

## ESc 22 MECHANICS II: MATERIAL SCIENCE

### LABS 6-8: HEAT TREATMENT OF STEEL

**INTRODUCTION.** The heat treatment of metals, in this case, medium-carbon 1045 steel, is a way to improve its mechanical properties (strength and ductility). Above  $\sim 730^{\circ}\text{C}$ , medium-carbon steel exists as austenite, which is an FCC structure. Below that temperature, austenite becomes energetically unstable and transforms into a BCC structure. Depending on the cooling scheme from the austenitic phase, this BCC structure can have three types of microstructure: (coarse and fine) pearlite, bainite, and martensite. In the following weeks, we will heat treat a 0.45 wt % C (0.45% by weight carbon) steel specimens and then polish and etch its surface to observe the microstructure resulting from the heat treatments. We will also measure the hardness of the heat-treated specimens. You will work in groups of 3 to 4 students, and your group will have a specific heat treatment recipe. You will give a poster presentation as indicated on your syllabus where you will present and describe this entire process to a panel of experts and intelligent non-experts. You will also have an opportunity to describe the phase structure that you obtained using your heat treatment recipe and explain why it was different from the expected phase structure (if it was different).

#### LAB 6 HEAT TREATMENT PROCEDURES

*Safety is of utmost importance! Temperature of  $800^{\circ}\text{C}$  ( $1,472^{\circ}\text{F}$ ) will vaporize skin!*

Split up into groups of 3 to 4 students. Each group will be assigned a heat treatment per the following table:

Group	Heat Treatment	Expected Microstructure*	Compare To*
A	(1) air cool		B, C & E
B	(1) cool at $395^{\circ}\text{C}$ for 30 minutes (2) air cool		C & G
C	(1) cool at $500^{\circ}\text{C}$ for 30 minutes (2) air cool		D, B & G
D	(1) cool at $500^{\circ}\text{C}$ for 5 seconds (2) water quench		E & C
E	(1) water quench		D, F & H
F	Austempering (1) cool at $350^{\circ}\text{C}$ for 10 seconds (2) water quench		E & D
G	Martempering (1) cool to $350^{\circ}\text{C}$ for 30 minutes (2) air cool		C, B & H
H	Tempering (1) water quench (2) heat at $350^{\circ}\text{C}$ for 45 minutes (3) air cool		E, F & G

\*Determine from the diagram on the following page.

†Compare the expected microstructure and hardness of the specimens of your group with the groups listed

**LAB 7 PROCEDURES**

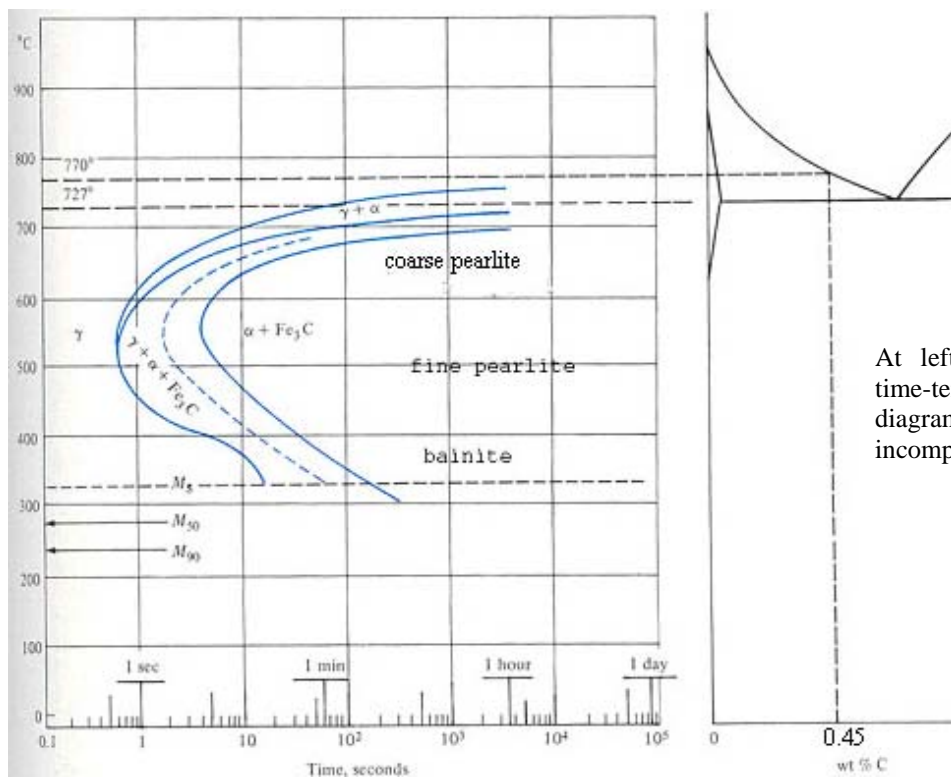
Meet in the Machine Shop on the 2nd Floor of the Engineering Lab to perform Rockwell C hardness testing on your specimens according to the following schedule. Testing must be completed at the end of the lab period if not completed during the designated time period.

Group	Time Period
A	1:45 - 2:10 pm
B	2:10 - 2:35 pm
C	2:35 - 3:00 pm
D	3:00 - 3:25 pm
E	3:25 - 3:50 pm
F	3:50 - 4:15 pm

Proceed to 005 Olin to prepare your specimens for the scanning electron microscope (SEM). Polish your samples using the two polishing wheels (two grades of cloth grit) until you reach a mirror-like finish. Etch your specimens with 2% Nital.

**LAB 8 PROCEDURES**

Meet in 005 Olin. Use the SEM to photograph the surface microstructure of your specimen.



At left, isothermal transformation (I-T, or time-temperature-transformation, T-T-T) diagram for 0.45 wt % C steel. At right, incomplete iron-iron carbide phase diagram.