Lab Report Template

Lab 2 – Cold Working & Annealing

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1. Summary

In groups of 6, 3 samples were given: brass, SAE 1020 and an unknown steel. The 3 samples were cold worked 3 times each and their hardness and height were measured to be able to gain their percent cold work and tensile strength. Once cold-worked they were annealed at various temperatures and their hardness and tensile strength were measured and calculated again to attempt to predict what the unknown sample is. With the information gathered from: **Table 1:** Hardness, height, percent cold work (%CW), and tensile strength (TS) measurements and **Table 1 -** Typical mechanical properties and applications of plain-carbon steels. It was concluded that the unknown substance must be in between SAE 1020-1040. During this, two other samples of steel were given, unknown which one was cold rolled, and which was hot rolled. The bend test was used to determine which sample was cold or hot rolled as well as certain properties of the two samples of metal. It was found that the dark, skinny, less ductile sample was the hot rolled one and the light, thick, hard sample was cold rolled. The micrographs were then taken, examined and it was determined that the cold worked iron ingot had the deformed microstructure due to how cold working is done and the annealed iron ingot had the regular microstructure as seen before in previous labs.

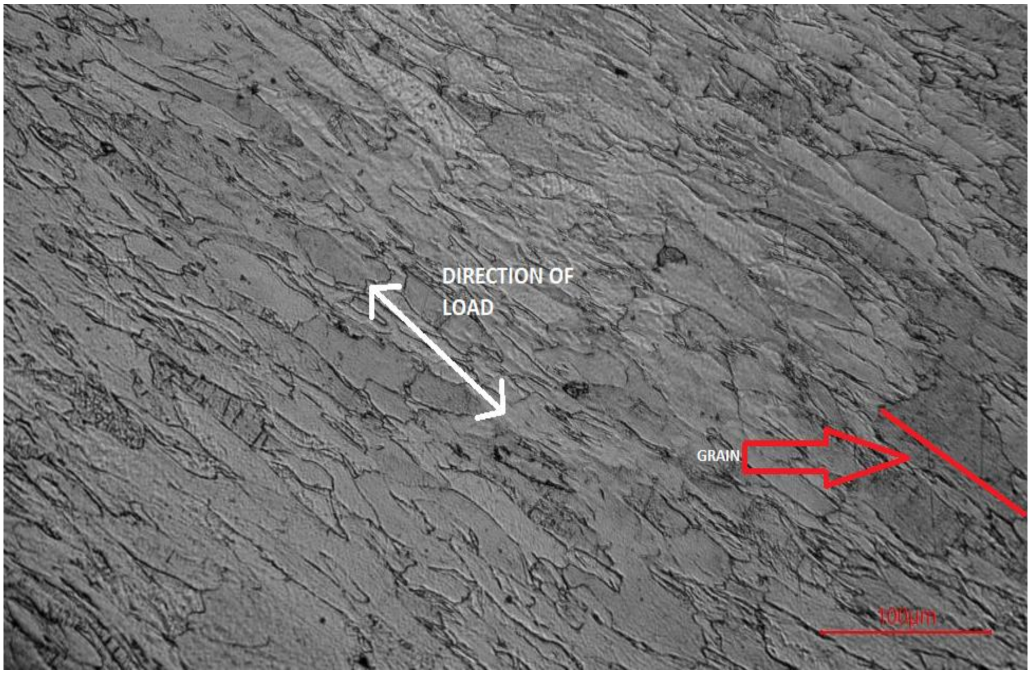
2. Results and Observations

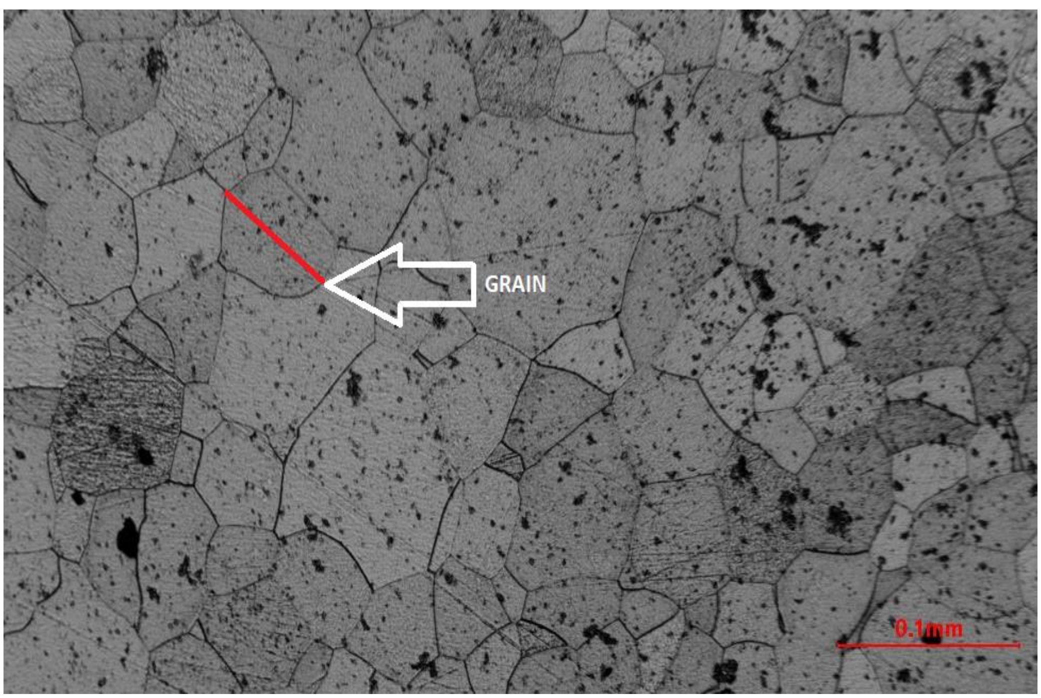
2.1 Record the hardness and height of each sample in Table #1. Ensure to indicate the proper unit of measure for all data in the table.

Table 1: Hardness, height, percent cold work (%CW), and tensile strength (TS) measurements

			Sample Material		
Condition	**Measurement or Calculation**	**Units**	**Brass**	**SAE 1020 steel**	**Unknown steel**
Initial sample	Hardness	Rb	70	85	90.8
	Height	mm	9.44	7.48	6.36
5 tons	Hardness	Rb	60	----	----
	Height	mm	9.34	----	----
	%CW	%	1.06	----	----
	Tensile Strength	MPa	305.76	----	----
10 Tons	Hardness	Rb	68	100	104
	Height	mm	8.46	7.36	6.16
	%CW	%	10.4	1.6	3.14
	Tensile Strength	MPa	323.4	735	752.64
20 Tons	Hardness	Rb	82	90	90
	Height	mm	5.92	7.02	5.44
	%CW	%	37.3	6.14	14.5
	Tensile Strength	MPa	529.2	588	588
30 Tons	Hardness	Rb	----	96	98
	Height	mm	----	4.38	5.04
	%CW	%	----	41.4	20.8
	Tensile Strength	MPa	----	676.2	705.6
After annealing at 300°C for 15 min.	Hardness	Rb	86	98	102
	Tensile Strength	MPa	543.9	720.3	793.8
After annealing at 500°C for 15 min.	Hardness	Rb	68	----	----
	Tensile Strength	MPa	373.38	----	----
After annealing at 800°C for 15 min.	Hardness	Rb	----	70	90
	Tensile Strength	MPa	----	382.2	588

2.2 Attach the micrographs of the 70%CW and 70%CW + annealed samples in the space provided on page 3. Outline a grain in each photograph and indicate which grain is “deformed” versus “annealed”. Indicate the direction of applied load for the deformed sample.

Sample #1 - 70% Cold Worked Ingot Iron	Additional Observations
 (Figure 1: Deformed, cold worked microstructure)	This is the cold worked, deformed sample because of the way that the grain boundaries are stretched and going towards a certain direction compared to the various normal grain boundaries that were looked at in Lab 1. Direction of load application As seen on figure 1.

Sample #2 - 70% Annealed Ingot Iron	Additional Observations
 	The annealed ingot iron sample is very clearly like the various microstructures looked at in Lab 1, with normal grain sizes and non-stretched boundaries.

2.3 Record your observation of the hot rolled and cold rolled steel strips at your workbench. Make comments about the surface appearance, edge definition, and thickness of each sample. Using your engineering judgment, indicate which sample you believe is cold rolled and which sample you believe is hot rolled based on the bend test and your observations.

There were two samples given: a light sample and a dark sample. The light sample on the surface appeared rusted and much thicker than the dark sample. When the bend test was conducted on it, it was difficult to bend and even more so to bend back. Once bent back, the light sample's edges appeared to have slight cracks that indicate some permanent breakage in the microstructure. As well as the light sample has a lower hardness and a lower elasticity (resistance against tension breaking and deformation). The dark sample has a very smooth, clean, sleek surface appearance and is not very thick. When the bend test was conducted it was easily bent but returned to its original state easily without deformations. Therefore, due to the fact that the light sample is corroded and has a higher tensile strength (harder to bend) and that the dark sample is more ductile, the dark sample was hot rolled, and the light sample was cold rolled.

2.4 Calculate the total percent cold work (%CW) for all samples and place the values in Table #1. Show a sample calculation in the space provided below.

$$\%CW = \left[\frac{h_o - h_f}{h_o}\right] \times 100$$

$$= \left[\frac{9.44\,mm - 9.34\,mm}{9.44\,mm}\right] \times 100$$

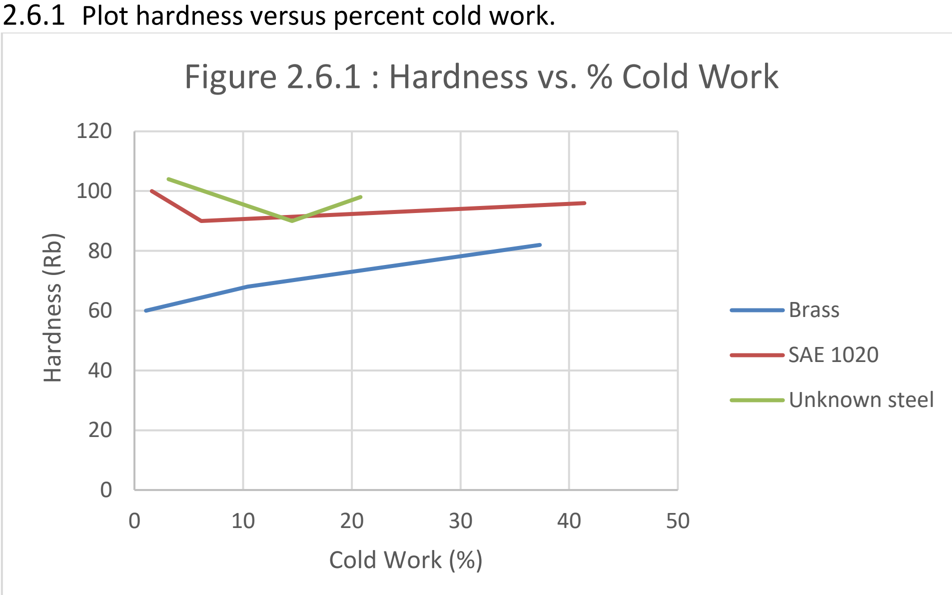
$$= 1.06\,\%$$

2.5 Calculate the tensile strength (TS) for all samples and place the values in Table #1. Show a sample calculation in the space provided below.

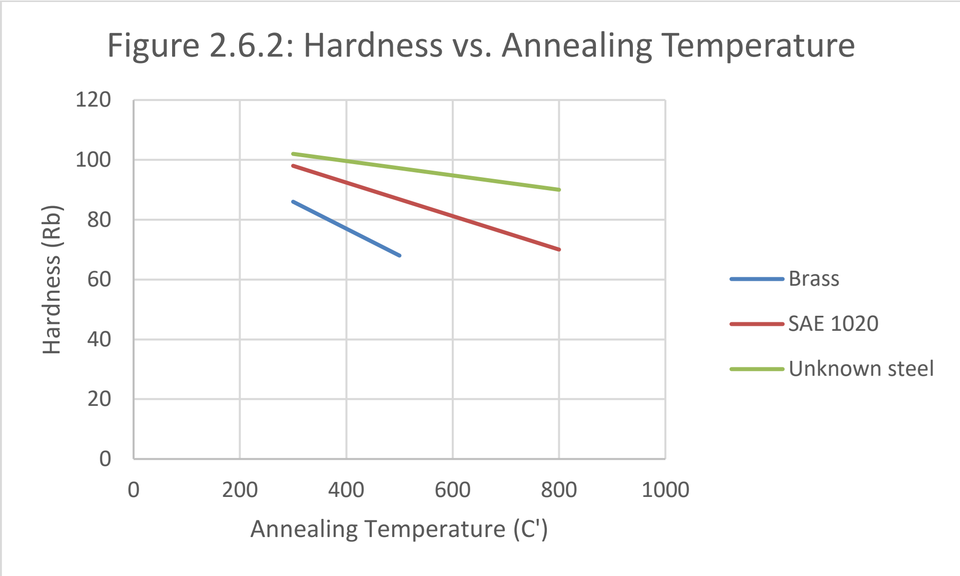
$$TS = (Brinell\ Hardness)(HB)$$
$$= \left(110\frac{kgf}{mm^2}\right)(2.94)$$
$$= 323.3\ MPa$$

2.6 Plot the following relationships for each of the three materials (Brass, SAE 1020 steel, and the unknown steel). Attach your plots in an Appendix at the end of this template. Ensure that the x and y axes are properly labeled, and a legend is constructed for each plot in order to distinguish the curve for each material.

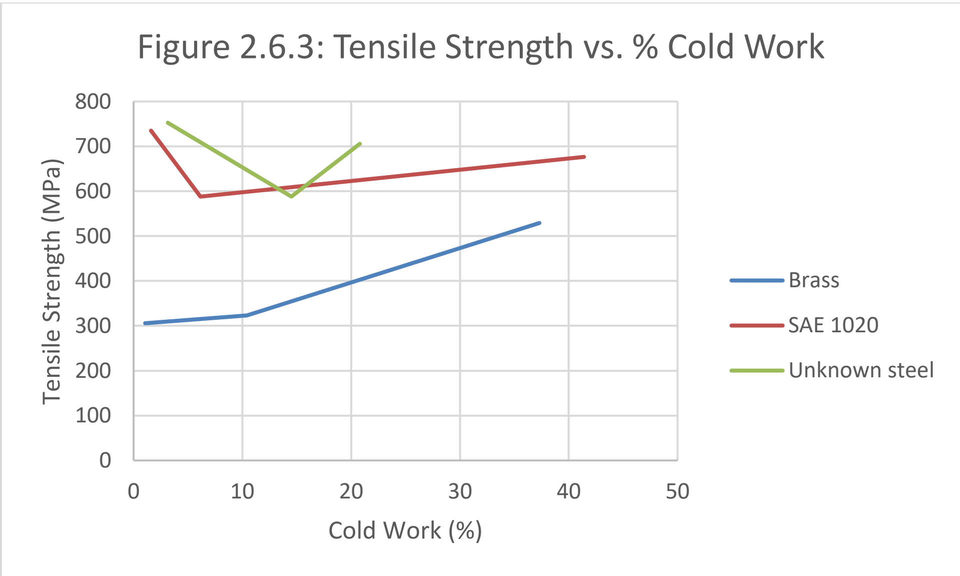
2.6.1 Plot hardness versus percent cold work.



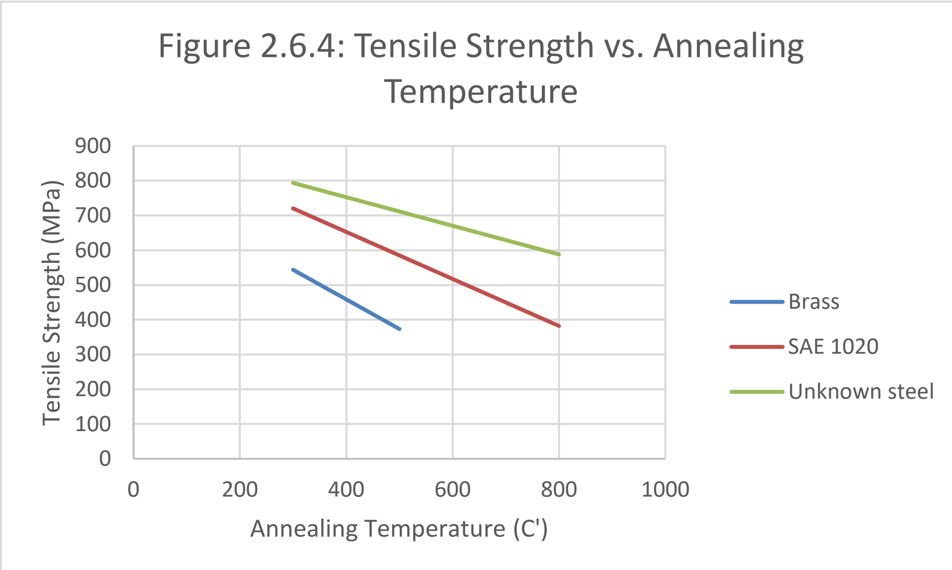
2.6.2 Plot hardness versus annealing temperature.



2.6.3 Plot tensile strength versus percent cold work.



2.6.4 Plot tensile strength versus annealing temperature.



2.7 In the space below, identify the unknown steel sample and provide a short paragraph to justify your answer.

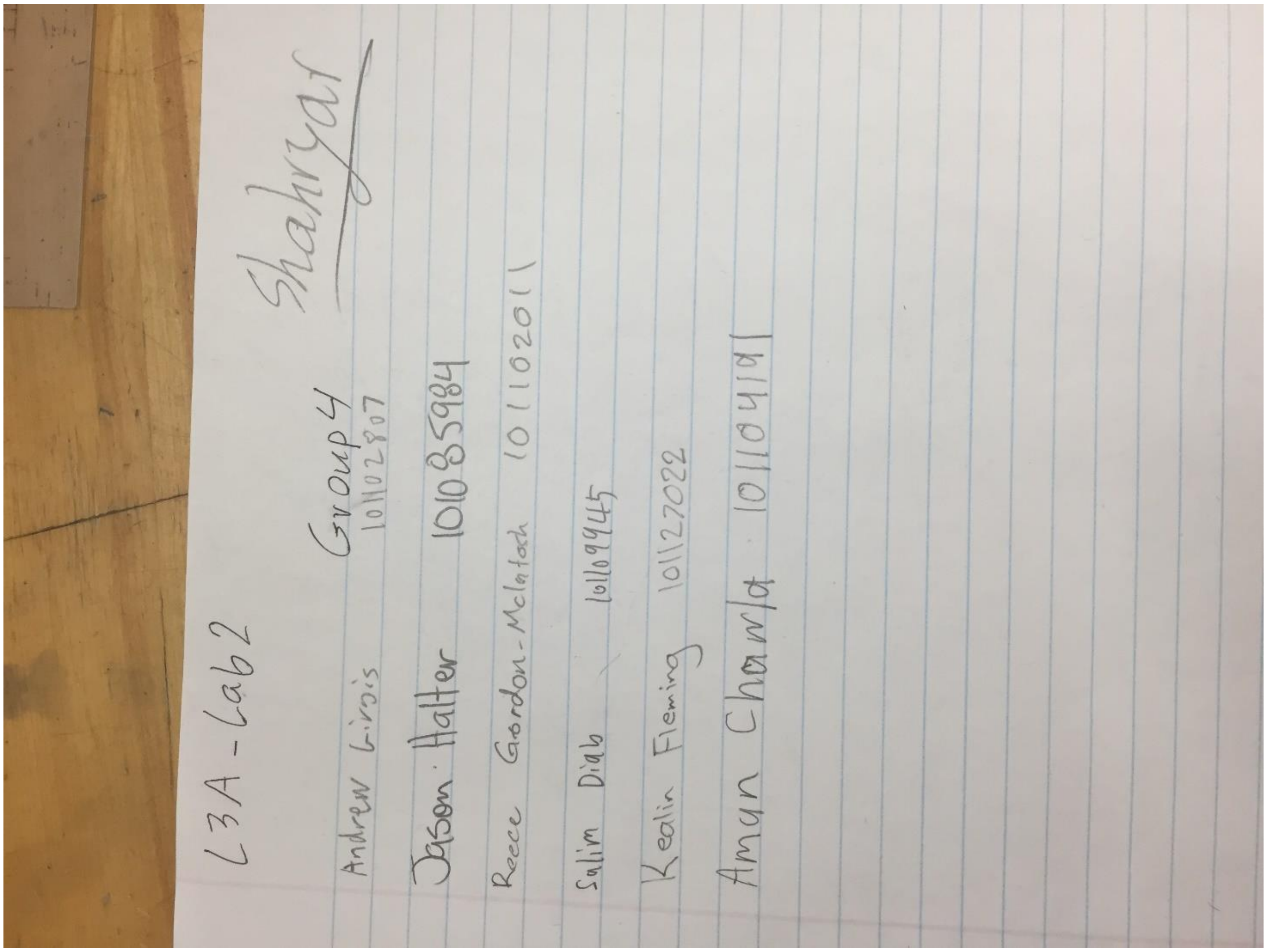
After looking at the tables, **Table 1:** Hardness, height, percent cold work (%CW), and tensile strength (TS) measurements and **Table 1 -** Typical mechanical properties and applications of plain-carbon steels, it was seen that the annealed tensile strength of SAE 1040 was 617, while the annealed tensile strength of the unknown steel was 588. Based on this, it can be extrapolated that the unknown steel is somewhere in between SAE 1020-1040, but it closer towards SAE 1040.

3. Provide answers to the questions given by the TA and attach them to the end of this template.

i) It is the process of making a metal harder through plastic deformation, during this process dislocations move around and more dislocations are created. At the lower temperatures strain hardening prevents the atoms from moving around a rearranging themselves, whereas in hot rolling they are able to do this. The advantage of this being that the dislocations will entangle themselves and this will cause the metal to strengthen itself, however, will result in a reduction of ductility.

ii) There are various major differences between hot and cold rolled materials. One being how they are made, cold rolled steel is pressed at an ambient temperature such that it can be molded into a certain shape, while hot rolled steel is rolled at extremely high temperatures causing it to be malleable and easier to be shaped. In terms of mechanical properties of hot and cold rolled materials, cold rolled materials are generally more resistant to tensile strain, harder and are more susceptible to corrosion. Hot rolled materials are more ductile, malleable and have a greater resistance to corrosion, giving them a sleek exterior.

iii) The hardness test has many advantages and disadvantages to it. For a quick, rudimentary lab the advantages out-weigh the disadvantages. The advantages being that the Rockwell test is convenient with the fact how there is only one tool needed to conduct it. Another one being that the specimen does not need to be prepared before it is tested and the last one being that the Rockwell test is very quick, it could take under a minute to complete it. The only clear disadvantage to the Rockwell test is that the indentations are very small, therefore the results must be interpreted and analyzed with care due to the amount of error there could be associated with the test.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