58%

Prifysgol Cymru
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APPENDIX GA36a

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	M EVANS	**Student ID number:**	204775
Programme:	HNC Mechanical Engineering		
Module:	Materials		
Module code:	SGDM4003	**Contribution to Overall Module Assessment (%):**	50%
Lecturer:	Chris Davies	**Internal Verifier:**	Robert Rees
Assignment Title:	Assignment 1 Tensile Test to Destruction.	**Word count (or equivalent):**	2000
Submission deadline:		**Return date of provisional marks & written feedback:**	
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) **Alternative submission method (if applicable):** **Late submission of the assessment will result in a late penalty mark.** Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Demonstrate a detailed knowledge and understanding of the structure, properties, processing and subsequently the use of engineering materials;
2. Use standard materials testing apparatus and derive the mechanical properties of materials and analyse and understand the cause of materials failures.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	20	
You identified suitable detail but often you did not relate the theory to the test. Generalised points included.		11
2. Knowledge and Understanding Skills	30	
Reasonable knowledge and understanding included but you did not fully explore theory and your evaluation of theory to results to Suffered.		18
3. Cognitive and Intellectual Skills	20	
Good use of data and correct Calculations made. You did not fully explore the results and how they compared to each other and theoretical values.		12
4. Practical Application Skills	15	
Some reasonable points made but I would have liked to see some specific examples in use included.		8
5. Transferable Skills for Life and Professional Practice	15	
Well presented report. Structure could have been included by having seperate theory and discussion sections.		9

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	**Late Submission Penalties (tick if appropriate)**		58 %
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



Materials Assignment 1

Tensile Test to Destruction

HNC Mechanical Engineering - Year 2

Matthew Evans

coleg sirgâr

HNC Mechanical Engineering

Materials Assignment 1

Tensile Test to Destruction

SGDM4003

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Chris Davies

21-11-19

1. Summary

A tensile test is a simple test, yet can have some good information and results on a materials properties. By carrying out this test on a test piece to destruction the result can be used to determine the properties of the material such as the stiffness, hardness, strength, malleability and ductility. With these properties it is also important to understand how the material is built up at the atomic level. Some of the key areas to look at and understand, is how the structure of the material is built up. This is from how the atoms bond to how the lattice structure is formed.

Once there is an understanding of the material properties, it is then possible to change the properties by either heat treating a material, or by alloying a material. By heat treating a material the grain structure can be changed. By changing the grain structure the properties can change from being a stiff hard material, to a softer more ductile material, or from a soft material to a harder and stiffer material if rapidly cooled.

When alloying a material two or more elements are added and mixed. With this mixture of elements there will be defects added into the material such as point defects. There are three main defects that have been studied in this report, known as Substitutional & Interstitial and the Grain Boundaries.

Some reasonable point included but it remains unclear how they specifically relate to the results of your tests.

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Good structure.

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4. Introduction

The tensile test is one of the simplest ways to test the strength of a material. By measuring the forces required to elongate a material it is then possible to determine the material properties. With these results it is then possible to select a material with the correct properties for the required design specification.

The Assignment was to carry out a lab tensile test on 5 different materials and compare the results. These materials where 70/30 brass, 70/30 brass annealed, copper annealed, 0.1% carbon steel and 0.4% carbon steel. With these result it is then possible to explore the material properties of these materials. Another area to be able to study is the affect annealing has on the properties of the same material. There will also be some research into how the material bonds at the atomic level along with the lattice structure and the affect alloying and heat treating has on the material properties.

5. Objective

Tensile tests are performed for several reasons. The main reason is to understand the material strengths and properties. With these results from a tensile test it is then possible to select materials engineering designs and applications. Tensile properties are frequently included in material specifications to ensure that the correct quality is selected. Tensile properties often are measured during development of new materials and processes. Finally, the material properties are often used predict the behaviour of the material under forms of loading other than uniaxial tension.

6. Background

Below (Figure 1) is a typical example of a force / extension graph of mild steel. On this graph there are 4 point of interest of the material properties. The points of interest can be best described as: Section 1, the elastic ZONE. This is known as "Hookes law". The second point of interest is known as the yield point of the material. The third point of interest is known as the plastic zone and the final point of interest is known as the ultimate tensile strength UTS and the final break point. With these points of interest, the following information can be determined on the material properties. The yield strength, the UTS, the elasticity and the ductility of the material.

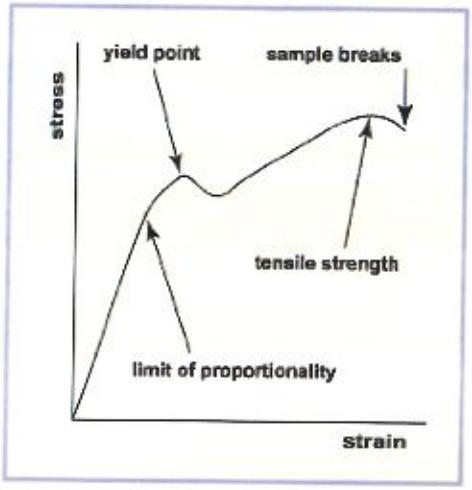


Figure 1: Basic Stress Strain Graph (learneasy, 2019)

The below graphs (Figure 2) shows a typical result for materials with different properties. One graph is showing how ductile the material can be and the other is show how brittle a material could be.

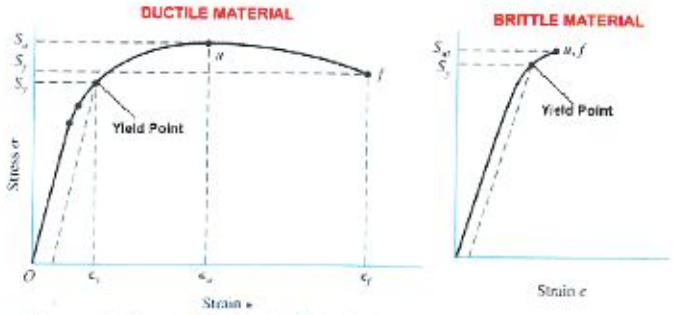


Figure 2: Ductile Vs Brittle Graph Example (umesweb info, 2018)

7. Equipment

The equipment to be used in this lab test is a "Hounsfield H20K-W" Tensometer, and can be seen below in (Figure 3 & 4).



Figure 3: Hounsfield Tensometer



Figure 4: Tensometer Chuck and Display

8. Method

Before using any testing equipment, it is recommended to follow all manufacture instruction and guild lines.

Step 1: To set up the testing machine as indicated in the manual.

Step 2: To load the test sample into the chucks of the testing machine.

Step 3: Slowly apply a steady load until the sample fractures.

Step 4: Take readings as the load is being applied for the load and change in length at regular intervals.

Step 5: Remove the sample and measure the final fracture cross sectional area.

Step 6: Repeat steps 2-5 for all other test samples.

Step 7: Input results into excel to produce force/extension graph results.

9. Results

Below are the results from the lab test of 5 different materials. The material tested were as follows, 70/30 Brass, 70/30 Brass annealed, annealed Copper, 0.1% carbon Steel and 0.4% carbon steel. With these results we are able to calculate the material properties. By reviewing and studying these graphs we are also able to see how strong or ductile a material is. We are also able to see the difference between two of the same material but one has been annealed.



Figure 5: 70/30 Brass Forces extension Graph

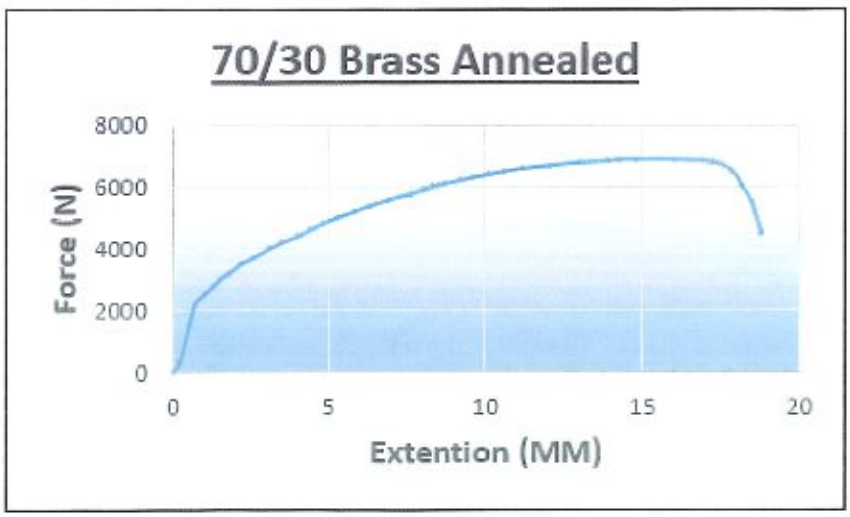


Figure 6: 70/30 Annealed Brass Forces extension Graph

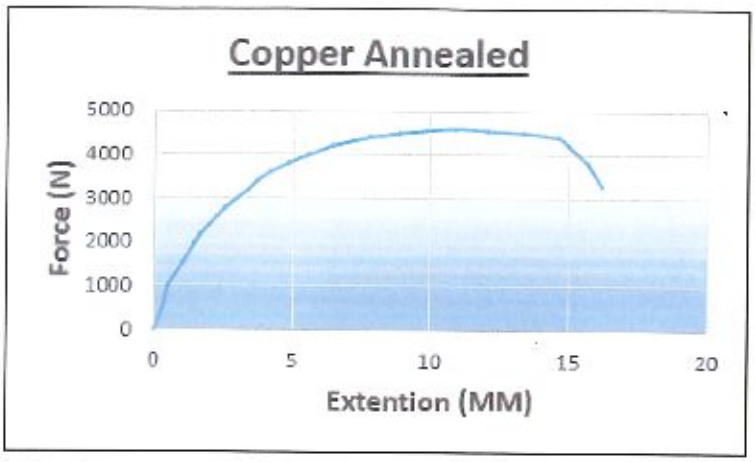


Figure 7. Annealed Copper Forces extension Graph

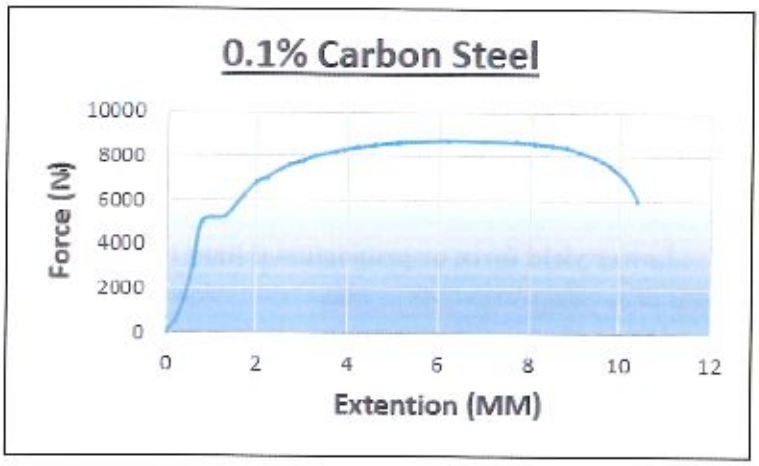


Figure 8 0.1% carbon Steel Forces extension Graph

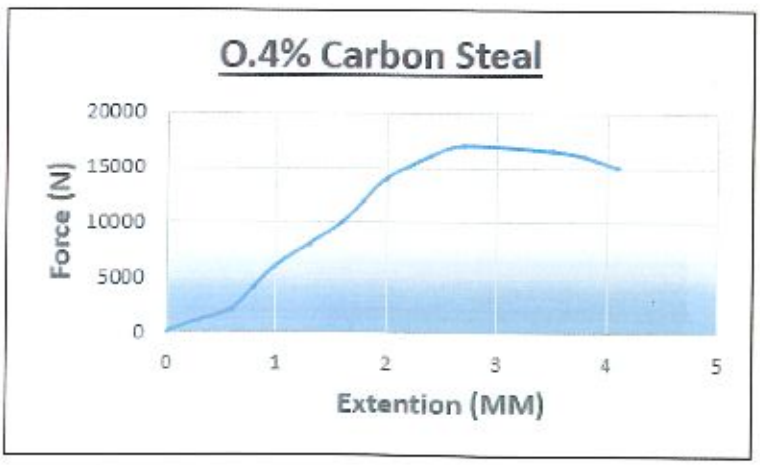


Figure 9 0.4% Carbon Steel Forces extension Graph

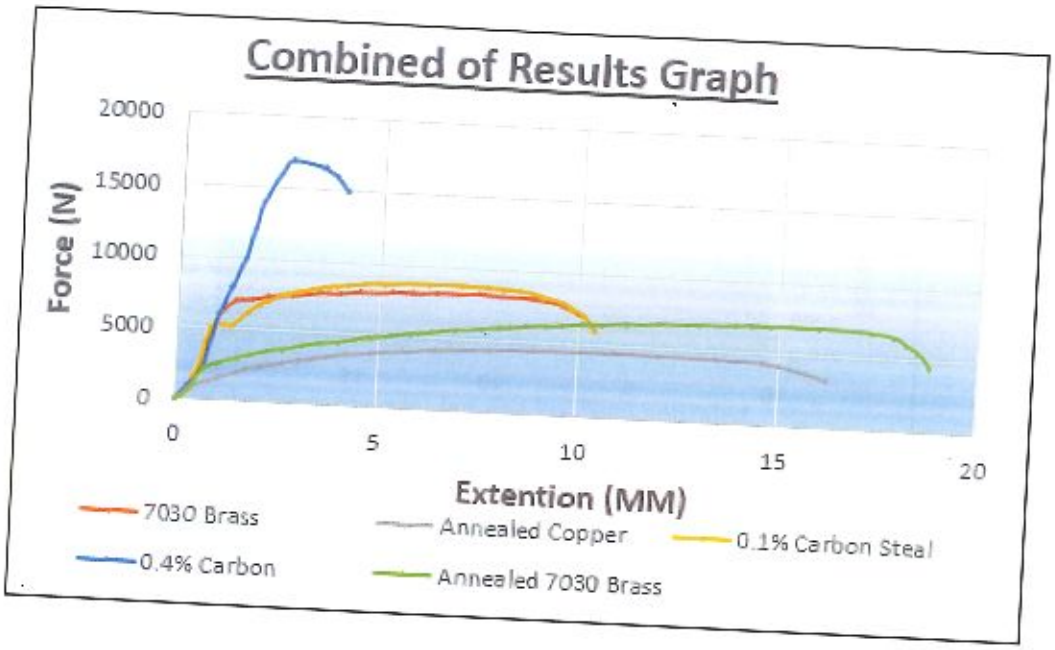


Figure 10. Combine Results Forces extension Graph

By using these results and values, the following can be calculated by using the below formulas.

Lower yield force or proportional limit (kN)

$$Lower\ Yeild\ Stress = \frac{Lower\ Yield\ Force}{Original\ Cross\ Sectional\ Area}$$

Yield or flow stress (kN)

$$Flow\ Stress = \frac{Elastic\ Limit\ (Force)}{Original\ Cross\ Sectional\ Area}$$

Tensile strength (MN/m²)

$$Tensile\ Strength = \frac{Maximum\ Force}{Original\ Cross\ Sectional\ Area}$$

Reduction in area % at fracture

$$RA\% = \frac{Original\ Cross\ Sectional\ Area - Original\ Cross\ Sectional\ Area\ At\ Fracture}{Original\ Cross\ Sectional\ Area} X100$$

Elongation % at fracture

$$Elongation\ \%\ At\ Fracture = \frac{Gauge\ Lenght\ At\ Fracture - Original\ Gauge\ Length}{Original\ Gauge\ Length} X100$$

By using these equations, it is then possible to calculate the material properties. The results of these tested materials can be seen in the table below. The original Cross-sectional area for all samples was 20mm^2. The length for all the samples was 25mm. All Calculations are as per Appendix 14.3.

	70/30 Brass	70/30 Brass Annealed	0.1% Carbon Steel	0.4% Carbon Steel	Annealed Copper
Lower Yield Force (kN)	6	2.25	5	15.5	1
Max Force (kN)	8.25	6.9	8.7	17	4.6
Yield Stress (MN/m^2)	300	112.5	250	775	50
Tensile Strength (MN/m^2)	412.5	345	435	850	230
Reduction in Area %	60	70	45	25	72
Elongation % at Fracture	40	75.2	41.6	16.4	64.8

Table 1: Test Results

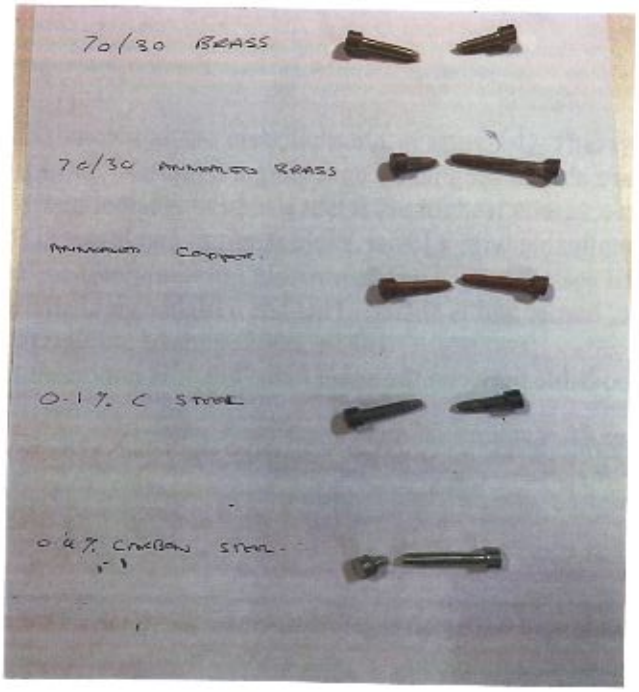


Figure 11: Fractured Tested Peace's

10. Discussion

10.1. Results and findings

From these results we are able to determine the material properties for the yield strength, the U the elasticity, the ductility and how malleable the material is. The most interesting result from this test is the difference between the same materials "70/30 Brass" whilst one has been annealed as see in (Figure 12).

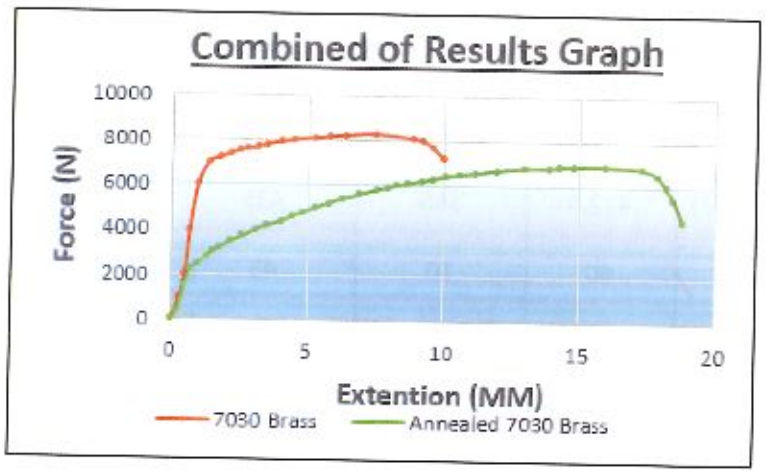


Figure 12: 70/ 30 Annealed Brass & 70 / 30 Brass combined Graph

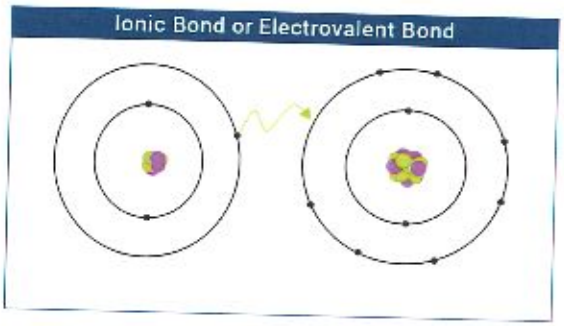
From these results we are able to see that by annealing a material "70/30 Brass Annealed" it wi become more Ductile and malleable with a lower Yield strength and lower UTS whilst the normal "70/30 brass" is less ductile, harder and is stiffer. This has a higher yield strength and higher UTS. To understand how this is possible between the same materials it is important to understand the materials properties at an atomic level. what about the other results?

10.2. Atomic bonds and Structures of Materials

This section would b better in a seperate

To be able to understand the material properties we need to look into how a material is made up and its type of bond at an atomic level. (Ashby, 2005, p. 44). The way in which an atom bonds is imported to understand as this affects the materials properties. There are primarily know as ionic

bond, metallic bond and covalent bond. The ionic bond is the most obvious bond as this is the attraction between + and – charges (Figure 13).



Better to have a dedicated theory section and before your results. Your discussion would then be related to expected theory and results.

Figure 13: Ionic bonding (byjus, 2019)

An ionic bond is formed between two atoms by the transfer of one or more electrons from one atom to the other, as a result of which the atoms complete their nearest outer shell configuration. This then will turn one atom to a positive charge and the other to a negative charge know as ions. With the change in charge the atoms are then attracted forming the ionic bond between atoms. "The electrons are attracted to the nucleus by electrostatic forces and therefore have negative energies" (Ashby, 2005, p. 45).

Another primary bond is known as the metallic bond. (Figure 14). This type of bond is the more dominate type of bond between metals. Within a metal the highest energy electron will leave the parent atom to form a "sea" of freely moving electrons. The higher the sea of electrons the higher the conductivity of the material will be. (Ashby, 2005, p. 48).

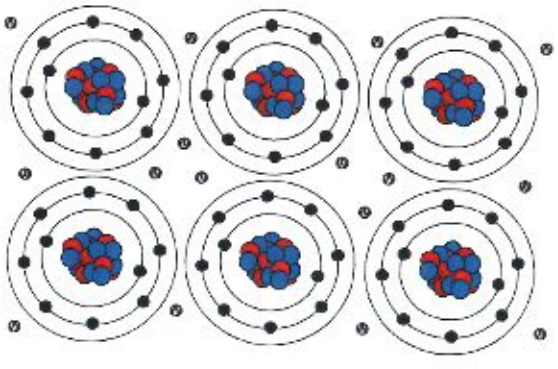


Figure 14: Metallic bonding (www.nde-ed.org, 2019)

The final primary bond is known as the covalent bond. (Figure 15). This is when the atoms an electron to form a complete outer shell. "The proximity of the two nuclei create a new electr orbital, shared by the two atoms, into which the two electrons go. This sharing of electrons lead reduction in energy, and a stable bond" (Ashby, 2005, p. 47) .

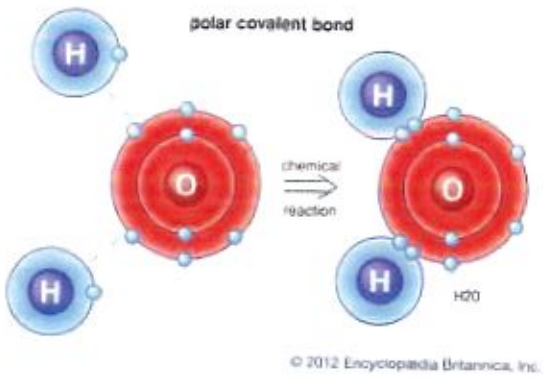


Figure 15: Covalent Bond (britannica, 2019)

Another important factor to consider at the atomic level is the structure and how the atoms bo and form. These structures are the make-up of the material properties to how malleable, ductile a stiff they are. The type of structure can be:

- Body centered cubic (BCC).
- Face centered Cubic (FCC).
- Hexagonally closed Packed (HCP).

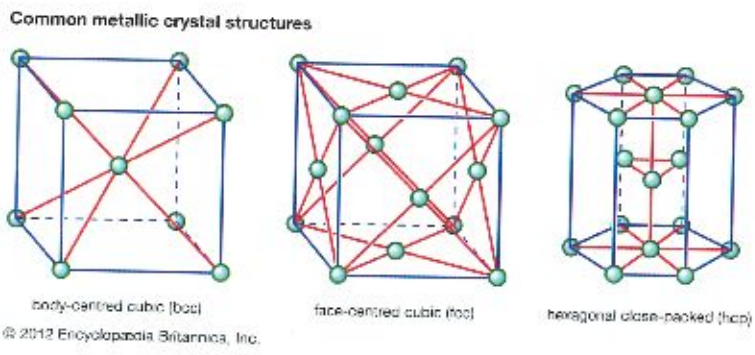


Figure 16: Atomic Structures (britannica, 2019)

Please Refer to Appendix 14.2 for full details on Structure Build up. (Structure and Classification of Material, 2019)

10.3. Heat treating of Materials

By heat treating a material you are able to change the material properties by changing its grain structure. By changing the materials grain structure at an atomic level, you can change the material properties to make it harder, stiffer or more malleable and ductile. This is what is shown in the below (Figure 17).

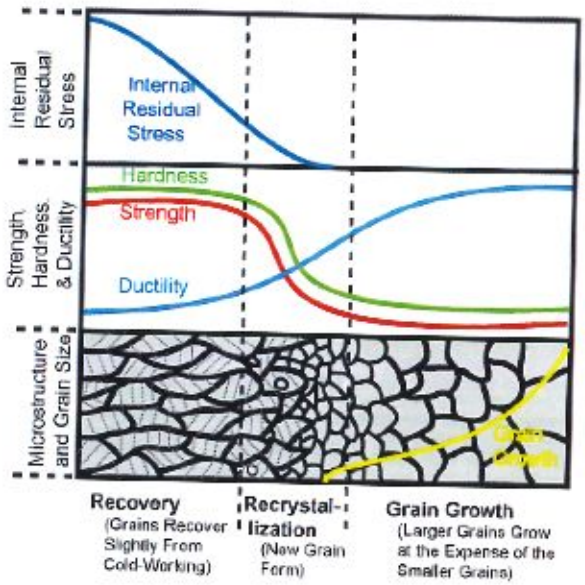


Figure 17 Heat treatment Effect on Grain Structure (www.nde-ed.org, 2019)

There are three main stages to a heat treatment process.

- Recovery
    - At this stage you are heating the material up to an elevated temperature where the strained atoms can freely move to relief the strain between the atoms moving back into a relaxed position. "Diffusion increases rapidly with rising temperature and this allows atoms in severely strained regions to move to unstrained positions. In other words, atoms are freer to move around and recover a normal position in the lattice structure." (www.nde-ed.org, 2019).

- Recrystallization
    - At higher temperatures new grains can start to form. These new grains grow to replace the deformed grains produced by stain hardening.
- Grain growth
    - This is when the material is held at higher temperatures for longer to allow the new grain growth to grow in size. By allowing the grains to grow this will change the material properties. Larger grains mean less strength and toughness and more ductil (www.nde-ed.org, 2019).

There are two main type of heat treatment. These are known as annealing and the other is know as tempering. Dependent on what method is used will determine the outcome of the material properties. By annealing a material you will make the material properties more ductile, softer and more malleable. This process is to heat the material up to a desired temperature, soak and then allow to cool naturally. (Figure 18). This allows for larger grain growth.

By tempering a material you will be making the material properties harder, stronger, stiffer and less ductile but also fragile. This process is to heat the material up to a desired temperature, soak and then rapidly cool the material down. This is then followed by another heating cycle. (Figure 18). This keeps the grains to a smaller size with more boundary's defects making the material properties harder.

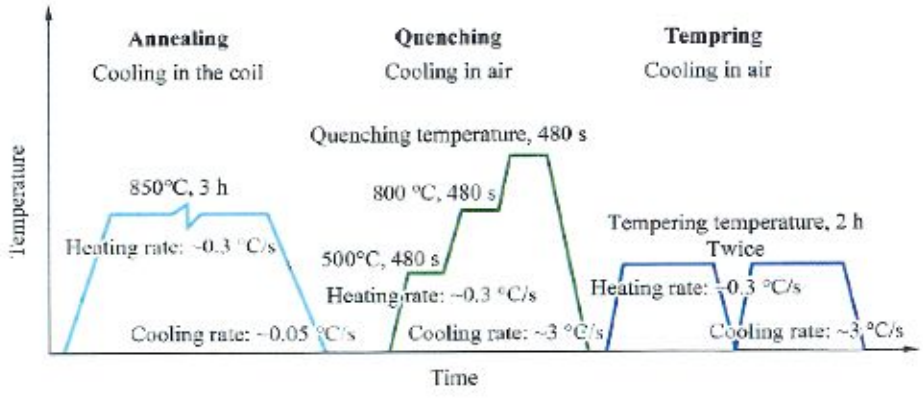


Figure 18 Types of Heat Treatment Cycles (Meng, 2014)

10.4. Alloying of Materials

Alloying is a mixture of two or more metals or one metal and an element. "An alloy is a metal made by taking a pure metal and adding other elements (the "alloying elements") to it. Examples are brass (Cu + Zn) and Monel (Ni + Cu)". (Ashby, 1998) Examples of these metals have been used in this lab test for this report. One metal was a 70 / 30 brass, made up of 70% copper and 30% Zinc and would have a Substitutional mix. The other test peace was carbon steel with the base metal being iron and the element being 0.1% of carbon and would have an Interstitial mix. When alloying a material the properties will change along with the material strength, Ductility, Hardness and yield.

When alloying a material, there are defects being added into the material. These are known as Point defects. These point defect are substitutional and interstitial (Figure 19). And boundary defects (Figure 20).

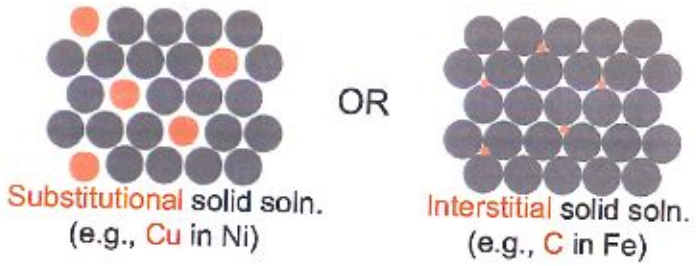


Figure 19. Substitutional & Interstitial Alloying (e-education, 2018)

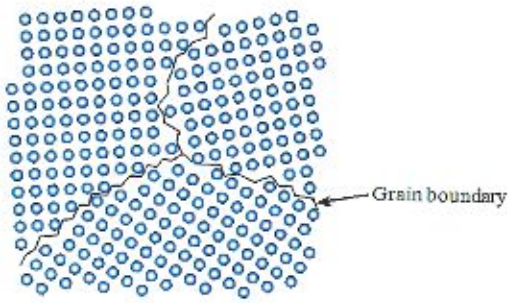


Figure 20. Grain Boundaries (engineeringarchives.com, 2012)

11. Conclusion

By caring out a simple tensile test it is then possible to calculate the material properties. important to understand how a material will behave, so that the correct and suitable material be selected when designing a product to a specification. It is also important to understand the effects of alloying and heat treatment can have on the materials properties. When reviewing material test graphs and data it is visibly possible to see the effects of alloying and the effects treatment can have on the materials properties. By understanding these affects it is then possi to select the correct material for the design of a product.

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14. Appendix

14.1. Properties of Generic Metals

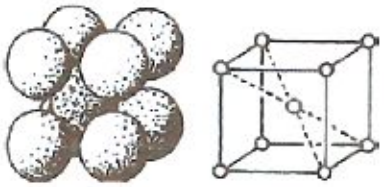
Metal	Cost (UK£ (US$) tonne^{-1})	Density (Mg m^{-3})	Young's modulus (GPa)	Yield strength (MPa)	Tensile strength (MPa)
Iron	100 (140)	7.9	211	50	200
Mild steel	200–230 (260–300)	7.9	210	220	430
High-carbon steel	150 (200)	7.8	210	350–1600	650–2000
Low-alloy steels	180–250 (230–330)	7.8	203	290–1600	420–2000
High-alloy steels	1100–1400 (1400–1800)	7.8	215	170–1600	460–1700
Cast irons	120 (160)	7.4	152	50–400	10–800
Copper	1020 (1330)	8.9	130	75	220
Brasses	750–1060 (980–1380)	8.4	105	200	350
Bronzes	1500 (2000)	8.4	120	200	350
Nickel	3200 (4200)	8.9	214	60	300
Monels	3000 (3900)	8.9	185	340	680
Superalloys	5000 (6500)	7.9	214	800	1300
Aluminium	910 (1180)	2.7	71	25–125	70–135
1000 Series	910 (1180)	2.7	71	28–165	70–180
2000 Series	1100 (1430)	2.8	71	200–500	300–600
5000 Series	1000 (1300)	2.7	71	40–300	120–430
7000 Series	1100 (1430)	2.8	71	350–600	500–670
Casting alloys	1100 (1430)	2.7	71	65–350	130–400
Titanium	4630 (6020)	4.5	120	170	240
Ti–6 A14 V	5780 (7510)	4.4	115	800–900	900–1000
Zinc	330 (430)	7.1	105		120
Lead–tin solder	2000 (2600)	9.4	40		
Diecasting alloy	800 (1040)	6.7	105		280–330

(Ashby, 1998)

14.2. Atomic Structure Body Details

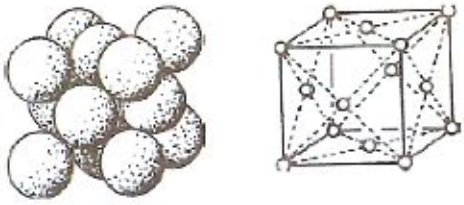
Body Centred Cubic

A body centred cubic (b.c.c) structure has an atom at each corner of an imaginary cube and an atom in the centre of this cube. A b.c.c structure generally produces strong metals which are reasonably ductile. Examples of b.c.c metals are tungsten, chromium and 'alpha' iron.



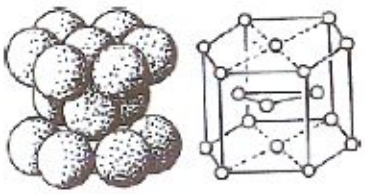
Face Centred Cubic

A face centred cubic structure has an atom at each corners of a cube and an atom at the centre of each face of the cube. Metals with f.c.c structures tend to be soft and ductile over a wide range of temperatures. An example of a f.c.c metals are gold, silver, copper, aluminium and gamma iron.



Hexagonally Closed Packed

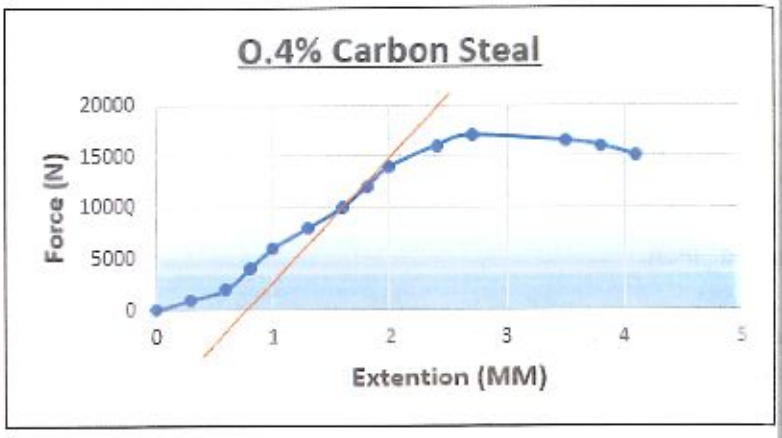
Hexagonally closed packed (sometimes referred to as "close packed hexagonal or cph") structures have an atom at the corners of an imaginary hexagonal prism and an atom at the centre of each hexagonal face and tree atoms in the centre forming a 'prism'. These metals are relatively brittle such as cobalt and magnesium.



(Structure and Classification of Material, 2019)

14.3. Data And Result Calculations

Force (N)	Ext (MM)
0	0
1000	0.3
2000	0.6
4000	0.8
6000	1
8000	1.3
10000	1.6
12000	1.8
14000	2
16000	2.4
17000	2.7
16500	3.5
16000	3.8
15000	4.1



Original Cross Sectional Area	**20**	**mm**
Lower Yield force:	**15.5**	**KN**
Maximum Force:	**17**	**KN**
Reduction of Area at Fracture:	**25%**	**%**

Yield or flow stress:

$$\frac{\text{Elastic Limit}}{\text{Original c.s.a}} = \frac{15500}{20} = 775 \text{ MN/m2}$$

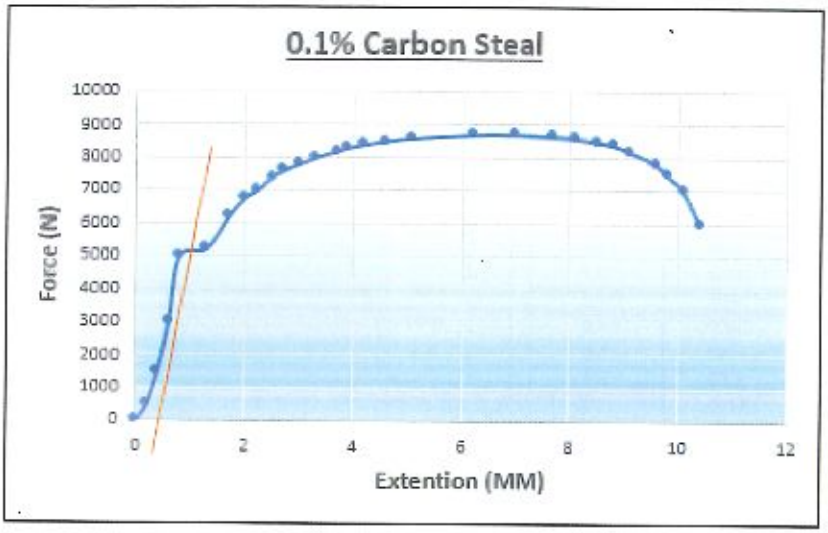
Tensile Strength:

$$\frac{\text{maximum Force}}{\text{Original c.s.a}} = \frac{17000}{20} = 850 \text{ MN/m2}$$

Elongation % at Fracture:

$$\frac{\text{Extension at Fracture}}{\text{Original gauge length}} \times 100\% = \frac{4.1}{25} = 16.4\%$$

Force (N)	Ext (MM)
0	0
500	0.2
1500	0.4
3000	0.6
5000	0.8
5250	1.3
6200	1.7
6800	2
7000	2.2
7400	2.5
7600	2.7
7800	3
8000	3.3
8200	3.7
8300	3.9
8400	4.2
8500	4.6
8600	5.1
8700	6.2
8700	7
8650	7.7
8600	8.1
8500	8.5
8400	8.8
8200	9.1
7800	9.6
7500	9.8
7000	10.1
6000	10.4



Original Cross Section **20** **mm**
Lower Yield force: **5** **KN**
Maximum Force: **8.7** **KN**
Reduction of Area at F **45%** **%**

Yield or flow stress:

$$\frac{\text{Elastic Limit}}{\text{Original c.s.a}} = \frac{5000}{20} = 250 \text{ MN/m2}$$

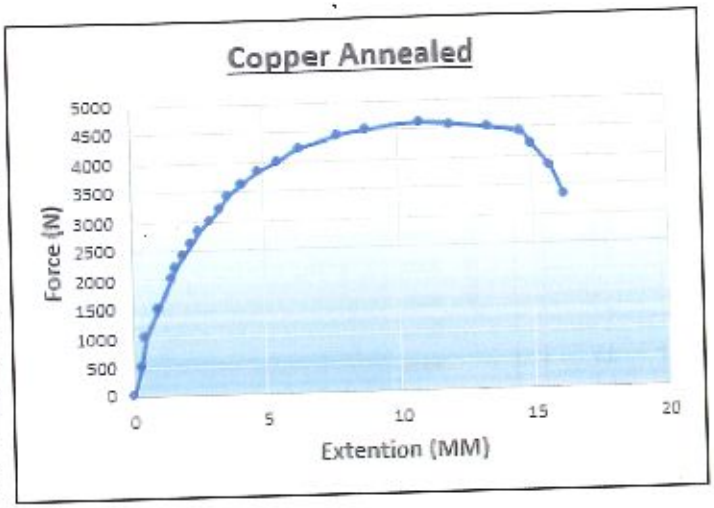
Tensile Strength:

$$\frac{\text{maximum Forc}}{\text{Original c.s.a}} = \frac{8700}{20} = 435 \text{ MN/m2}$$

Elongation % at Fracture:

$$\frac{\text{Extension at Fracture}}{\text{Original gauge length}} \times 100\% = \frac{10.4}{25} = 41.6\%$$

Force (N)	Ext (MM)
0	0
500	0.3
1000	0.5
1500	1
2000	1.5
2200	1.7
2400	2
2600	2.3
2800	2.6
3000	3
3200	3.4
3400	3.7
3600	4.2
3800	4.8
4000	5.6
4200	6.4
4400	7.8
4500	8.9
4600	10.9
4550	12
4500	13.4
4400	14.6
4200	15
3800	15.7
3300	16.2



Original Cross Sectional . **20** **mm**
Lower Yield force: **1** **KN**
Maximum Force: **4.6** **KN**
Reduction of Area at Frac **72%** **%**

Yield or flow stress:

$$\frac{\text{Elastic Limit}}{\text{Original c.s.a}} = \frac{1000}{20} = 50 \text{ MN/m2}$$

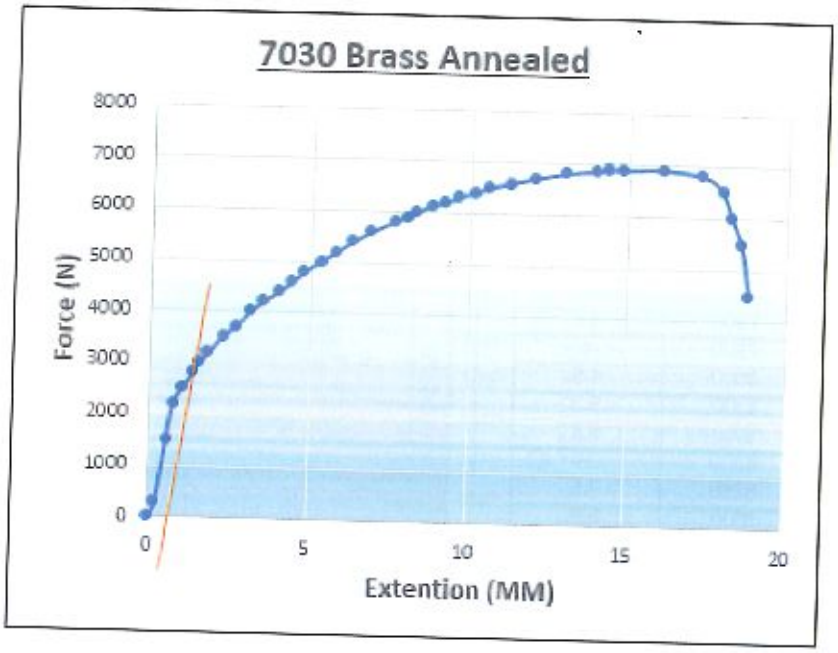
Tensile Strength:

$$\frac{\text{maximum Force}}{\text{Original c.s.a}} = \frac{4600}{20} = 230 \text{ MN/m2}$$

Elongation % at Fracture:

$$\frac{\text{Extension at Fracture}}{\text{Original gauge length}} \times 100\% = \frac{16.2}{25} = 64.8\%$$

Force (N)	Ext (MM)
0	0
300	0.2
1500	0.5
2200	0.7
2500	1
2800	1.3
3000	1.5
3200	1.8
3500	2.2
3700	2.6
4000	3.1
4200	3.5
4400	4
4600	4.4
4800	4.8
5000	5.3
5200	5.8
5400	6.3
5600	6.9
5800	7.6
5900	8
6000	8.3
6100	8.7
6200	9.2
6300	9.6
6400	10.1
6500	10.6
6600	11.2
6700	12
6800	13
6850	13.9
6900	14.3
6900	14.8
6900	16
6800	17.3
6500	17.9
6000	18.2
5500	18.5
4500	18.8



Original Cross 20 mm
Lower Yield fo 2.25 KN
Maximum Forc 6.9 KN
Reduction of 70% %

Yield or flow s

$$\frac{\text{Elastic Lin}}{\text{Original c.s}} = \frac{2250}{20} = 112.5 \text{ MN/m2}$$

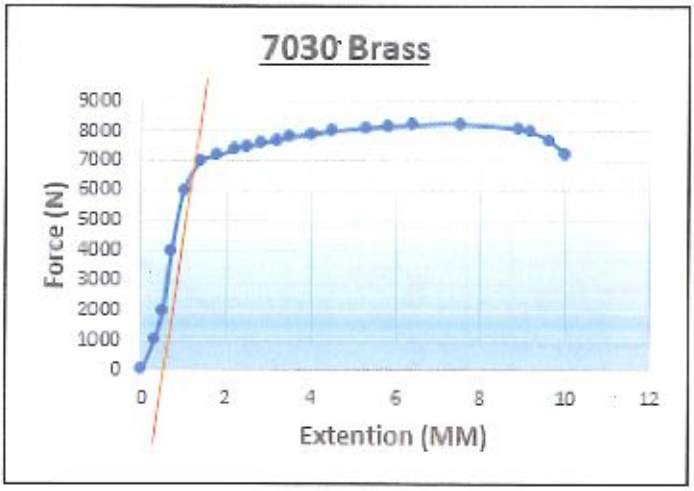
Tensile Strength:

$$\frac{\text{maximum Fo}}{\text{Original c.s}} = \frac{6900}{20} = 345 \text{ MN/m2}$$

Elongation % at Fracture:

$$\frac{\text{Extension at Fracture}}{\text{Original gauge length}} \times 100\% = \frac{18.8}{25} = 75.2\%$$

Force (N)	Ext (MM)
0	0
1000	0.3
2000	0.5
4000	0.7
6000	1
7000	1.4
7200	1.8
7400	2.2
7500	2.5
7600	2.8
7700	3.2
7800	3.5
7900	4
8000	4.5
8100	5.3
8150	5.8
8200	6.4
8250	7.5
8100	8.9
8000	9.2
7700	9.6
7200	10



Original Cross Sectional A **20** **mm**
Lower Yield force: **6** **KN**
Maximum Force: **8.25** **KN**
Reduction of Area at Fract **60%** **%**

Yield or flow stress:

$$\frac{\text{Elastic Limit}}{\text{Original c.s.a}} = \frac{6000}{20} = 300 \text{ MN/m2}$$

Tensile Strength:

$$\frac{\text{maximum Force}}{\text{Original c.s.a}} = \frac{8250}{20} = 412.5 \text{ MN/m2}$$

Elongation % at Fracture:

$$\frac{\text{Extension at Fracture}}{\text{Original gauge length}} \times 100\% = \frac{10}{25} = 40.0\%$$