ME 280 Lab #2

Microstructure and Property Control of Metals

Experimental Procedure

Heat Treatment of your sample

Each student will receive a steel sample to put into the furnace preheated to 900C. Two students will each wear a face shield and high temperature gloves with one student opening the furnace door and the other student using tongs to place the sample on the fire brick in the furnace. The furnace will be allowed to come back up to temperature and samples will soak for approximately 30 minutes. While you are waiting, Chris Pratt will talk you through the steps that you will be taking to prepare your samples for cross-sectioning and microstructure observation.

When the samples have finished their soak in the furnace, the students will again put on their face shield and high temperature gloves. The first sample will be cooled in a bucket of cold water and the students will record the time in seconds that it takes the sample to cool. The second sample will be set on the firebrick outside the furnace to air cool. **Do not touch this sample until a mounting press is available for you to use.** You can use the thermocouple to periodically check the surface temperature, when it reaches room temperature; record the amount of time it took. The third sample will be cooled in a bucket of quench oil; record the time for its cooling.

Students will pick which sample they want to be responsible for to carry out the rest of the lab.

Cross-sectioning and Sample Preparation

Each student will cut their sample approximately in half with a hacksaw. Using the three piece mold, place your two halves with one cut side down and the other half cut side up on the smallest piece of the mold with the sharp edge up. Place the outer piece of the mold around this small piece forming a cylinder with your samples inside. Measure out 25mls of Bakelite powder and pour this in the cylinder over your samples. Insert the third part of your mold with the sharp edge down into the cylinder. Carefully slide the mold off the table with your hand under it and place it into the Buehler Mounting Press. Align the mold in the press and add pressure with the jack handle to the preload for your size mold, (1.25” diameter mold = 2500 psi) Drop the heater around the mold and increase the pressure to 5000 psi on the gauge. As the Bakelite heats up it melts and the pressure drops. Keep adding pressure to 5000 psi until it stabilizes at that pressure. Leave the press alone for about 4 minutes for the powder to cure. After the 4 minute cure time, raise the heater up to its holding spot and put the cooling fins around the mold. The fins will slightly cool the mold and the pressure will drop slowly. Once the pressure reaches 4500 psi, the cooling fins can be removed and the release valve on the jack can be activated. Using a high temperature glove, move the mold out to the demounting position and add pressure to push the sample out. Hold the glove under the hole to catch the mold pieces and sample. **Use caution because the mold and the sample are still hot!**

Grinding and Polishing
Use the Buehler Belt Grinder fitted with 180 grit SiC paper to grind flat your sample and put a small bevel on both edges of your mount. Use water at all times when grinding. Move on to the Buehler Hand Grinding station. Grind in steps, starting with the 240 grit SiC paper and working your way down the line to the 600 grit SiC paper. Rotate your sample 90 degrees as you proceed and make sure that any damage from the previous grit is removed before moving on to the next grit size. Once the surface has a 600 grit finish you can move on to the polishing table.

Rinse your sample in the sink and then start polishing with the polishing wheel closest to the door. Turn the motor on high and wet the polishing cloth with water. Spray the cloth with 1.0 micron Alumina powder slurry. Lightly hold your sample on the cloth and add slurry as needed to eliminate any scratches from grinding. Rinse the sample in the sink to get rid of any remaining slurry. Turn on the polishing wheel closet to the sink and use the same technique as above except now use the 0.05 micron Alumina slurry to get a mirror like finish. Rinse your sample in the sink and dry it with the hand dryer on the wall above the polishing bench.

Etch your sample with a 2% nital solution (nitric acid and methanol). Put on nitrile gloves and use the etch solution in the fumehood. The etchant will be in a watch glass and you will use the tongs to quickly dip your sample facedown into the etchant. The etchant will make your sample go from a mirror like surface to a cloudy grey surface. Etching removes the final sub-micron damage layer and differentially attacks the different portions of the microstructure. Rinse your sample in the sink, moving it at arms length from the fumehood, so that you do not drip any acid on your clothes. Use the hand dryer to dry the sample.

**Microstructure Observation**

Use the Olympus BH-2 microscope to observe your microstructure. Put your sample faceup on a glass slide with a piece of clay between them. Insert this set up into the mounting press with a kimwip to protect your sample face. Lightly press your sample to flatten your surface for the microscope. Make sure that your microscope has the lowest magnification objective lens in place (5x) and that the stage is low enough so that you can insert your slide and sample into the sample stage without hitting the lens. Turn on the light source and focus your sample using the outer knob for coarse focus and inner knob for fine focus. Turn on the computer and open the Infinity Capture software to view your sample using the digital camera. Once focused you can move up to the next objective lens (10x) and refocus. Continue this procedure for the 20x lens and the 50x lens. Take a micrograph of your microstructure at the 50x objective and the 100x objective. (Click on the camera icon and save your file in your group folder) Save your files with the quench type and objective used.

To determine what your magnification is for each objective lens, take a micrograph of the objective micrometer slide with each objective lens. The objective micrometer has a 1mm scale with 0.01mm marking equally spaced. This scale can be used to put micron markers on a micrograph to show the scale for publication. Free software called Image J can be used for this purpose. You know what the distance is between the lines so you can calibrate the number of pixels to that distance.
**Rockwell Hardness Testing**

Rockwell Hardness testing will be done using the Wilson Rockwell Series 2000 testing machine. This machine uses a load cell and an indenter to make an indentation on your sample.

Two different Rockwell Hardness scales will be used in this lab.

<table>
<thead>
<tr>
<th>Scale Designation</th>
<th>Indenter Type</th>
<th>Load (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rockwell B</td>
<td>1/16” steel ball</td>
<td>100</td>
</tr>
<tr>
<td>Rockwell C</td>
<td>Brale</td>
<td>150</td>
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</tbody>
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Use the Rockwell C scale for the water quenched sample and Rockwell B scale for the oil quenched and air cooled sample. Start near the edge of the sample and make approximately 10 measurements spiraling toward the center making sure to space the indents 2.5 diameters of the indent apart. You want to ensure that you are far enough away from the damage made from the previous indents. Keep track of where your indents are and their position on the sample so that you can comment on any change you might get from edge to center.

You can use the Hardness Conversion chart on the wall opposite the Rockwell Hardness tester to get the tensile strength for your material. Find your Rockwell Hardness Scale and your average hardness and follow across to tensile strength. Rockwell Hardness testing is considered a non-destructive test which allows you to get tensile strength without the need of machining tensile specimens from your material.