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LABORATORY OUTLINE:
TENSILE TESTING OF STEEL & ALUMINUM ALLOYS (ASTM E8)

OBJECTIVE
To carry out a standard tensile test on specimens of a hot rolled steel (AISI 1045), Type 2024-T351 aluminum, polymers (UHMW-PE, acrylic) and, from the results, to determine the yield strengths, tensile strengths and ductility (%EL, %RA) of the metallic specimens.

EQUIPMENT REQUIRED
SATEC testing machine and integrated load vs. displacement (x – y) plotter.
Hammer
Center punch
Micrometer calipers
Extensometer

MATERIALS REQUIRED
Standard tensile test specimens (1/2 in. diameter) AISI 1045HR, 2024-T351, UHMW-PE, acrylic

PROCEDURE
Mark and record 2.0 in. gage length on specimen
Measure initial diameter of specimen
Screw specimen into grips; attach extensometer
Apply load gradually; remove extensometer well before fracture
Apply load until fracture occurs; remove specimen from grips
Record maximum load and load at fracture
Measure final gage length and final diameter

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LABORATORY OUTLINE:
STRAIN HARDENING & RECRYSTALLIZATION OF COPPER

OBJECTIVE
To determine the effects of cold working and subsequent annealing on the hardness of a specimen of the nominally pure copper.

EQUIPMENT REQUIRED
Manual Rolling Mill
Micrometer Calipers
Rockwell Hardness Tester
Blue-M Muffle Furnace (2)
Band Saw
Bucket

MATERIALS REQUIRED
Specimen, Nominally Pure Copper, ¼ in. x 1 in. x 2 in. (2)

PROCEDURE
Preheat Blue-M furnaces #1 and #2 to 450^{o}F and 650^{o}F respectively
Measure initial Rockwell F hardness of each specimen
Subject each specimen to 3 – 5% cold work, using manual rolling mill
Measure Rockwell F hardness of each specimen
Repeat preceding two steps, until about 50% cold work has been obtained
Cut each specimen into five equal parts
Place parts from one specimen into Blue-M #1 and parts from other into Blue-M #2
Remove, quench, and measure the Rockwell F hardness of a part from each furnace, at intervals of 5, 10, 15, 20 and 30 minutes

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LABORATORY OUTLINE:
HEAT TREATMENT OF ALUMNINUM ALLOY (cf. ASTM B918)

OBJECTIVE
To determine the effects of time and temperature on the precipitation hardening of Type 2024 aluminum.

EQUIPMENT REQUIRED
Blue-M Box Furnace (2)
Hoskins Box Furnace
Rockwell Hardness Tester
Tongs / Gloves
Metal Bucket

MATERAILS REQUIRED
Specimen (1/2 in. Diameter, ½ in. long), Type 2024 Aluminum (11)

PROCEDURE
Preheat Blue-M #1 to 950^{o}F; Preheat Blue-M #2 to 500^{o}F; and Preheat Hoskins to 250^{o}F
Place all eleven specimens into Blue-M #1; hold for one hour
Quench all eleven specimens in agitated ice water
Measure the Rockwell B hardness of one of the as-quenched specimen; set this specimen aside for room temperature aging
Place five of the remaining as-quenched specimens into Blue-M #2 and five into Hoskins
Quench one specimen from each furnace, after 5,10, 15, 20, and 30 minutes
Measure Rockwell B hardness of each of the above specimens

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LABORATORY OUTLINE:
HARDENABILITY OF STEEL, JOMINY TEST (ASTM A255)

OBJECTIVE
To determine the effects of quenching on the hardness of Type AISI 1045, 4140, and 4340 steels

EQUIPMENT REQUIRED
Blue-M Box Furnace (1)
Jominey quencher.
Rockwell Hardness Tester, C scale
Belt Grinder
Tongs / Gloves
Metal Bucket

MATERIALS REQUIRED
Jominy specimens: AISI 1045, 4140, 4340

PROCEDURE
Preheat Blue-M to 1600^{o}F (per ASTM A255)
Place one of each specimen in Blue-M, at 10 minutes intervals
Remove the first specimen place in the furnace after 30-35 minutes (per ASTM A255) and quickly place on functioning Jominy stand.
Grind a flat area into the specimen at least 2 inches from the quenched end
Quench on the Jominy stand for 10 minutes (minimum).
Measure hardness every 1/8 of an inch from the quenched end, up to 2 inches.
Repeat with each of the specimens (each should be in the furnace for 30-35 minutes).

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LABORATORY OUTLINE:
MICROSCOPIC EXAMINATION OF METAL ALLOYS

OBJECTIVE
To observe and analyze the microstructures of a variety of typical ferrous and non-ferrous metal alloys.

To prepare a typical metallurgical specimen for microscopic examination and to examine, analyze, and record the resulting microstructure.

EQUIPMENT NEEDED
Nikon Epiphot, with TV Camera and High Resolution TV Monitor
Nikon Optiphot, with DSLR Camera
Buehler Abrasive Cut-off Saw
Buehler Abrasive Belt Grinder
Buehler Manual Grinder (2)
Buehler Polishing Machine
Chemical Hood, with Exhaust Blower
Tanks and Holders, for processing Polaroid Negatives
Blow Dryer
Rockwell Hardness Tester

MATERIALS REQUIRED
Specimen (1/2 in. Diameter, ½ in. long or broken Charpy bars) steel, water quenched, air quenched, or furnace cooled (1 per student).
Silicon Carbide Abrasive Belts / Rolls, 50, 120, 240, 320, 400 and 600 Grit
Felt Polishing Cloths, 8 inch Diameter
0.2 Micron Alumnia
Methanol
2.0 Percent NITAL Solution
18.0 Percent Sodium Sulfite Solution
Distilled Water
Petri Dishes
Q-Tips
Squirt / Storage bottles

PROCEDURE – PHASE I
Instructor reviews principles of equilibrium and non-equilibrium microstructure development and the relationship of microstructure to macroscopic (engineering) properties.

Instructor displays microstructures of a variety of ferrous and non-ferrous alloys on TV monitor and describes each in terms of its source, constitution, and practical significance.

PROCEDURE – PHASE II
Instructor describes typical procedure used to prepare a metallurgical specimen for microscopic examination

Instructor provides each student a specimen

Instructor assists each student in the performance of a Rockwell C hardness test on his / her specimen

Instructor guides students through processes of grinding to 600 grit, polishing to 0.21 micron alumina, and etching with 2.0 percent NITAL

Instructor briefs students on use of Optiphot metallurgical microscope and assists students in the examination and recording of their microstructures

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LABORATORY OUTLINE:
IMPACT TESTING OF METAL ALLOYS (ASTM E23)

OBJECTIVE
To determine the effect of temperature on the impact energy of AISI Type 1040 Cold-rolled steel, AISI Type 1040 Hot-rolled steel, ASTM Type A36 Steel and Type 2024 Aluminum

EQUIPMENT NEEDED
Pendulum Impact Testing Machine
Containers for Ice Water, Boiling Water and Liquid Nitrogen
Electric Hot Plate
Tongs

MATERIALS REQUIRED
Charpy V-Notch Specimen, AISI Type 1018 Cold-Rolled Steel (8)
Charpy V-Notch Specimen, AISI Type 1040 Cold-Rolled Steel (8)
Charpy V-Notch Specimen, AISI type 1040 Hot-Rolled Steel (8)
Charpy V-Notch Specimen, Type 2024 Aluminum (8)
Ice Water, Boiling Water, and Liquid Nitrogen

PROCEDURE
Place two specimens of each material into each medium. Allow to equilibrate
Measure Charpy impact energy for each specimen within each medium
Plot impact energy versus temperature, for each material

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LABORATORY OUTLINE:
STRAIN GAGE and application in DETERMING POISSION'S RATIO

OBJECTIVE

Learn the basics of strain gages and their application. Strain gages are widely used to measure strains (and calculate stress) under conditions of plane stress (2-dimensional stress, $\sigma_z=0$). They may be used, as in this lab, to determine Poisson's ratio, but that is ***not*** their typical use.

EQUIPMENT NEEDED

- VE-20 Digital Strain Indicator (to measure the resistance change and expresses this as strain)
- 2 unidirectional strain gages – one mounted along the axis of the beam, the other mounted transversely.
- 1 test beam and loading apparatus

MATERIALS REQUIRED

No expendable materials will be used in this laboratory.

PROCEDURE

- Load the test beam to seven different target deflections, from zero to 0.18 inch, inclusively (0.00, 0.03, 0.06,…,0.18 inch).
- Record the strain reading in both the axial and transverse mounted gages for each deflection.