KING ABDULAZIZ UNIVERSITY- FACULTY OF ENGINEERING
Department of chemical and materials engineering

Material Science– CHE210

Spring-2021

Due date: 20-11-2021

submission date: 29-11-2021

Name: Mohammed Ayid Albaqami
ID Number: 2035729

Instructor: Sami Allah rather

Experiment No.: 1

(Metallic Crystal Structure)

Introduction:

There are 14 specific varieties of crystalline unit cell systems or lattices observed in Nature. However, maximum metals and lots of different solids have a unit cell shape. Described as (BCC) body center cubic, (FCC) face-centered cubic, or (HCP) hexagonal Close Packed. Because those systems are the maximum common. The body-center cubic unit cell has one atom in every of the 8 corners of the cubic (as the cubic unit cell) and an atom inside the center of a cubic. Each of the nook atoms is that another dice nook. The nook atoms are shared via way of means of the 8 unit cells. It is stated that the coordination quantity is eight. The bcc unit cell includes the sum of the 2 nets Atoms; one inside the center, eight from the nook atom as proven with inside the center. The face-centered cubic structure has atoms at each corner, Centers of all cube surfaces. Each of the nook atoms is that another cube nook. The nook atoms are shared by the eight unit cells. In addition, each of its six face-centered atoms is involved with neighboring atoms. It has a coordination number of 12 because 12 of that atom are shared. The (FCC) unit cell contains of a total of four atoms. Eight of the nook atom and six halves of aspect atoms.

Objective:

Investigation of crystallographic properties of metal crystals.

Instruments:

Calculator, Vernier caliper, and Simple and Close Packed

Procedure:

- Measure the diameter of the sphere.
- Calculate the volume of the sphere.
- Calculate the number of spheres in each unit cell.
- Measure the grid constants of SC, BCC,
- Calculates linear and planar densities for FCC and BCC structures Ball per meter
- Discuss SC, BCC, and FCC findings.

Results:

Diameter of the ball = 37mm

r = 18.5mm = 6.332 cm^3

Volume of the ball=4/3 πr^3

Volume of the ball=26.522 cm^3

LD=$\frac{no.\ of\ atoms\ centered\ on\ direction\ vector}{length\ of\ direction\ vector}$

Table 1: The linear density [100],[110] and [111] of BCC and FCC structure

Direction	[100]	[110]	[111]
BCC Structure	LD= $\frac{1}{2r} = 0.027027\ ato$	LD= $\frac{1}{2r} = 0.027027\ atc$	LD=$\frac{2}{4r} = \frac{1}{2r}$ $0.027027\ atom/mm$
FCC Structure	LD= $\frac{1}{2r} = 0.027027\ ato$	LD= $\frac{1}{2r} = 0.027027\ atc$	LD= $\frac{1}{2r} = 0.027027\ atc$

The planar densities of (100), (110) and (111) planes of FCC and BCC structure:

LD=$\frac{no.\ of\ atoms\ centered\ on\ plane}{area\ of\ plane}$

For FCC structure:

- (100)→→$PD = \frac{1}{a^2} = \frac{1}{(2X\sqrt{2}r)^2} = 6.76X10^{-4}$
- (110)→→$PD = \frac{2}{aX4r} = \frac{2}{2X\sqrt{2r}\ X\ 4r} = 2.22X10^{-3}$
- (111)→→$PD = \frac{1}{\sqrt{3}a^2} = \frac{1}{\sqrt{3}X(2X\sqrt{2}r)^2} = 3.9X10^{-3}$

For BCC structure:

- (100)→→$PD = \frac{1}{a^2} = \frac{1}{(\frac{4r}{\sqrt{3}})^2} = 5.48X10^{-4}$
- (110)→→$PD = \frac{2}{aX\sqrt{2}a} = \frac{2}{(\frac{4r}{\sqrt{3}})^2 X\sqrt{2}} = 7.75X10^{-4}$
- (111)→→$PD = \frac{1}{\sqrt{3}a^2} = \frac{1}{(\frac{4r}{\sqrt{3}})^2\ X\ \sqrt{3}} = 3.163X10^{-4}$

Which of the following crystal structures is made of close packed planes?

FCC

What structure do you get from stacking close packed planes as A / B / C?

Close packed planes structure.

Table 2:The planer densities for (100),(110) and (111) planes for BCC and FCC structure

Crystal structure	Lattice parameter(s)	Vu.c.	Number of Balls / u.c.	APF
SC	a=2r=37mm	$a^3 = 50653mm^3$	8/8=1	0.52
BCC	a=$\frac{4r}{\sqrt{3}}$=42.724mm	$a^3 = 77985.8mm^3$	8/8+1=2	0.64
FCC	a=$2\sqrt{2}r$=12.17mm	$a^3 = 1802.5mm^3$	8/8+6/2=4	0.74

Note:

APF=$\frac{Number\ of\ balls\ u.cX\ volume\ of\ one\ ball}{V\ u.c.}$

Discussion:

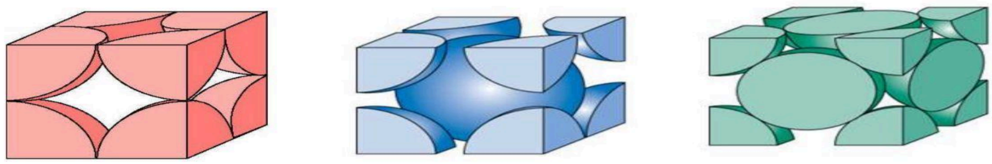
Founded on our information, a meeting should be held for the next experiment to know the aspect. In this lab, we use the crystal structure SC, BCC, and the FCC. Then the diameter was measured with Vernier calipers. Second, we applied this method to compute linear and planar densities and found linear and planar densities for multidirectional vectors and planes in BCC and FCC crystal structures. In this experiment, we educated how to calculate the packing factor of an atom. The method used to find the occupied volume for each crystal structure Atoms represented in our case as plastic ball samples.

Conclusion:

In this lab report, we've provided some clarifications as can look at the outset. After that, we rewrite the tools and procedures for this experiment to clarify the equipment and how to conduct this experiment. Then we've moved on to the important part that represents the results we got. Apply this experiment. To recap, we learned a lot by applying this Experiments have expanded our vision of crystals. Now that's done. We will move on to our first experiments on metallurgy and grain size analysis and we will elucidate this further.

Appendix:

Crystal structure that have been used during our experiment:



(a) Simple Cubic (b) Body Centered Cubic (BCC) (c) Face Centered Cubic (FCC)

Figure 1.1: Types of cubic crystal structure (a) Simple cubic (b) Body Centered Cubic (BCC), (c) Face Centered Cubic (FCC)

(a) Simple packed plane (b) Close packed plane

Figure 1.2: (a) Simple packed plane- Successive layers are superimposed over the base (b) Close packed plane- third layer is placed over voids in both underlying layers

Report: 2

(METALLOGRAPHY& GRAIN SIZE ANALYSIS)

:Introduction

Our capacity to connect characteristics to microstructures is important to our knowledge of material behaviour. The microstructure of a material refers to the geometric arrangement of grains as well as the various phases present. Individual crystalline sections known as grains make up a metal's interior structure. The material composition alloy determines the shape, size, and orientation of these grains. After completing this experiment, the team will have learned some things that will benefit us in the future to become great engineers. This report will contain tools, results, and discussion.

Objective:

The aim of this experiment is to learn about metallurgy and how to apply it in the Study the grain size of the material.

Instruments:

Grinding machine, Polishing machine, Optical microscope.

Procedure:

- Cutting a sufficient size sample, which is generally between 5 and 50 mm in length or diameter
- Using an appropriate resin base holder to mount the sample
- Grinding using various grades of sand paper Begin with a coarse grade and progress to finer and finer grades. Using No. 120 paper, mill the sample on the hand grinding device. Grind in one direction from top to bottom, keeping the water flowing. Turn the sample 90 degrees and grind it in the same way as in the previous step, but with a finer grade paper. Using finer paper, repeat the process until you achieve grade 600
- Polishing, using a series of polishing
- Silicon carbide No. 600
- Silicon carbide No. 1000
- Etching in a corrosive solution to selectively dissolve sections of the grain boundaries in order to differentiate the grains. For 20 seconds, etch in Nital (2 percent HNO_3 in alcohol). Wash as soon as possible. After rinsing it with alcohol, pat it dry
- Observe the microstructures, shown in Figure 2.4, under the optical microscope (Figure 2.5)
- Measure the width and length of the photomicrograph in inches. Calculate the square inches of the area
- In the micrograph, draw seven lines of similar length, i.e. 5 cm, at random

- Count how many grains are crossed by the lines
- Using the formulae, calculate the grain size number, G

Questions:

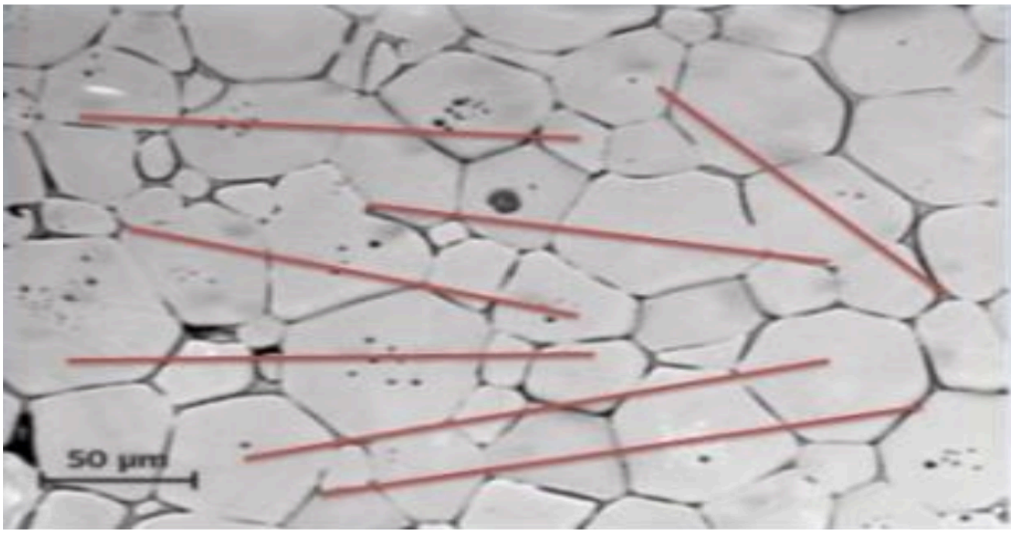
What is etching?

etching is a printing technique that involves incising a pattern into a metal plate, generally copper, using acid. The copperplate is initially covered with the etching ground, an acid-resistant material through which the design is drawn with a sharp tool.

What is over etching?

The impact of microscopic quantities of acid escaping through the ground to generate slight pitting and scorching on the surface is known as over etching in the etching process. The surface can be smoothed and polished to remove the inadvertent roughening.

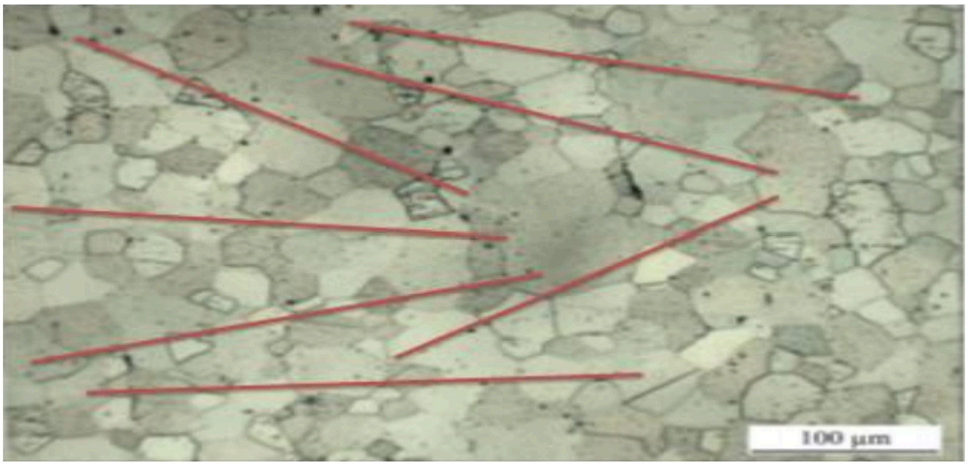
Results:



- M, magnification=X440
- P, total number of intersections =28

No. Lines	No. of grains intersected
1	4
2	4
3	3
4	4
5	5
6	3
7	4

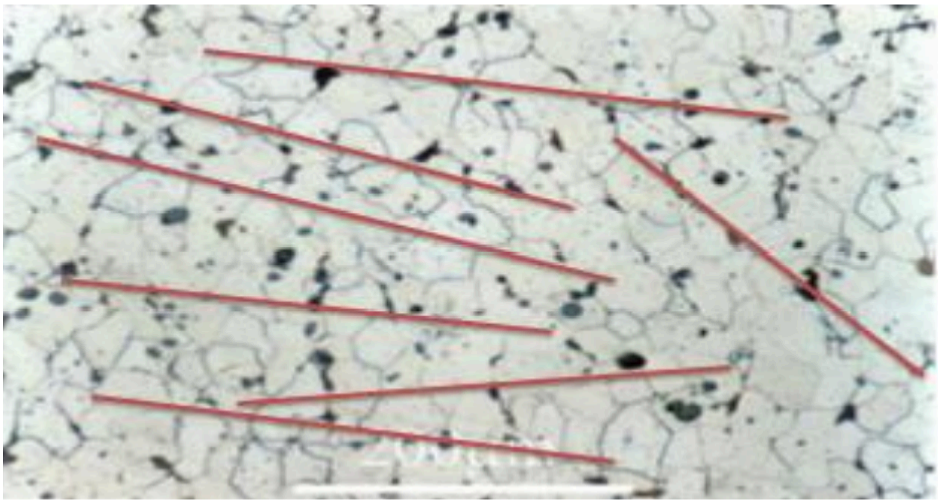
- Lt, total length of all the lines=350mm
- l, mean intercept length=0.02841
- G, the ASTM grain size=6.9798



- M, magnification=X290
- P, total number of intersections =50

No. Lines	No. of grains intersected
1	6
2	8
3	7
4	6
5	8
6	7
7	8

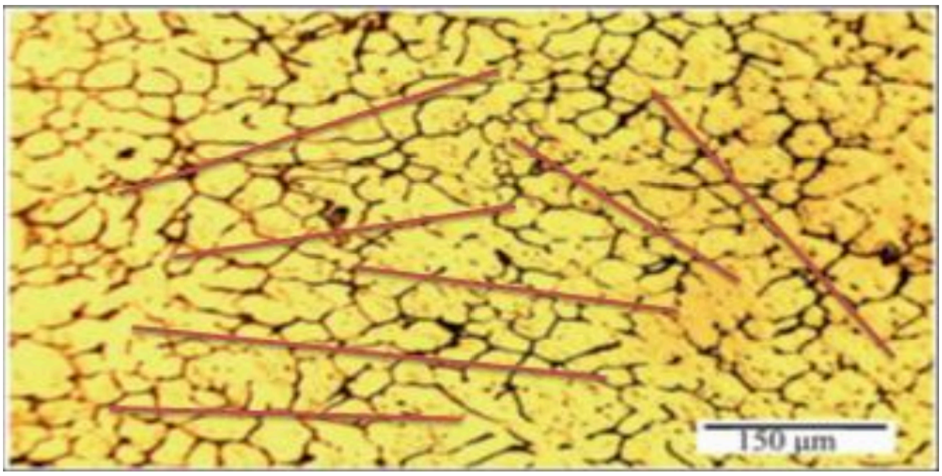
- Lt, total length of all the lines=350mm
- l, mean intercept length=0.024137
- G, the ASTM grain size=7.45020



- M, magnification=X275
- P, total number of intersections =60

No. Lines	No. of grains intersected
1	9
2	9
3	10
4	9
5	7
6	10
7	6

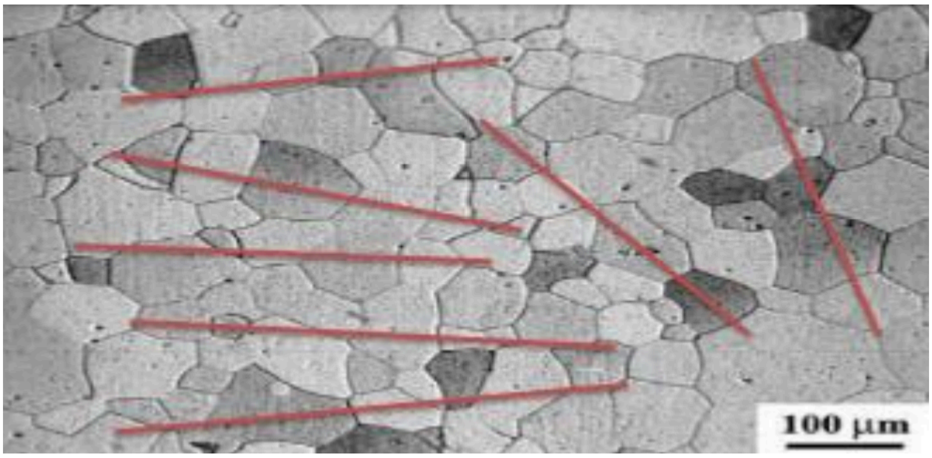
- Lt, total length of all the lines=350mm
- I, mean intercept length=0.021212
- G, the ASTM grain size=7.8233



- M, magnification=X193.9
- P, total number of intersections =56

No. Lines	No. of grains intersected
1	9
2	8
3	7
4	8
5	8
6	7
7	9

- Lt, total length of all the lines=350mm
- l, mean intercept length=0.03223
- G, the ASTM grain size=6.61565

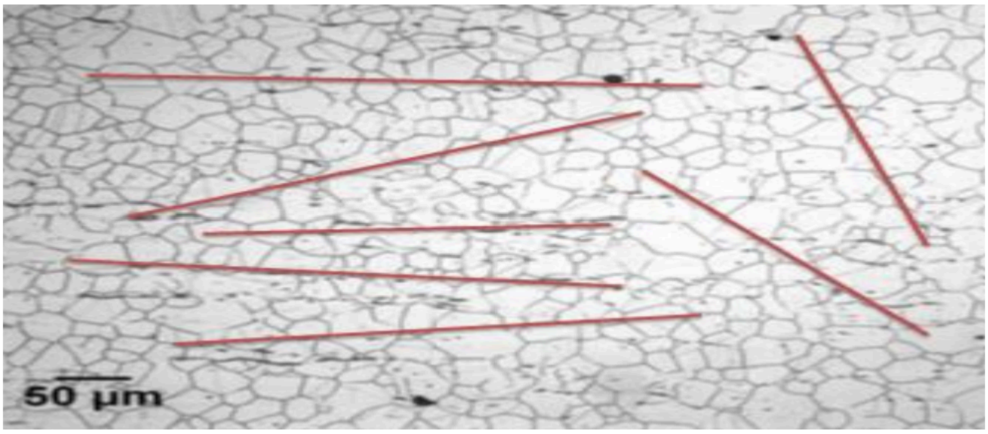


- M, magnification=X190
- P, total number of intersections =50

No. Lines	No. of grains intersected
1	7
2	6
3	8
4	7
5	9
6	6
7	7

- Lt, total length of all the lines=350mm

- I, mean intercept length=0.03684mm
- G, the ASTM grain size=6.22980



- M, magnification=X240
- P, total number of intersections =87

No. Lines	No. of grains intersected
1	12
2	14
3	10
4	12
5	13
6	11
7	15

- Lt, total length of all the lines=350mm
- I, mean intercept length=0.01617mm
- G, the ASTM grain size=8.5029

Discussion:

After the team finished this experiment, the team knows that The majority of engineering alloys are polycrystalline, with several grains. It indicates that each metal piece is made up of a large number of single crystals, or grains, each with a regular crystal structure such as FCC, BCC, or HCP. The experiment is divided into two parts, practical and theoretical. In the practical section, the team grinds and polishes samples and examines them under a microscope, in order to put our theory into practice. In the theoretical section, the team made the calculations to reach the required results.

Conclusion:

After we finished this lap. The team learned many things from this experience. The practical application helped us a lot in understanding the experience and how it works. This experiment demonstrated how to count the amount of grains in each substance using the same equation that is used in ASTM standards. Now we should focus on the next experiment, which is stress strain behaviour.

References:

1- https://www.britannica.com/topic/etching-printing

2- https://en.wikipedia.org/wiki/Etching

Appendix:

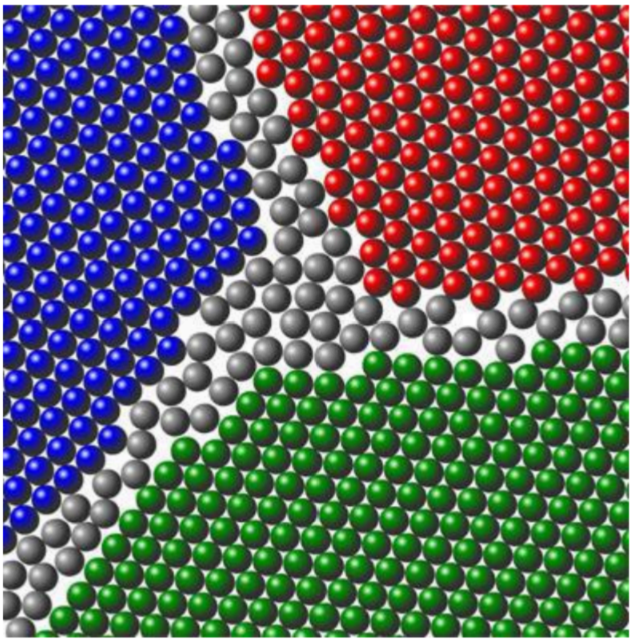


Figure 2.1: Atomic disorder at grain boundaries

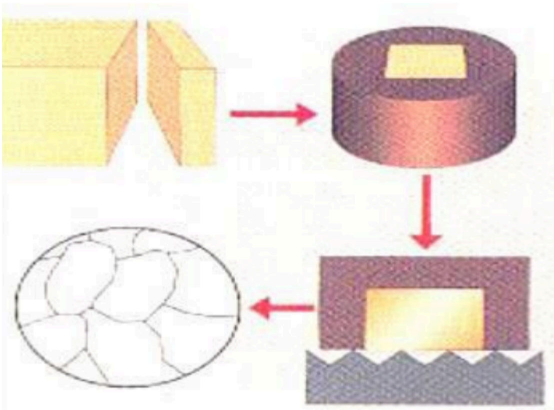


Figure 2.2: Metallographic techniques

EXPERIMENT No. 03

STRESS-STRAIN BEHAVIOR

Introduction:

The third experiment, which involves conducting a compressive investigation to confirm the tensile levels of various materials and derive their material properties, is the subject of this article. This experiment is carried out by applying controlled stress on aluminum, brass, and mild steel samples before they are used. Using an "Instron Tensile measuring machine; nominal capacity 50 KN," the experiment failed. This study's findings. Studies are frequently done to determine how a substance would react to various stresses. To select a material for a specific application, you must first comprehend the relationship between the two. The material's ductility and resistance to loads. The equipment and processes used in the experiments, as well. The report will include the results of the experiment as well as some discussion.

Experimental Apparatus and Methods:

Throughout this experiment, just one device will be utilized which we called it (Instron tensile testing machine) to determine component strength, and three pieces of aluminum, bras, and mild steel will be used to calculate tensile strength and determine Stress and Strain. In furthermore, to realize the relationship between the materials' ductility and strength.

- **List of equipment:**
  1. Instron Tensile testing machine. maximum capacity 50 KN.
  2. Aluminum specimen.
  3. Brass specimen
  4. Mild Steel specimen

- **Procedures:**

  This section will explain the process of doing the experiment. To begin, we discovered the "Instron Tensile measuring machine; full power 50 KN," which is used to evaluate Stress and Strain as well as the thermal conductivity of "Metals." Second, in order to determine the initial data of the specimens, we begin the experiment by placing the test piece in the loading frame and slowly extending it until it breaks. The elongation of the gauge section is measured against the force applied during this technique.

- **Methods of calculation:**

1 - To calculate the Engineering Stress (sg) and Engineering Strain (e):

$$\sigma = \frac{F\ (N)}{A_0\ (m^2)}$$

$$\epsilon = \frac{l - l_0}{l_0} = \frac{\Delta l}{l_o}$$

Young's modulus (E) = Engineering Stress (sg) / Engineering Strain (e)

2 - To calculate % Elongation or % Reduction in Area (RA):

$$\%\ Elongation = \frac{\Delta l}{l_o}\ x\ 100$$

$$\%\ RA = \frac{A_o - A_F}{A_0} = \frac{\Delta A}{A_o}\ x\ 100$$

3 - To calculate modulus of resilience (UR):

$$U_R = \frac{1}{2}\sigma_o\varepsilon_o = \frac{\sigma_o^2}{2E}$$

Result:

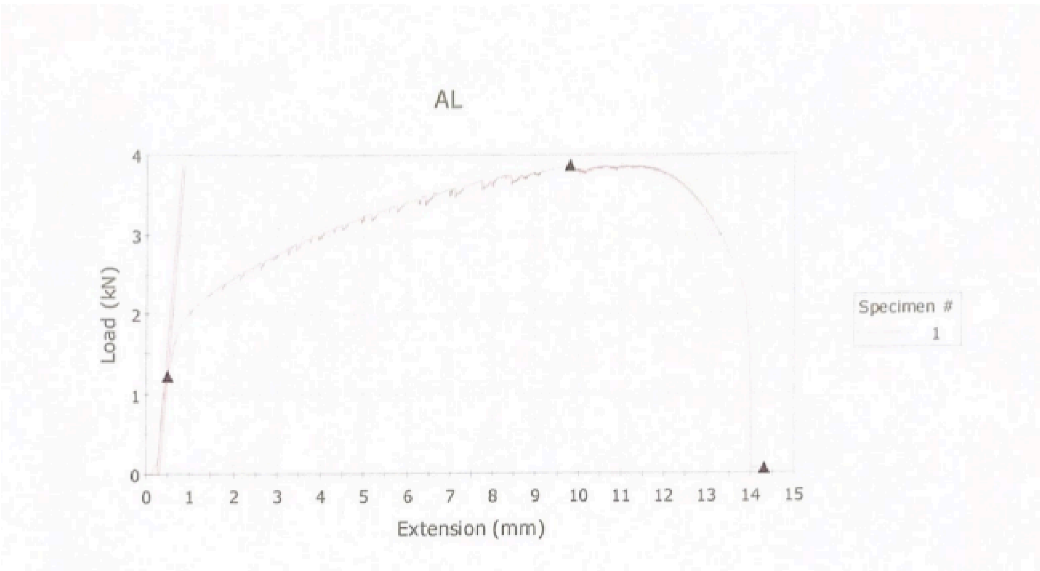
Materials	l_o, mm	D_o, mm	Extension rate mm/min
Mild Steel	27	5.05	2
Aluminum	27	5.05	2
Brass	27	5.05	2

Table 1: Specimen data before test

Sample No.	l_f, mm	D_f, mm	A_o, m^2	A_f, m^2
Mild Steel	30.5	3.75	20.029×10^{-6}	11.044×10^{-6}
Aluminum	36	2.5	20.029×10^{-6}	4.908×10^{-6}
Brass	33	3.05	20.029×10^{-6}	7.306×10^{-6}

Table 2: Specimen data after test

Aluminum Result:

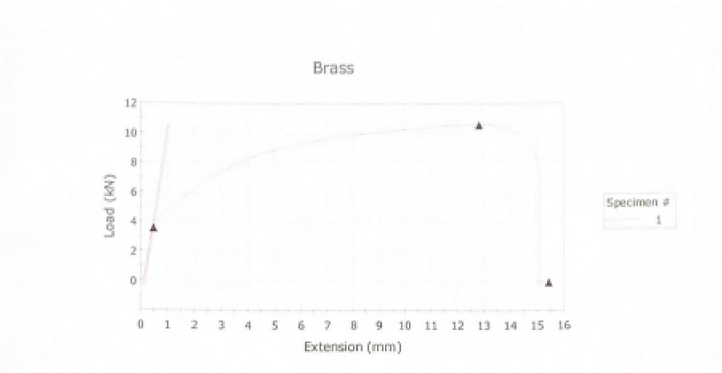


Load (N)	Extension(mm)	ε	σ (Mpa)
0	27	0	0
500	27.186	0.007	25
1000	27.257	0.010	49.9
2000	27.38	0.014	99.9

3000	27.514	0.019	149.8
4500	27.789	0.029	224.7
5500	28.587	0.059	274.6
6500	30.723	0.138	324.5
7000	32.5	0.204	349.5
7500	35.257	0.306	374.4
5600	37.157	0.376	279.6

Table 3: Aluminum Result

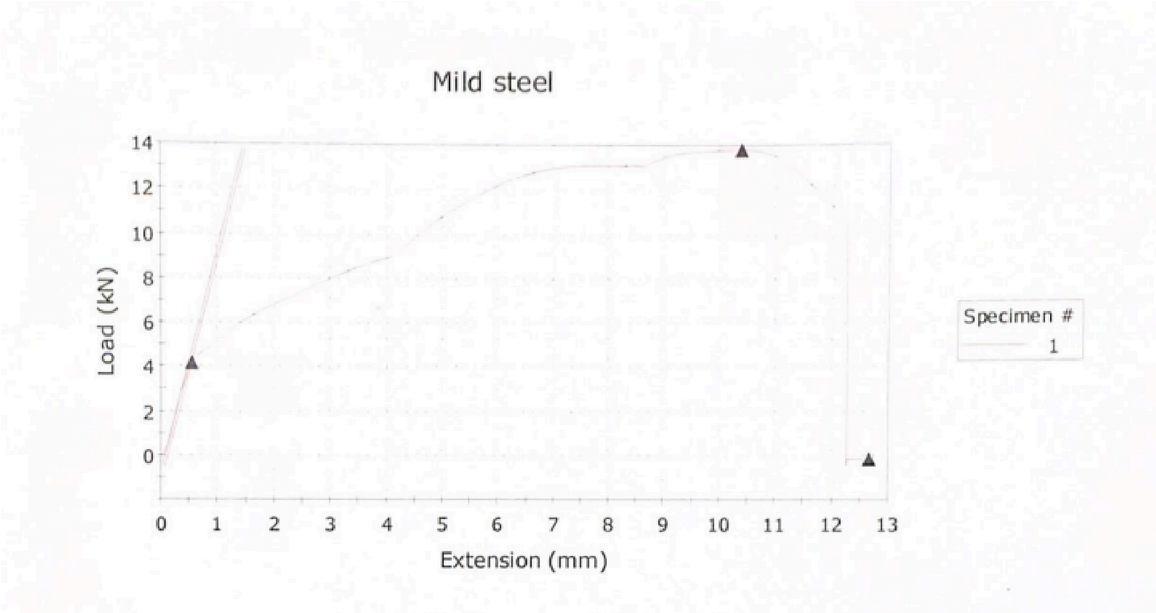
Brass Result:



Load (N)	Extension(mm)	ε	σ (Mpa)
0	27	0	0
1000	27.18	0.007	49.9
2000	27.35	0.013	99.9
3000	27.943	0.035	149.8
5000	28.931	0.072	249.6
7000	29.814	0.104	349.5
8000	30.892	0.144	399.4
9000	31.776	0.177	449.3
10000	34.57	0.280	449.3
11000	36.71	0.360	549.2
8100	39.13	0.449	404.4

Table 4: Brass Result

Mild Steel Result:



Load (N)	Extension(mm)	ε	σ (Mpa)
0	27	0	0
1000	27.251	0.009	49.9
2000	27.516	0.019	99.9
4000	27.811	0.030	199.7
5500	27.925	0.034	274.6
5200	28.011	0.037	259.6
7000	29.101	0.078	349.5
9000	30.211	0.119	449.3
11000	33.891	0.225	549.2
13800	35.441	0.313	689.0
10600	37.513	0.389	529.2

Table 5: Mild Steel Result

Property	Mild Steel	Aluminum	Brass
E Mpa	5378	3629	7500
YS Mpa	110	170	120
TS Mpa	690	375	550
FS Mpa	530	280	405
%El	38.8%	37.4%	W044.8%
U_R	1.12×10^6	3.98×10^6	960×10^3

Table 6: Calculation of properties from stress vs strain curves

Questions:

All answer is from highest to lowest

a. Which one has brittle and ductile behavior? Aluminum – brass – Mild steel

b. Which one has the highest and lowest yield strength, YS? Mild steel – Brass – Aluminum

c. Which materials has the least and largest elongation? Aluminum – Mild steel – Brass

d. Briefly explain how the 0.2% offset yield strength is determined.

When the strain is 0.002%, we go up parallel with the curve and the stress at this point.

Discussion:

Based on the information presented above, we learnt a lot about how to conduct a tensile test to determine the tensile behavior of various materials as well as their mechanical properties. Before we began the experiment, we first determined the equipment and materials that we would require. The first tool we'll use is a "Instron Tensile measurement machine" with a 50 KN capability. Aluminum, Mild Steel, and Brass were the three different specimens that we used. We may deduce a number of things from the aforementioned findings, including the fact that aluminum has a high ductility and, as a result, a higher fracture strength. Also, because the other two specimens have a higher elongation ratio, Brass has a poorer ductility than the other two.

Conclusions:

We learnt several things regarding tensile behavior of materials that we didn't know before the end of this assignment, and we acquired crucial concepts that helped us boost the quantity of information we learned in class in addition to what we learned in class. By understanding the qualities of the materials and learning about their benefits, tensile testing assisted us in determining which material would be the best. We had three specimens and a measuring instrument to aid us in our job, and once the experiment was completed, we began computing the data for each specimen. Finally, we feel that an understanding of tensile behavior has given us insight into identifying the mechanical properties of materials.

References:

1- https://drive.google.com/file/d/1UCnvswuHaULnaqX1600mrgbGDtN-YUj1/view?usp=sharing

Appendix:

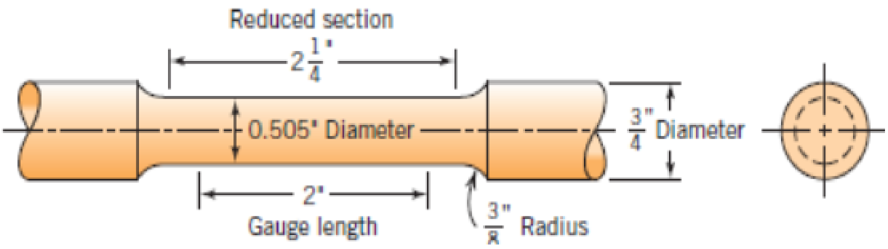


Figure 1: A standard tensile specimen with circular cross section

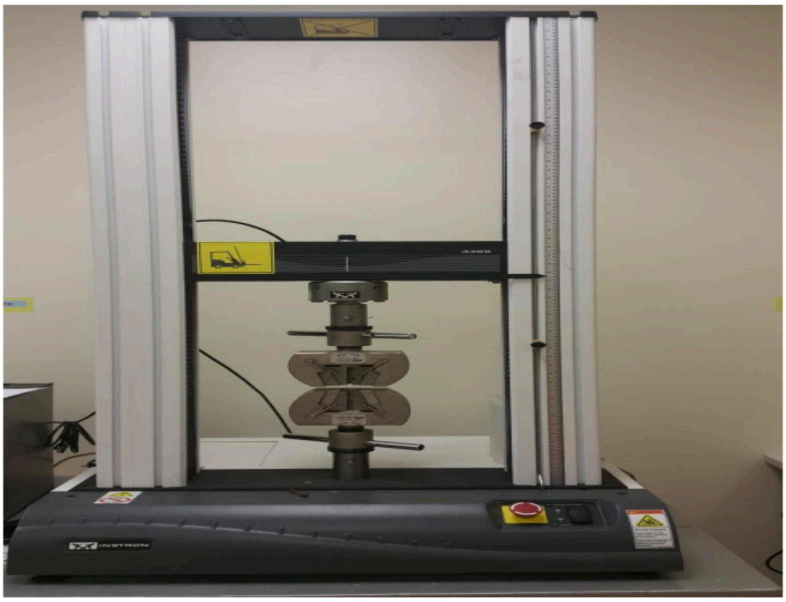


Figure 2: Instron tensile testing machine

Experiment No.: 4

(Hardness Measurement)

Introduction:

This report represents the fourth experiment in the CHE210 lab that is about hardness measurement. Hardness means resistance Indentation, so we can explain it as ability or how the substance can repel any power that can affect a substance. There are numerous ways to measure Hardness of all materials such as Rockwell tests of rocks and Brinell tests. In this trial we will only apply one test, the Rockwell test. In the Rockwell test Consists of pressing the test substance into a diamond cone or hardened steel sphere indenter. The indenter is pressed into the material under study in a preliminary process. The secondary load F0 is typically 10 kg. This report shows everything.

Objective:

The Rockwell test is used to test the hardness of various materials.

Instruments:

Rockwell hardness tester.

Figure 1: The Brinell/Rockwell hardness tester

Procedure:

- Rockwell hardness is used to measure the hardness of the same sample.

- Report the results to the Rockwell table.
- Discuss the consequences for the hardness of the material.

The Brinell method

In the Brinell method, the indenter in the shape of a sphere owing diameter, D, ranges from 1 mm to 10 mm and is made of tough steel. It is indented into the material by implementing a known load P.

The notch on the left is portion of the sphere. The diameter d of the indentation is calculated to compute Brinell hardness value, BHN.

$$BHN=\frac{2P}{\pi D[D-\sqrt{D^2}-d^2]}$$

Where D is diameter of indenter, d is depth of indentation, and P is the load

The Rockwell method

The Rockwell test method contains of an indentation test substance with diamond cones or indenters with hardened steel balls. Indenter is pressed into the test substance with a preliminary small load F0, typically 10 kg. When equilibrium is reached, an indicator such as it responds to modification in penetration depth according to the movement of the indenter. The indenter is set to its original position. During the spare secondary load Additional base load F1 still applied, with net increase applied Penetration. When equilibrium is reached again, additional main the load is removed, but the reserve minor load is retained. Deleting of the additional base load allows for partial recovery, reducing the depth of infiltration. As a result, a continuous increase in the depth of infiltration the application and elimination of additional base loads are used in the calculation the Rockwell hardness value.

There are nine Rockwell measures from A to K. Each measure specifies, in addition to the indenter type, it represents the main load F1, but preload, F0 is 10 kg on all scales. The various Rockwell measures are shown below.

Table 1: Rockwell hardness test

Scale Symbol	Indenter	Major Load, F_1 kgf.
A	Diamond Cone	60
B	Steel Ball, 1/16"	100
C	Diamond Cone	150
D	Diamond Cone	100
E	Steel Ball, 1/8"	100
F	Steel Ball, 1/16"	60
G	Steel Ball, 1/16"	150
H	Steel Ball, 1/8"	60
K	Steel Ball, 1/8"	150

Results:

Table2: Data of Brinell Test

Sample no.	material	F(w) N(kg)	D mm	D^2 mm	d^2 mm	BHN
1	Steel	612.5 (62.5)	5	25	1.11	70.885
2	Brass	612.5 (62.5)	5	25		
3	Aluminum	612.5 (62.5)	5	25	1.628	48.1

d=I*N=0.004*(B-A)

d (Al)→B=617, A=298

d^2 (Al)=$(0.004 * (617 - 298))^2$ =1.628 mm

d (Steel)→B=565, A=302

d^2(Steel)=$(0.004 * (565 - 302))^2$ =1.11 mm

BHN (Al) =$\frac{2P}{\pi D[D-\sqrt{D^2-d^2}]}$ = 48.1

BHN (Steel) $= \frac{2P}{\pi D[D-\sqrt{D^2-d^2}]} = 70.885$

Tabel3: Data and Result of Rockwell Tests

Sample no.	material	Load, kg	Scale	Hardness
1	Steel	150	C	48
2	Brass	100	B	
3	Aluminum	100	B	2

Question:

Why steel is harder than brass and aluminum?

There is a connection between tensile stress and hardness. Tensile stress is directly comparative to hardness, so Steel has a higher tensile strength than brass and aluminum.

Discussion:

During this experiment, we learned the consequences shown in Table (3). That Using Rockwell's appliance wasn't too difficult. We utilize the first trial, that was steel and we started implementing with a Rockwell machine with effect. The hardness is determined by the machine itself (65). Same process used with another sample (aluminum) and found to have hardness 33.5.

Conclusion:

After finishing this experiment, we educated something new at handle some materials and compute their hardness CHE210 lab class using Rockwell apparatus. We used Rockwell Methods and formulas for obtaining overall hardness measurement results. However, we expect that the entire process can continue as well as right calculation. Now that this experiment is complete, do the following: Make the following preparations to measure the toughness of the material.

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Report: 5

(Material Toughness Measurement)

:Introduction

In this experiment, the team will determine the amount of energy needed to be absorbed by the sample during its crushing. There are two ways to determine the hardness and they are Izod and Charpy. Heavy duty hammer A pendulum has a definite amount of potential energy. A weighted pendulum hammer discharged from a cocked position at a set height h delivers the load as an impact strike. When the pendulum is released, a knife-edge mounted on the pendulum impacts and fractures the specimen at the notch, which serves as a stress concentration location for this high-velocity impact blow. This report will contain tools, procedure, question, calculations, results, and discussion.

Instrument:

Impact testing machine, vernier caliper

Procedure:

- Place the sample in the holder provided at the base of machine
- Raise the pendulum to its highest point, h0
- Allow the pendulum to strike the sample
- Note the energy after striking the specimen, h1
- Compute the energy absorption by taking the difference between before and after the pendulum height by using formula E= mg (ho-h1)

Question:

Why toughness of ductile materials is higher than brittle materials?

Because the ductile surface crack is larger than the brittle surface crack, it requires more energy.

Calculations:

- The area of the specimens Brass and Steel used in this experiment = 10mm x 8mm =

80mm^2 = 0.8cm^2

- The area of the specimens Aluminium used in this experiment= 12mm x 10mm =

120mm^2 = 1.2cm^2

- Toughness Brass = $Enegy\ absorbed$ / $Unit\ area$ = 17.9 / 80∗10−6 = 22.4 J / cm^2.

- Toughness Steel = $Enegy\ absorbed$ / $Unit\ area$ = 110.4 / 80∗10−6 = 13.8 J / cm^2.

-Toughness Aluminium =$Enegy\ absorbed$ / $Unit\ area$ = 63.4 / 120∗10−6 = 52.8 J / cm^2.

Result:

Brass

Energy absorbed in Charpy test= 17.9 Joules.

Toughness (energy absorbed/unit area)= 22.4 J/cm^2

Stell

Energy absorbed in Charpy test= 110.4 Joules.

Toughness (energy absorbed/unit area)= 138.1 J/cm^2

Aluminium

Energy absorbed in Charpy test= 63.4 Joules.

Toughness (energy absorbed/unit area)= 52.8 J/cm^2

Discussion:

In this experiment, we learned how to measure the hardness of a material using the effect test, which helped us get the results. The experiment was performed with ASTM standards. Toughness refers to a metal's capacity to bend ductility and absorb energy in the process before fracture. The discrepancy in hardness values determined by manual and electronic machines is owing to differences in the energy utilized and the % of inaccuracy between the two specimens, therefore they are seldom identical. You can notice from the results of the experiment that steel absorbs the highest energy, followed by aluminium and finally copper.

Conclusion:

After we finished this experience, we learned many things. We learned how to measure the hardness of a material using an impact test. We also learned that if the material breaks on the surface, the fracture will be brittle. The team learned what happens to the material when a high exertion rating is used. Now we should focus on the next experiment, which is heat treatment of stell.

Appendix:

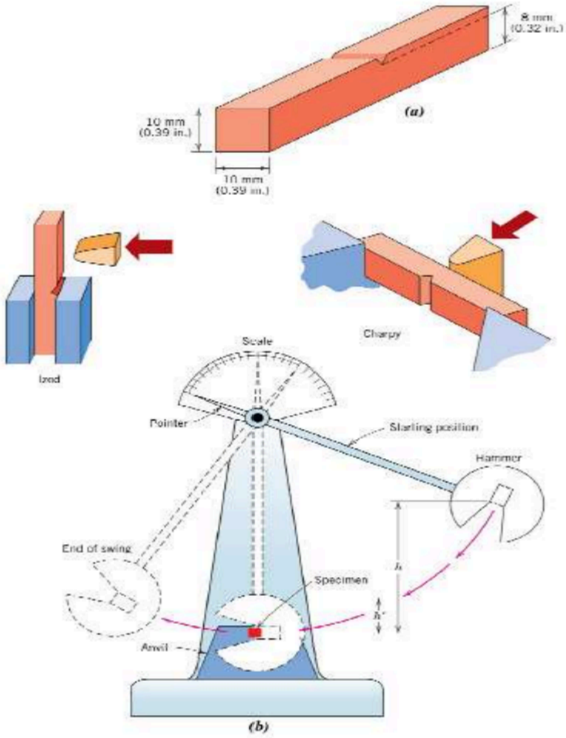

Figure 5.1: (a) sample dimension (b) principle of Impact test

EXPERIMENT No. 06

HEAT TREATMENT OF STEEL

Introduction:

Heat Treatment is largely about understanding the physical properties of materials and altering them to the best possible state for engineering to accomplish the job successfully. We can change a substance's mechanical properties by heating it, holding it at that temperature, and then cooling it down. This is because temperature alters the microscopic structure of the substance; the major purpose of our investigation is because temperature alters the microscopic structure of the substance; the major purpose of our investigation

Experimental Apparatus and Method:

- **Objective**

  To investigate the impact of cooling rate on the hardness of plain carbon steels that have been chilled from an austenite condition.

- **Applications:**

  Heat treatment can modify the microstructure, electrical, and mechanical properties of materials by adjusting the temperature and cooling rate.

- **List of equipment and materials:**
  - Ceramic plate
  - Carbon steel
  - Furnace
  - Water pot
  - Hardness testing machine
  - Microscope

- **Procedure:**

In this section, we'll go over the steps we'll take during the experiment. 6 mild steel specimens have been given for your research. First, we'll heat four specimens in furnace 1 at 1600 degrees Fahrenheit. 1/2 hour at + 25oF (870 + 15oC). Second, we'll place the remaining two specimens in furnace 2 at the same time. 1/2 hour at the same temperature Third, we will take one specimen from the furnace, two specimens from the furnace, and three specimens from the furnace. We must know how to cool it in air and then turn off the furnace 2 with the one surviving specimen. That the sample should be left in the furnace for one hour, and that both air-cooled and furnace-cooled specimens can be chilled in water after that time. Fourth, we'll rapidly remove the four specimens from furnace 1 and drop them into water (quenching); the transfer should take less than a second (a little practice could help), and we shouldn't touch the specimens until they've cooled in water. Before moving on to the next phase, we'll measure the quenched specimens' Rockwell hardness. Then, for 30 minutes at 350oC, 450oC, and 550oC, temper three of the quenched specimens. Then, using the Rockwell hardness scale, determine the hardness of each of the six samples.

Results:

Alloy	Rockwell Hardness, HRC				
	As received	Annealing	Normalizing	Quenching	Tempering
	43	-	50	60.5	-

Table 1: Hardness of steel before and after heat treatment

Questions:

(a) What is the purpose of heat treatment of steel?
modifying mechanical properties such as hardness

(b) What is isothermal and athermal transformation?
Isothermal: provides perlite and binate and is time dependent.
Athermal: delivers martensitic and is time independent and difussionless.

(c) Describe the following iron-based alloys in terms of the range of compositions (particularly carbon)

(i) Eutectoid steel

0.76% C.

(ii) Hypo eutectoid steel
lower than 0.76% C

(iii) Hyper eutectoid
steel higher than 0.76% C

(d) Describe, in general terms, the following standard types of heat treatments in terms of the processing

(i) Austenitizing: Heating in the austenite range

(ii) Annealing: Inside the furnace, heat is applied above the Eutectoid temperature, and then the temperature is slowly lowered.

(iii) Normalizing: Heating above the Eutectoid temperature and thereafter cooling at a range of around 5-20 C outside the furnace

(iv) Quenching: Heating above the Eutectoid temperature and after that cooling with a cooling rate of nearly 160 C inside water or oil

(v) Tempering: After quenching, heat under Eutectoid temperature and then cool down to reduce hardness and the heat is below 727 C.

Discussion:

The main goal of this experiment is to figure out how the hardness of the samples utilized changes after tempering. Annealing, Quenching, Austenitizing, and Normalizing are just a few of the common heat treatments we studied about. We were also aware of the distinctions between them. The annealing process, for example, involves heating the workpiece to a specified temperature in the furnace, keeping the sample or piece at that temperature for a length of time, and then progressively cooling down inside the furnace.

Conclusions:

We believe that by the end of this experiment, we have gained a great deal of knowledge regarding the many sorts of therapies. We hope that we have accomplished the purpose of this experiment. In addition to a machine we used in previous tests, such as the Rockwell hardness tester to measure the hardness of material, we employed Carbon steel, Furnace, and Water pots.

References:

https://drive.google.com/file/d/1UAY3sBKPRpDsRxncldmgT9zjTgT3jMod/view

Appendix:

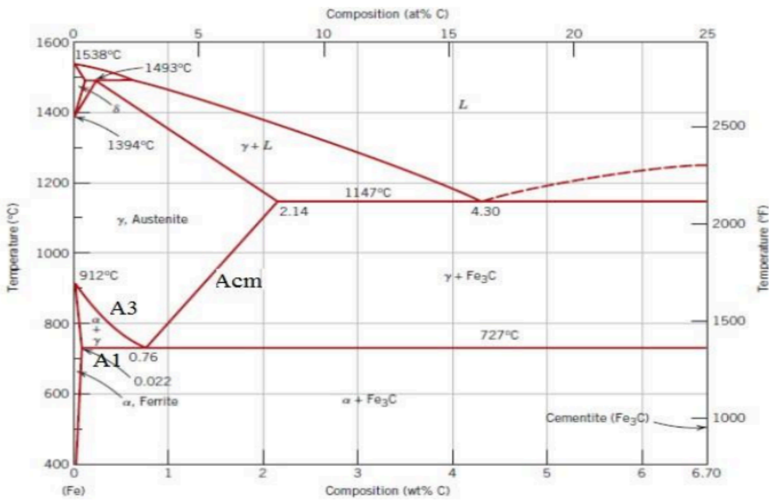

Figure 1: The iron- iron carbide phase diagram

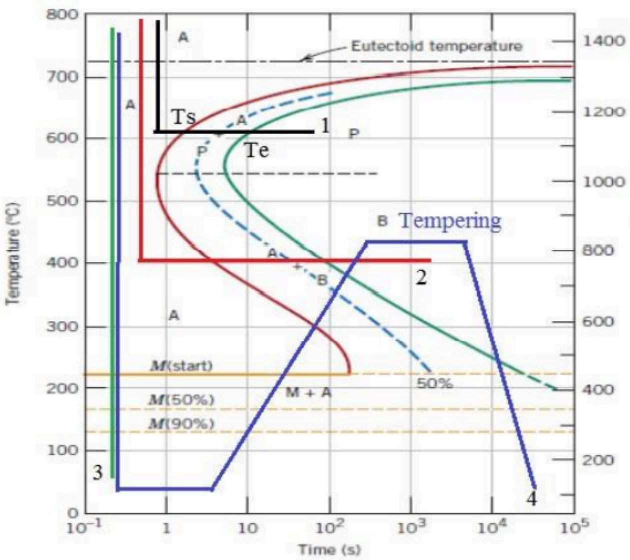

Figure 2: Complete isothermal transformation diagram of an iron- carbon alloy of eutectoid composition, A: Austenite, P: Pearlite (curve 1); B: Bainite (curve 2), M: Martensite (curve 3): Tempered Steel (curve 4)