Safety Hazards
Material Processing Laboratory Room 232

HAZARD: Rotating Equipment / Machine Tools

Be aware of pinch points and possible entanglement

Personal Protective Equipment: Safety Goggles; Standing Shields, Sturdy Shoes
No: Loose clothing; Neck Ties/Scarves; Jewelry (remove); Long Hair (tie back)

HAZARD: Projectiles / Ejected Parts

Articles in motion may dislodge and become airborne.

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Heating - Burn

Be aware of hot surfaces

Personal Protective Equipment: Safety Goggles**;** High Temperature Gloves; Welding Apron, Welding Jacket, Boot Gauntlets, Face Shield

HAZARD: Chemical - Burn / Fume

Use Adequate Ventilation and/or Rated Fume Hood. Make note of Safety Shower and Eyewash Station Locations.

Personal Protective Equipment: Safety Goggles; Chemically Rated Gloves; Chemically Rated Apron

HAZARD: Electrical - Burn / Shock

Care with electrical connections, particularly with grounding and not Using frayed electrical cords, can reduce hazard. Use GFCI receptacles near water.

HAZARD: High Pressure Air-Fluid / Gas Cylinders / Vacuum

Inspect before using any pressure / vacuum equipment.
Gas cylinders must be secured at all times.

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Water / Slip Hazard

Clean any spills immediately.

EXPERIMENT # 2:

MICROANALYSIS

Goal: To define the relationship between microstructure of different materials and their mechanical properties.

Objectives: To learn surface preparation and etching procedure, to study how to operate optical microscope, and to determine the structure of materials by microscopic examinations (Optical Microscopy or Microanalysis).

The primary purpose of microscopic examination is to reveal details of metal structures, which are too small to be seen with the unaided eye.

Equipment and Tools: Optical microscope connected with television screen, optical microscopes for each student, eyepiece micrometer, two-wheel metallographic specimen, preparation table, sink.

Materials: Different Ferrous & Non-ferrous Alloys, sand papers, coolant, etching solutions

Each group of students must complete microstructural investigation of minimum one specimen, sketch its microstructure and label all defined constituents, to produce the Data Sheet, and to give the answers on the Set of Questions.

A report has to be prepared according to the requirements of the General Instruction.

LABORATORY ASSIGNMENT:

In carrying out your assignment, follow the sequence given below:

1. A steel specimens, designation—(set 8: samples N1-N28; X17-X20; X24-X28, X34)
2. Cast iron specimens, designation—(set 5: samples M7-M10; M11-M17; J5-J7; J9)
3. A non-ferrous heavy alloy(i.e. copper alloy) specimen, designation—(set 7: samples C5-C10; V1-v17; B8-B11; R1; E5-E8; S3-S7 or X2-X7; X31, X33)
4. A non-ferrous light alloy(i.e. aluminum, titanium or magnesium alloy) specimen, designation—(set 1: samples H1-H6; set 6: samples G1-G11; A1-A3 or X14-X16)

The various microstructures should be examined at magnifications 200X, 300X or 400X.

1. Read the characteristics and description of the microscope;
2. Select the specimens;
3. Prepare surface of the specimens for microscopic examination;
4. Etch the surface of specimens;

5. Discuss how to obtain the microstructure of selected specimens with your instructor;
6. Select, check and verify the magnification of the microscope for studying the microstructure;
7. Sketch the microstructure observed under the microscope (**do not make exact copy**);
8. Label different observed constituents of specimen's microstructure and describe their properties;
9. Discuss the difference in the microstructures of the various specimens examined;
10. In tabular form indicate the mechanical properties of comparable materials examined (use the Table 2-1);
11. List typical uses for the materials examined, [1];
12. Give the answers in details to the Set of Questions.

1. Characteristic and Description of Microscope

The primary purpose of microscopic examination is to reveal details of metal structures that are too small to be seen with unaided eye.
The metallurgical microscope is equipped with revolving nosepieces, which may contain up to four objective lenses. This set-up makes it possible to go rapidly from one magnification to another without inconvenience of unscrewing and changing lenses. Total magnification of a microscope may be determined by the product of the eyepiece number and objective lens magnification number. For example: 10X-power eyepiece used in conjunction with a 50X objective lens gives a magnification of 500; or X500.

Lenses must be maintained free of fingerprints, dust and oil films.

2. Selection of Specimen

Eight specimens have to be selected in accordance with the laboratory exercise requirements given before.

3. Specimen Surfaces preparation

Suggested specimens need only be polished on pile cloth for removal of the oxygen film formed on the tested surface to be viewed under the microscope.

Care must be taken to prevent overheating the specimen during polishing. Excessive pressure during polishing will form deep scratches and will increase the depth of disturbed metal on the surface of the specimen.

Fine polishing is often done using a water coolant and silicon carbide abrasive paper mounted on a rotating disc. The two-wheel unit in the laboratory can be equipped with rough polishing wheel and a final polishing wheel. Wheel speed for final polishing has to be set at a second position (about 1150 rpm). A small stream of water is directed at the center of the rotating wheel

Rough polishing

This operation can be performed by means of different type sand paper. For rough polishing, a adhesive sand paper should be used as a covering for the rotating polishing wheels. During rough polishing the specimen is moved in a clockwise direction around the polishing wheel to

insure equal metal removal from the entire surface by not allowing prolonged polishing in any one direction.

Final Polishing

Final polishing is very similar to that used for rough polishing. Aluminum oxide is the most popular final polishing abrasive for ferrous and non-ferrous materials. It is also possible to use chromium oxides for soft materials.
The abrasive particles used in final polishing are generally carried on a napped or short pile cloth such as billiard cloth or microcloth. Most polishing cloths can be obtained cut to size and coated with an adhesive backing. The adhesive back eliminates the need for mechanical clamping.

CAUTION!
Be sure that you supply the rotating wheel with continuous flowing water. This step is taken to insure cool surface during polishing.

4. Etching of specimens

Polished metal specimens usually show no structural characteristics. Etching of the metal surface is done to make visible the crystalline structure of the metal and to produce optical contrast between the various constituents. Etching is done by exposing the cleaned and polished specimen surface to suitable etching solution such as those described in Table 2-1. These etching reagents are powerful, hazard and must be handled with care.

CAUTION!
Do not forget: etchants are composed of organic and inorganic acids, alkalis or other complex substances.

If the specimen is not sufficiently etched after the first application the process may be repeated. If the specimen is overetched it must be repolished prior to re-etching. Immediately following the etching the specimen should be washed in warm water to stop the etching, then immersed in alcohol and finally dried in a blast of warm air. Rapid drying is important to prevent water spots. Etching reveals structural characteristics by preferential etching. That means that some areas such as grain boundaries are more highly stressed than other areas and are more subject to chemical etching.

5. Discussion of the Final Microstructure

The final structure must be discussed with the instructor. In order to carry out this discussion it is necessary to use a group microscope hooked up with a television screen.

6. Selection of Magnification for Microstructure studying

You are required to study the grain structure of different suggested materials. In this experiment the magnification ranges between 200X to 500X times. Do not forget: total magnification is a product of eyepiece magnification and magnification of lens

7. Sketching of Microstructure
Draw the microstructure observed under the microscope and put it in the Data Sheet furnished, filling in the 1 X 1" frames. Identify and label each constituent present in the microstructure of the alloy.

8.Characterizing of Microstructure
The microstructural components of an alloy are its individual portions, each portion having a single structure with characteristic features when observed through the microscope. Structural components can consist of one, two or more phases. You are required to determine the relationship between the structure and properties of the examined metallic alloy. Discuss the influence of grain size on the ductility of the material being studied.

9. Discussion of the microstructure
Discuss, compare and distinguish the difference in the microstructure of the various specimen examined.

10. Tabulation of Mechanical Properties
Using Handbook or any references related to Ferrous and Non-ferrous materials complete the Table 2-2 entitled "Properties of the Metal Examined"

11. Typical uses of materials
Using knowledge of the properties of examined materials, discuss whether or not such materials are suitable for certain definite end uses and also underline their machinability in order to get the most desirable configuration.

	Etchants	***Composition***	***Remarks***
Iron and steel	No. 1 Nital	1-5% Nitric acid 95%-99% methyl alcohol	Carbon steels-Darkens pearlite, reveals ferrite boundaries, general use for high speed steels time:5-60secons.
	No. 2 Picral	4g picric acid 100ml methyl alcohol	Carbon and low alloy steels Time: 5-120 seconds
	No. 3 Ferric chloride and Hydrochloric acid	5g $FgCL_3$, 50ml HCL, 100ml H_2O	Teveal structures of austenite nickel and stainless steels
	No. 4 Heat treating	Heat specimen on hot plate, face up, 400-700 degree. F	Pearlite first to pass through a given color followed by ferrite, cementite lessaffected. Esp. useful for cast iron. Time: 10-60 min.
Copper and its alloys	No.5 Ammonium Hydroxide-hydro-gen peroxide(mak e fresh daily)	5 parts NH_2OH, 5 parts water 2-5parts H_2O_2(3%)	General etchant for copper and many of its alloys. Time: 1min
	No.6 Chromic acid	Saturated aqueous solution(CrO_3)	Copper, Brass, Bronze, and Nickel silver
	No.7 Ferric chloride	5g $FeCL_3$ 96ml ethyl alcohol 2ml HCL	Copper, aluminum, magnesium, nickel, and zinc alloys. Time: 1sec. To several min.
Aluminum and its alloys	No.8 Hydro-fluoric acid	0.5ml HF(conc.) 9.5ml water	General ecthant, apply by swabbing. Time: 15 sec.
	No. 9 Sodium hydroxide	10g NaOH 90ml water	General etchant, can be used for both micro- and macro-etching. Time: 5 sec.
Magnesium and its alloys	No. 10 Glycol	75ml ethylene glycol 24ml water 1ml HNO_3	For almost all magnesium alloys. Time 3-60 sec.
Nickels and its alloys	No.11 Flat solin(make fresh daily)	50ml HNO_3 50ml glacial acetic acid	Nickel, monel, and other nickel-copper alloys. Time: 5-20 sec.
	No. 12 Aquaregia	5ml HNO_3 25ml HCL 30ml water	Inconel
Tin, lead, and zinc alloys	Refer to "Principles of Metallographic Laboratory Practice" by George L. Kehl, Mcgraw-hill, 1949, page 421-432, and ASTM E3-58T on "Methods of Preparing Metaalographic Specimen"		

DATA SHEET FOR LAB. # 2:

	Group Members Last Name	GROUP LEADER:			Instructor's Approval
		LIST OF MATERIALS:			
1					
2				GROUP	
3					
4					
5					
6				Date:	
7					
8					

MICROSTRUCTURE

1		**ALLOY:** Magnification: X Etching Solution:	**5**		**ALLOY:** Magnification: X Etching Solution
2		**ALLOY:** Magnification: X Etching Solution	**6**		**ALLOY:** Magnification: X Etching Solution
3		**ALLOY:** Magnification: X Etching Solution	**7**		**ALLOY:** Magnification: X Etching Solution
4		**ALLOY:** Magnification: X Etching Solution	**8**		**ALLOY:** Magnification: X Etching Solution

TABLE 2. Properties of the Metal Examined

Materials or Alloys	Mechanical Properties					
	Ultimate Tensile Strength psi	Yield Strength Psi	Elongation %	Hardness Rockwell or Brinell	Modulus of Elasticity Psi	Machinability

SET OF QUESTIONS:

1. List the common types of cast iron that can be produced.

2. What is the difference between the microstructures of gray and nodular cast iron?

3. Describe the difference between bronze and brass. Define these two alloys and give some detail of these alloys.

4. What is the chemical composition of 4340 steel? Assuming this steel is to be used as member in an aircraft assembly, what mechanical properties would be desirable for this application?

5. What are the main constituents of a medium carbon content alloy steel at room temperature?

6. Make sketch of pearlite grain and label pearlite components.

7. Does pearlite contain some portion of cementite? If yes, sketch how pearlite looks and identify the constituents.

8. Is it possible to weld a plain carbon content steel (1025)?

9. Is it true that aluminum is known for its excellent thermal conductivity? Name two additional characteristics of aluminum.

10. Describe the influence of different grain size on mechanical properties (ductility, tensile strength, and hardness)

SUGGESTED REFERENCES:

1. E. Paul De Garmo, J.T. Black, R.A. Kohser, Materials and Processes in Manufacturing, 8th Edition, Macmillan, NY, 1997.

2. R.Dubrovsky. Laboratory Manual, Engineering Materials & Processes, ME Department, NJIT, CAPCO, Oklahoma, 1998.

3. G. Petzow, Metallographic Etching, American Society for Metals, Metals Park, Ohio, 1976

4. J. L. McCall, W. M. Muller, Metallographic Specimen Preparation, Plenum Press, New York, 1971

5. D. G. Brandon, Modern Techniques in Metallography, Butterworth Publ. Co., London, 1966

6. R. C. Gifkins, Optical Microscopy of Metals, American Elsevior Publishing Co., Inc., New York, 1970