specimen. Use acetone or at least alcohol. Cleaning in an ultrasonic bath may be necessary.
- Dry the specimen well. Clean specimens should be handled with either gloves or tweezers.
- Weigh and mix components in a single cup (do not use wax-lined or paper cups)
- Mix thoroughly by scraping both sides and bottom of mixing cup for approximately 2-3 minutes until mixture appears homogeneous.
- Pour the mixture into a mounting cup over the sample and allow curing / hardening.

**Result**

Small specimen is successfully mounted by using epoxy resin and hardener.

## Questions

15. The purpose of mounting is to____________________________________.
16. Different types of resins are_______________________________________.
17. The ratio of resin and hardener used in the experiment is_______________.
18. Mounting material used in the experiment is_________________________.
19. The mounting temperature for thermo setting plastic is________________.
20. Diameter of the mount made in the experiment is_____________________.
21. Is there any pressure required for Cold Mounting? ______________________.

# EXPERIMENT No. 08

**Object**

To carry out the grinding and polishing of a given specimens.

**Apparatus**

Grinding Machine, Polishing machine, Grinding Papers, Polishing Papers, Polishing Suspension and Sample.

**Theory**

The purpose of the coarse grinding stage is to generate the initial flat surface necessary for the subsequent grinding and polishing steps. As a result of sectioning and grinding, the material may get cold worked to a considerable depth with a resultant transition zone of deformed material between the surface and the undistorted metal. Course grinding can be accomplished using 60 to 180 grit electrically powered disks, but care must be taken to avoid significant heating of the sample. The final objective is to obtain a flat surface free from all previous tool marks and cold working due to specimen cutting. An important factor throughout the Coarse Grinding and Fine Grinding Stages is that the scratches be uniform in size and parallel to each other in any one grinding stage. Proper grinding involves rotation of the sample by 90° between stages while the grinding angle must be held constant during the grinding at any one stage.

Medium and Fine Grinding of metallurgical samples are closely allied with the Coarse Grinding which precedes them. In general, successive steps are 240, 320, 400 and 600 grit SiC and the grinding rate should steadily decrease from one stage to the next. Proper grinding involves the rotation of the sample between stages while the grinding angle must be held constant during the grinding at any on stage. The sample must be washed thoroughly before proceeding from one grinding operation to the next"!

Wet grinding is generally applied in medium and fine grinding to avoid possible side effects due to heating such as tempering, transformation, aging, incipient melting, etc. Wet grinding also provides a flushing action for loose particles and keeps sharp edges of the grinding medium exposed at all times.


**Fig. 2 Grinding Machine**

**Mechanical Polishing**

Polishing involves the use of abrasives, suspended in a water solution, on a cloth-covered electrically powered wheel. Diamond abrasives provide the best, and most expensive, compounds utilized in polishing; standard sized aluminum oxide powders are applied for general use purposes. Following the final 600 grit fine-grinding stage, the sample must be washed and carefully dried before proceeding to the first polishing stage! At the polishing stages, even hard dust particles in the air which settles on the polishing cloth can cause unwanted scratching of the specimen! Careful washing of the specimen and the operator's hands must be carried out prior to each stage of polishing! Beginning with 5-micron suspended aluminum oxide particles (suspended in water) on a Nylon-cloth, the final fine-grinding surface layer resulting from the previous grinding procedure should be completely removed with a rotation rate of 150-200 rpm. The specimen is initially held at one position on the wheel, without rotation, until most of the previous grinding marks are removed. It can be rotated slowly, counter to the wheel rotation, until only scratches from the 5-micron aluminum oxide are visible. The final polishing stage with 1-micron suspended aluminum oxide particles should be carried out on a separate polishing wheel following "Careful washing of the specimen and operator's hands" at a slower speed of 100 - 150 rpm using a napped cloth. After 1 or 2 minutes a properly polished specimen should have a mirror-like surface free of scratches! During final polishing, minimal pressure should be applied and time should be kept to a minimum since the napped material will conform to the specimen shape under pressure. The wetness of the cloth used for Final Polishing has a great influence on the end result. If the cloth is too wet the sample will show pits; if too dry, buffing and/or smearing will result. To determine the proper wetness, the sample should be removed from the wheel and the time required for the polishing film to dry (five to eight seconds) should be checked.


**Fig. 3 Polishing Machine**

**Result**

Mounted specimen is successfully grinded and polished.

## Questions

1. The purpose of grinding is to______________________________________.
2. The grit papers used in grinding process are___________________________.
3. The purpose of water as medium is__________________________________.
4. Proper grinding involves rotation of sample by________________________.
5. The purpose of polishing is_________________________________________.
6. The medium used for polishing sample is_____________________________.
7. The samples after polishing have a surface like ______________________.

# EXPERIMENT No. 09

## Object

Preparation and application of Etchants for Ferrous materials alloys.

## Apparatus

Chemicals, Samples, Beaker, and Tong.

## Theory

Etching is used to highlight, and sometimes identify, microstructural features or phases present. Metallographic etching encompasses all processes used to reveal particular structural characteristics of a metal that are not evident in the as-polished condition. Examination of a properly polished specimen before etching may reveal structural aspects such as porosity, cracks, and nonmetallic inclusions.

Metallographic etching is done by immersion or by swabbing (or electrolytically) with a suitable chemical solution that essentially produces selective corrosion. Swabbing is preferred for those metals and alloys that form a tenacious oxide surface layer with atmospheric exposure such as stainless steels, aluminum, nickel, niobium, and titanium and their alloys. It is best to use surgical grade cotton that will not scratch the polished surface. Etch time varies with etch strength and can only be determined by experience. In general, for high magnification examination the etch depth should be shallow; while for low magnification examination a deeper etch yields better image contrast. Some etchants produce selective results in that only one phase will be attacked or colored. Different types of etchants techniques have been utilized such as tint etching and selective etching.

**Tint etching with Beraha's solution**: Colored the grains according to their crystallographic orientation. With the development of color image analyzers, this image can now be used quite effectively to provide accurate grain size measurements since all of the grains are colored.

**Selective etching**: This has been commonly applied to stainless steels for detection, identification and measurement of delta ferrite, ferrite in dual phase grades, and sigma phase. Selective etching techniques are not limited to iron based alloys, although these have more thoroughly developed than for any other alloy system. Selective etching of beta phase in alpha-beta copper alloys has been a popular subject.

Table: Different Etchants Used on Materials.

| Etchant | Composition | Conc. | Conditions | Alloys |
|---|---|---|---|---|
| Kroll's Reagent | Distilled water<br>Nitric acid<br>Hydrofluoric acid | 92 ml<br>6 ml<br>2 ml | Swab specimen up to 20 seconds | • Titanium and alloys |
| Nital | Ethanol<br>Nitric acid | 100 ml<br>1-10 ml | Immersion up to a few minutes. | • Fe, carbon alloys<br>• Cast iron<br>• Mn-Fe,<br>• Mn-Cu,<br>• Mn-Co alloys. |
| Picral | Ethanol<br>Picric acid | 100 ml<br>2-4 grams | Seconds to minutes Do not let etchant crystallize or dry – explosive | Recommended for microstructures containing<br>• Ferrite,<br>• Carbide,<br>• Pearlite,<br>• Martensite<br>• Bainite.<br>Also useful for<br>• Magnetic alloys,<br>• Cast iron,<br>• Magnesium. |
| Aluminum Al-NaOH Etchant | Sodium hydroxide<br>DI Water | 25 grams<br>245 ml | Immersion is recommended for several seconds | • Aluminum and aluminum alloys |

## Result

Polished specimen is successfully etched to examine microscopically.

## Questions

1. The purpose of etching is to________________________________________.
2. The chemicals used in etching process are______________________________.
3. The purpose of selective etching is____________________________________.
4. The composition of etchant used for steels______________________________.
5. The purpose of Tint etching is______________________________________.

# EXPERIMENT No. 10

## Object

Examination of microstructure using Optical Microscope

## Apparatus

Optical Microscope

## Theory

Optical microscopes as shown in fig.1 are used for identification and analysis of the structures of different metals and alloys. They are important instruments for the research of metallurgy. They can be used for quality research of foundry, smelt and heat treatment, for testing of raw and processed materials or for analysis of heat treatment materials. They are ideal instrument for scientific research, teaching, factories and so on.

**Principle of Metallurgical Microscope**

In Optical Microscope, a horizontal beam of light from some light source is reflected, by means of a plane-glass reflector, downward through the microscope objective onto the surface of the specimen. Some of this incident light reflected from the specimen surface will be magnified in passing through the lower lens system, the objective, and will continue upward through the plane glass reflector and be magnified again by the upper lens system, the eyepiece. The initial magnifying power of the objective and the eyepiece is usually engraved on the lens mount. When a particular combination of objective and eyepiece is used at the proper tube length, the total magnification is equal to the product of the magnifications of the objective and the eyepiece.

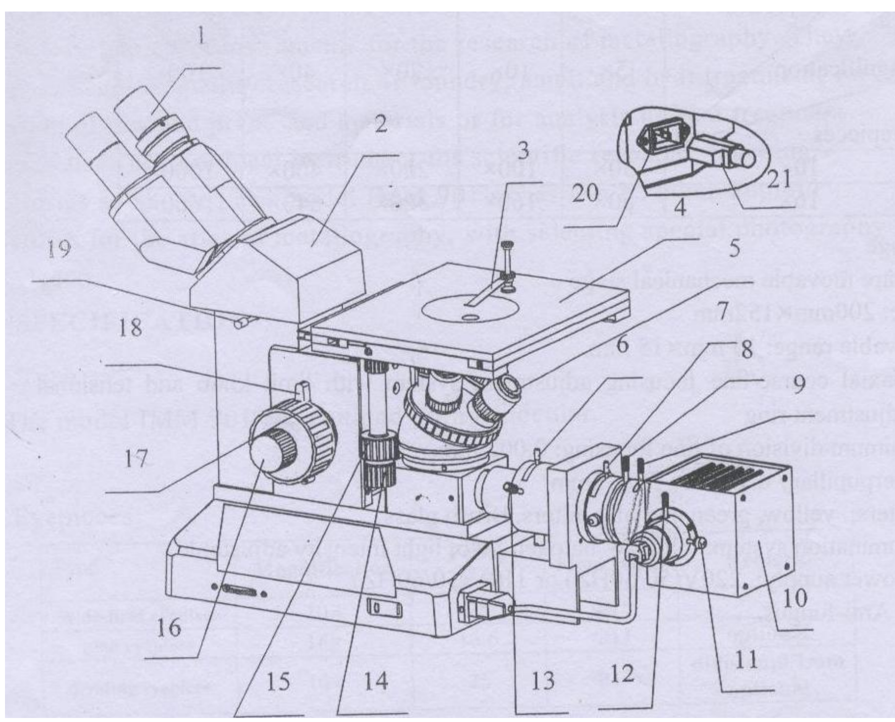
The maximum magnification obtained with the optical microscope is about 2OOOx

**Principle Limitation**

The principal limitation is the wavelength of visible light, which limits the resolution of fine detail in the metallographic specimen. The magnification may be extended somewhat by the use of shorter-wavelength radiation, such as ultraviolet radiation, but the sample preparation technique is more involved.

**(Fig.1) OPTICAL MICROSCOPE**

## Microscope Parts



| | |
|---|---|
| 1. Eye Piece | 10. Lamp Box |
| 2. Binoculars | 11. Lamp Holder Lock Screw |
| 3. Stretchy Clip | 12. Lamp Adjustment Pole |
| 4. Mechanical | 13. Field Diaphragm Adjustment Screw |
| 5. Objective | 14. Cross Movement Knob |
| 6. Field Diaphragm | 15. Lengthways Movement Knobs |
| Stage Adjustment Pole | 16. Fine Focusing Knob |
| 7. Aperture Diaphragm Adjustment Pole | 17. Coarse Focusing Knob |
| 8. Filter | 18. Limit Knob |
| 9. Condenser Adjustment Pole | 19. Tube Holding Screw |
| 20. Electrical Outlet | 21. Power Supply |

## Question

1. In Optical Microscope a horizontal beam of____________________________Passes through a plane glass reflector.

2. The total magnification is equal to the product of the magnification of the objective and the________________.

3. The maximum magnification obtained with the Optical Microscope is about __________________.

4. An Optical Microscope helps determine________________and____________.

5. In Optical Microscope illumination beam is__________________.

# EXPERIMENT No. 11

## Object

Hardness Testing Techniques for Ferrous materials.

## Apparatus

Brinell hardness tester.

## Theory

The Figure 1. Below shows the description of brinell hardness tester.
The principle of hardness tester:
Hardness is the resistance to penetration, scratching. In the Brinell hardness method, the indenter size and the load to be applied are determined from the scales provided for the type of material to be tested.

The hardness is calculated by the following formula.

$$BHN = \frac{P}{\pi D/2 \left(D - \sqrt{D^2 - d^2}\right)}$$

Where,

P= Major Load
D= Diameter of the ball
d= Indentation diameter

An indenter (A hard metal ball with diameter D) is forced into the surface of a test piece and the diameter of the indentation d left in the surface after removal of the force F is measured.

The brinell hardness is proportional to the quotient obtained by dividing the test force by the curved surface area of the indentation. The indentation is assumed to be spherical with a radius corresponding to half of the diameter of the ball.

The brinell number which normally raises from HB50 to HB750 for metals, will increase as the sample gets harder.


**(Fig. 1) BRINELL HARDNESS TESTER**

## Tester Parts

| | |
|---|---|
| 1. LCD | 2. Keyboard |
| 3. Protective Nose | 4. Indenter (Inside protective nose) |
| 5. Anvil | 6. Screw Pindle |
| 7. Emergency stop | 8. Printer |
| 9. RS232 | 10. Cable interface |
| 11. Main switch | 12. Fuse holder |

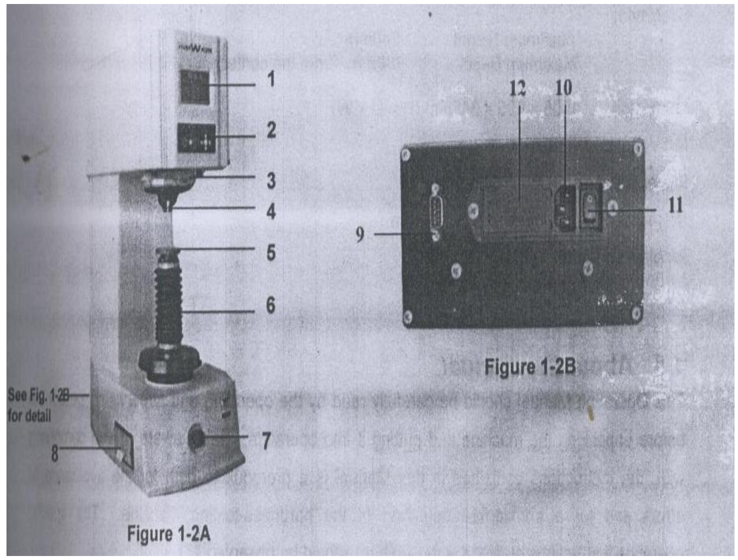


Figure 1-2A
Figure 1-2B

## Procedure

Explain yourself about this practical.

______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________
______________________________________________________________________

## Question

1. Unit for measuring Brinell's hardness is
   a. HRB
   b. Hardness number
   c. Grams /mm
   d. None of the above
2. Diamond indenter is used in

a. Brinell is Hardness test

b. Rockwell Hardness test

c. Both of the above

3. A Brinell's Hardness test was done on the following materials and results tabulated As follows

a. Materials A, HB=200

b. Materials B, HB=100

c. Materials C, HB=50

Which materials is the hardest?

Answer ____________

4. A ball of 5mm diameter is used as indenter in a brinell's Test on 3 different materials all subjected to the same load. The size of the indentation diameter was found to be

a. MATERIAL A, d= 1.5mm

b. MATERIAL B, d=1.3mm

c. MATERIAL C, d=1.1mm.

Which material is the hardest?

Answer _____________

F/OBEM 01/03/00

**NED University of Engineering & Technology**
**Department of ____________________ Engineering**

Course Code and Title: ______________________________________________

Laboratory Session No. ______________ Date: ____________________

| **Psychomotor Domain Assessment Rubric-Level P1** | | | | | |
|---|---|---|---|---|---|
| Skill Sets | Extent of Achievement | | | | |
| | 0 | 1 | 2 | 3 | 4 |
| **Equipment Identification** Sensory skill to ***identify*** equipment and/or its component for a lab work. | Not able to identify the equipment. | -- | -- | -- | Able to identify equipment as well as its components. |
| **Equipment Use** Sensory skills to ***demonstrate*** the use of the equipment for the lab work. | Doesn't demonstrate the use of equipment. | Slightly demonstrates the use of equipment. | Somewhat demonstrates the use of equipment. | Moderately demonstrates the use of equipment. | Fully demonstrates the use of equipment. |
| **Safety Adherence** Adherence to ***safety*** procedures. | Doesn't adhere to safety procedures. | Slightly adheres to safety procedures. | Somewhat adheres to safety procedures. | Moderately adheres to safety procedures. | Fully adheres to safety procedures. |
| **Equipment Handling** ***Equipment care*** during the use. | Doesn't handle equipment with required care | Rarely handles equipment with required care | Occasionally handles equipment with required care | Often handles equipment with required care | Handles equipment with required care |
| **Group Work** ***Contributes*** in a group based lab work. | Doesn't participate and contribute. | Slightly participates and contributes. | Somewhat participates and contributes. | Moderately participates and contributes. | Fully participates and contributes. |

| | |
|---|---|
| Weighted CLO (Psychomotor Score) | |
| Remarks | |
| Instructor's Signature with Date | |