

60%

APPENDIX GA36a

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	NICOLE FUNNING		Student ID number:	
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	
Some good points raised but some opportunities for wider reading were missed. In particular I would like to see some consideration of alloying (use of Carbon). We would allow a deeper evaluation of results.		13
2. Knowledge and Understanding Skills	30	
Clear understanding of underlying concepts. However some opportunities to demonstrate deeper knowledge were missed.		20
3. Cognitive and Intellectual Skills	20	
Sound application of theory to calculate property values (although some confusion evident in your report). Comments made were relevant but not fully explained (see above).		10
4. Practical Application Skills	15	
Some practical uses highlighted to demonstrate the importance of the test but I would like further detail here.		8
5. Transferable Skills for Life and Professional Practice	15	
Minor issues noted within the report but overall a well written and presented report.		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)

Up to 1 week late (40% Max)
Over 1 week late (0%)

60 %



HNC MECHANICAL ENGINEERING

Materials: Tensile test to destruction

Nicole Funning

Summary

This assignment describes the benefits of tensile testing, the objective of the test, the method and equipment used. The results were recorded through the lecturer shouting out the force vs extension results, and they were then displayed in a graphical form. The assignment then goes on to describe the graphs in more detail and comparing two of the materials that were tested. The results from the lab carried out in class are compared to a general data sheet from an online source, there was a few properties that didn't match as there could have been discrepancies such as the way the test was carried out. In the discussion the annealing process and the how the grain structures effect the materials properties are explained and how hot working the material could enhance the materials properties further. In the conclusion the benefits of the tensile test are stated and the properties that can be enhanced through heat work.

As card have included some of the specific results etc here to illustrate the points made

Contents

Summary	i
Table of Figures	1
Introduction	2
Objective	3
Theory	4
.....	6
Equipment	6
Method	7
Results	8
Discussion of the results	11
Conclusion	15
Bibliography	16



Remember to use a section numbering system

Table of Figures

Figure 1 stress vs strain graph source - https://www.smlease.com/entries/mechanical-design-basics/stress-strain-curve-diagram/	5
Figure 2 BCC and FCC structure source- https://www.coursehero.com/sg/general-chemistry/lattice-structure-of-crystals/	6
Figure 3 Tensile test machine and display screen.....	6
Figure 4 Table of results	8
Figure 5 Combined graphical data	9
Figure 6 Graphical data of individual materials	9
Figure 7 Table of material properties	10
Figure 8 Comparison of class results and general data.....	11
Figure 9 70/30 annealed brass vs 0.4% carbon steel	12
Figure 10 70/30 annealed brass vs 0.4% carbon steel.....	12
Figure 11 Fractured test samples.....	13
Figure 12 Grain structure source - https://www.slideshare.net/RakeshSingh125/annealing	14
Figure 13 Grain structure when hot rolling source - http://sainsmechanical.blogspot.com/2011/12/hot-working-of-metals.html	14

Introduction

A tensile test was performed on 5 materials, 70/30 brass, 70/30 annealed brass, normalised copper, 0.1% carbon steel and 0.4% carbon steel. The results were recorded then represented in a graph.

The results were then used to calculate the UTS, lower yield strength, % of elongation and reduction area %, using the results we could then use processes such as heat treatment and alloying to enhance the materials properties or change the materials properties depending on the grain structure to suit the materials end use.

Objective

The objective of the test undertaken was to test a range of materials and calculate the materials properties. The properties measured during the tensile test are the following:

- Tensile strength-

$$\text{ULTIMATE TENSILE STRENGTH} = \frac{\text{MAXIMUM FORCE}}{\text{ORIGINAL CROSS SECTIONAL AREA}}$$

- Lower yield stress-

$$\text{LOWER YEILD STRESS} = \frac{\text{LOWER YEILD FORCE}}{\text{ORIGINAL CROSS SECTIONAL AREA}}$$

- % of elongation at fracture-

$$\text{ELONGATION \% AT FRACTURE} = \frac{\text{GAUGE LENGTH AT FRACTURE} - \text{ORIGINAL GAUGE LENGTH}}{\text{ORIGINAL GAUGE LENGTH}}$$

- % reduction area-

$$\text{REDUCTION OF AREA \%} = \frac{\text{ORIGINAL CROSS SECTIONAL AREA} - \text{CROSS SECTIONAL AREA AT FRACTURE}}{\text{ORIGINAL CROSS SECTIONAL AREA}}$$

Theory

The tensile test is the most common destructive engineering test to determine how strong a material is, which can help select an appropriate material for an application. The results of the tensile test can determine some of the materials properties, ultimate tensile strength is the maximum force the test sample can withstand before fracture.

THE MODULUS OF ELASTICITY

The modulus of elasticity is an indication of how the material will behave under an application of a force, this is measured in pascals. For example, using steel to build an arched bridge, the steel is strong enough to support a load such as traffic, but also retains its shape when the load is removed.

THE YIELD STRENGTH *References needed for each definition*

Yield strength is the stress a material can take without permanent deformation, yield strength is measured in megapascals. An example where yield strength is taken into consideration, when manufacturing a car steel is often used for car panels because it absorbs the energy in car impacts due to it being tough and strong.

DUCTILITY

Ductile materials can be stretched without breaking and drawn into thin wires. It can be measured by fracture strain or percentage of elongation, another method used to measure ductility is the reduction of area at fracture. Gold is very ductile; a single ounce of gold can be beaten into sheets measuring roughly 5 metres on a side. These sheets of gold also known as gold leaf, are usually used for gilding. *Ref!*

HARDNESS

Hardness is the ability of a material to resist a permanent change in shape when a compressive force is applied and is measured by the durometer. Diamond cutting tools such as diamond coated end mills are a prime example for hardness, Diamond is the longest wearing surface of any material. Diamond coated end mills last 12 to 20 times as long as bare tungsten carbide tools which decreases production down time. It is also the lowest over cost of tooling and has the best edge retention for consistent finish.

TOUGHNESS

The toughness is the ability a material has to absorb energy and plastically deform without fracturing. Toughness is measured in units of joule per cubic meter. If a rod is made from a piece of high-carbon steel, under the impact of a hammer, if placed in a vice it would not shatter it would just bend, this would be a useful technique for bending flat steel bars.

BRITTLENESS

A material is brittle, when it is subjected to a stress or a change in length it will break without any significant strain. Brittle materials absorb very little energy prior to fracture, even those with a high strength. Materials such as iron carbide can be useful in a composite, steels use structures of the brittle iron carbide to change the properties of the material such as iron a lot stronger.

Below is a stress vs strain graph that is produced by the tensile test results:

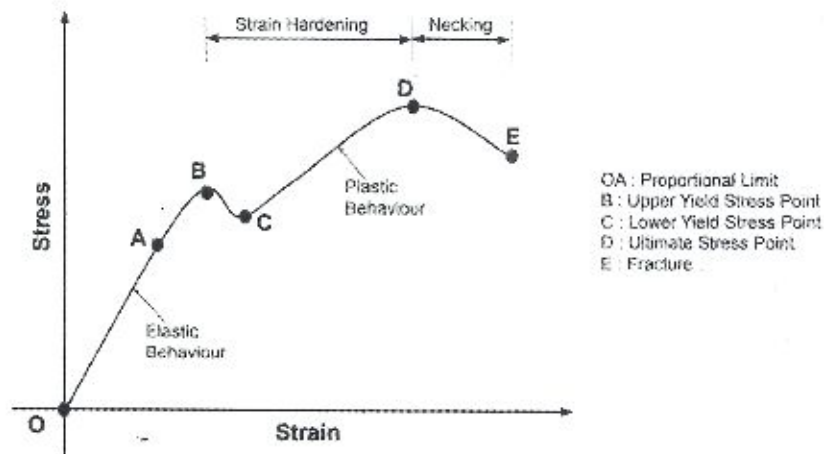


Figure 1 stress vs strain graph source <https://www.smilease.com/entries/mechanical-design-basics/stress-strain-curve-diagram/>

O-A is known as the proportional limit, it is a gradient which describes Hook's Law, that stress and strain are directly proportional.

A-B is the elastic limit, where the material deformed at its limit and will no longer return to its original shape when the load is removed.

B is the upper yield point is where the maximum load applied to material to start the internal plastic deformation.

C is the lower yield point is where the material has a required minimum load to maintain the plastic behaviour.

D is the UTS, the maximum load it can withstand before fracture.

E is the point where the material fails and fractures.

Each material has a lattice structure which also effects the materials properties, most metals are Body-Centred Cubic (BCC) or Face-Centred Cubic (FCC) as shown in the images below:

Could have discussed the packing factor here.

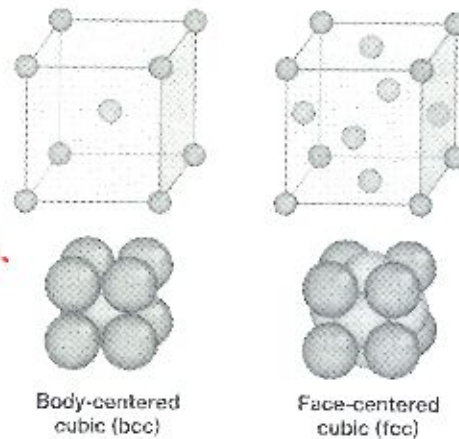


Figure 2 BCC and FCC structure source-
<https://www.coursehero.com/sq/general-chemistry/lattice-structure-of-crystals/>

The Body-centred cubic lattice structure is made up of 8 atoms in each corner of an imaginary cube and one in the centre. The atoms in this structure are not closely packed or stacked which causes the material to be less malleable but harder and more ductile than other materials with a close-packed atomic structure.

The Face-Centred Cubic lattice structure has an atom in each corner of the cube and an atom on the centre of each face of the cube. Materials with FCC structures tend to be softer and more ductile.

Equipment

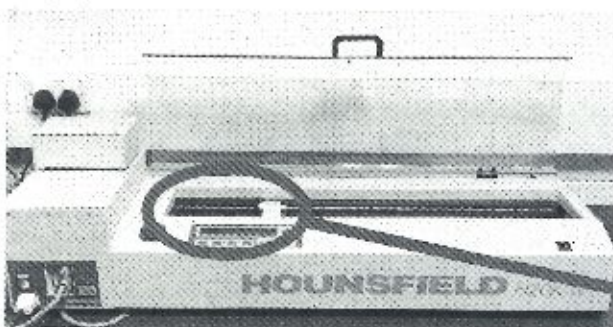
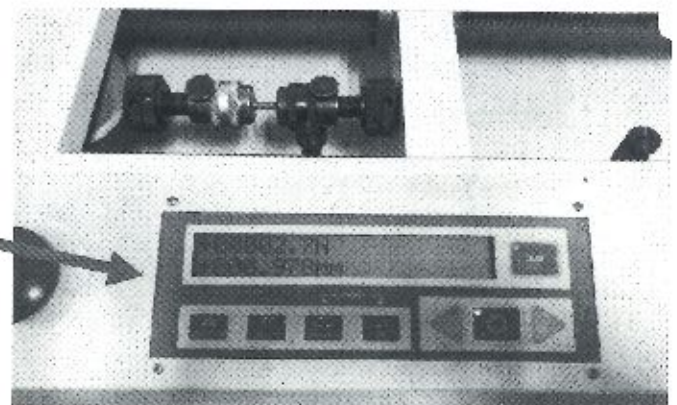


Figure 3 Tensile test machine and display screen



When carrying out the tensile test, a Hounsfield test machine was used as pictured above (Figure 3). Five different material test samples were used to collect data, which were 25mm in length and had a cross-sectional area of 20mm. The data was recorded by the tester reading out the force and extension values and the students writing down the values with a

pen and paper. When the test sample fractured, the sample was removed from the machine and the fracture area was measured with a reduction area gauge to record the % of area reduction.

Method

The method of the tensile test is as follows:

The test sample piece was loaded into the testing machine, then secured with grips and ensured the reading for load and extension was 0. An increasing load was applied onto the sample, as the load increased the extension was recorded at different load values. The sample eventually fractured and the test ended. The sample was removed from the grips, using a tensometer the reduction of area was measured. The process was repeated for each sample and the results were used to calculate the UTS, lower yield strength and % of elongation. The results of the test were represented in a load vs extension graph.

Results

70/30 annealed brass		annealed copper		0.1% normalised carbon steel		70/30 brass		0.4% carbon steel	
Force (N)	extension (mm)	Force (N)	extension (mm)	Force (N)	extension (mm)	Force (N)	extension (mm)	Force (N)	extension (mm)
0	0	0	0	0	0	0	0	0	0
300	0.2	1000	0.5	1500	0.4	300	0.8	2000	0.6
1500	0.5	1500	1	3000	0.6	2000	0.5	4000	0.8
2200	0.7	2000	1.5	5000	0.8	4000	0.7	6000	1
2500	1	2200	1.7	6250	1.3	6000	1	8000	1.3
2800	1.3	2400	2	6200	1.7	7000	1.4	10000	1.6
3000	1.5	2600	2.3	6800	2	7200	1.8	13000	1.8
3200	1.8	2800	2.6	7000	2.2	7400	2.1	14000	2
3500	2.2	3000	3	7400	2.5	7500	2.5	16000	2.4
3700	2.6	3200	3.4	7600	2.7	7600	2.8	17000	2.7
4000	3.1	3400	3.7	7800	3	7700	3.2	17500	3.5
4200	3.5	3600	4.2	8000	3.3	7800	3.5	18500	3.8
4400	4	3800	4.8	8200	3.7	7900	4	19000	4.1
4600	4.4	4000	5.6	8300	3.8	8000	4.5		
4800	4.8	4200	6.4	8400	4.2	8100	5.3		
5000	5.3	4400	7.8	8500	4.6	8150	5.8		
5200	5.8	4500	8.9	8600	5.1	8200	6.4		
5400	6.3	4600	10.9	8700	6.2	8250	7.5		
5600	6.9	4550	12	8700	7	8300	8.9		
5800	7.6	4500	13.4	8650	7.7	8000	9.2		
5900	8	4400	14.6	8600	8.1	7700	9.6		
6000	8.3	4200	15	8500	8.5	7200	10		
6100	8.7			8400	8.8				
6200	9.2	3800	15.7	8200	9.1				
6300	9.6	3500	16.2	7800	9.6				
6400	10.1			7500	9.8				
6500	10.6			7000	10.1				
6600	11.2			6000	10.4				
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								

Figure 4 Table of results

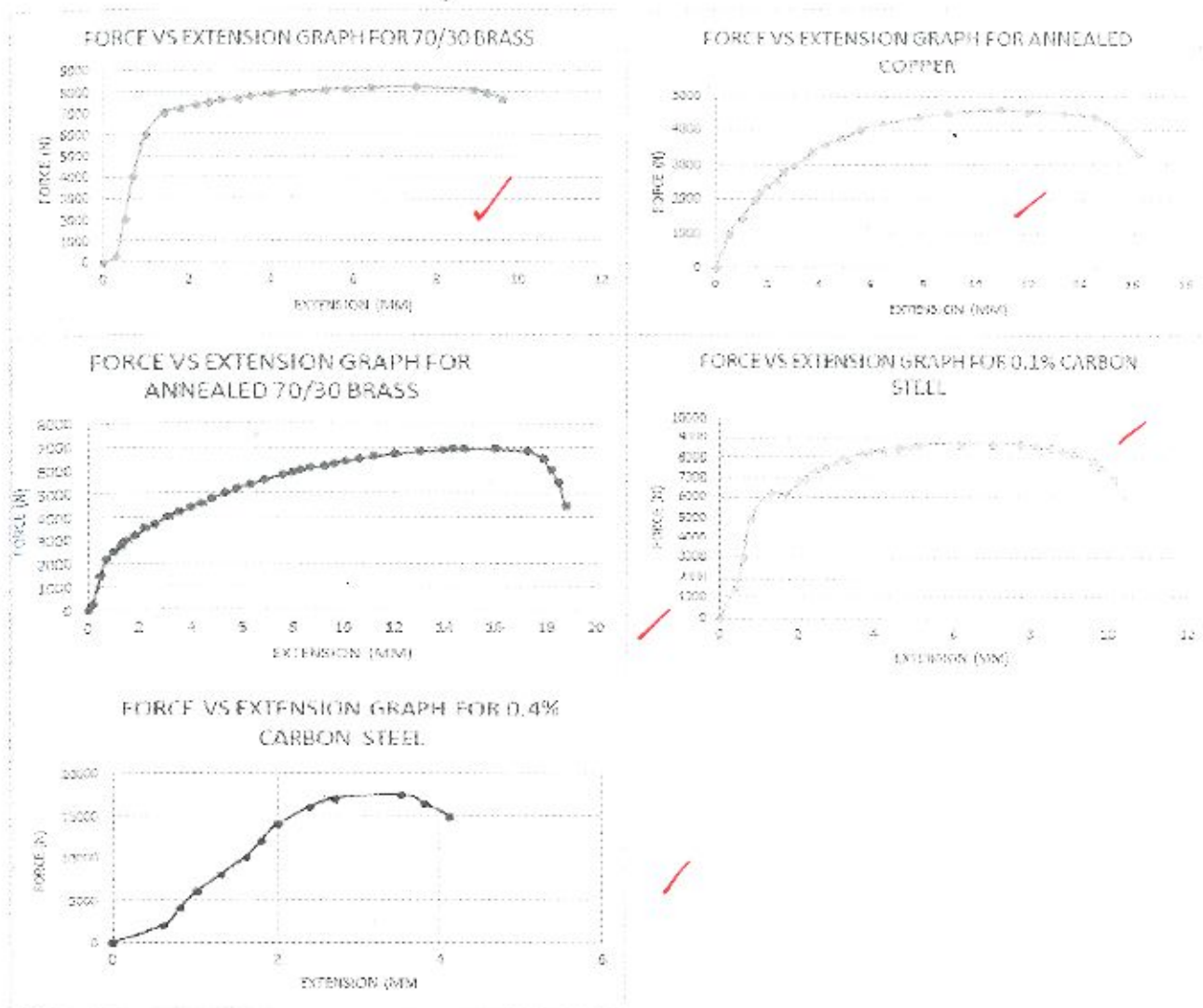


Figure 6 Graphical data of individual materials

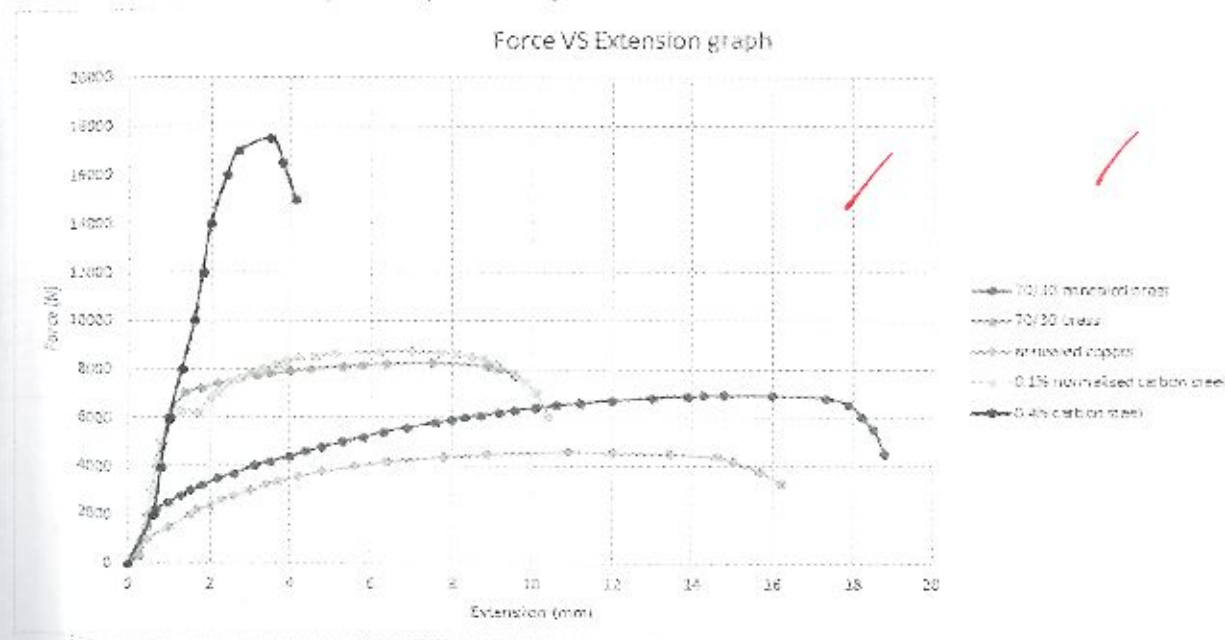


Figure 5 Combined graphical data

70/30 Brass

$$\text{ULTIMATE TENSILE STRENGTH} = \frac{\text{MAXIMUM FORCE}}{\text{ORIGINAL CROSS SECTIONAL AREA}}$$

$$\text{Area} = \frac{20}{1000,000} = 0.000020$$

$$\text{UTS} = \frac{8250}{0.02} = 0.4125 \text{ MN/M}^2 \quad 412.5 \text{ MN/m}^2$$

$$\text{LOWER YEILD STRESS} = \frac{\text{LOWER YEILD FORCE}}{\text{ORIGINAL CROSS SECTIONAL AREA}}$$

$$\text{LOWER YEILD STRESS} = \frac{6000}{0.02} = 0.3 \text{ MN/M}^2 \quad 300 \text{ MN/m}^2$$

$$\text{ELONGATION \% AT FRACTURE} = \frac{\text{GAUGE LENGTH AT FRACTURE} - \text{ORIGINAL GAUGE LENGTH}}{\text{ORIGINAL GAUGE LENGTH}}$$

$$\text{ELONGATION \% AT FRACTURE} = \frac{0.01454 - 0.025}{0.025} = 42\%$$

$$\text{REDUCTION OF AREA \%} = \frac{\text{ORIGINAL CROSS SECTIONAL AREA} - \text{CROSS SECTIONAL AREA AT FRACTURE}}{\text{ORIGINAL CROSS SECTIONAL AREA}}$$

$$\text{RA\%} = \frac{0.02 - 0.008}{0.02} \times 100 = 60\%$$

	70/30 BRASS	70/30 ANNEALED BRASS	ANNEALED COPPER	0.1% NORMALISED CARBON STEEL	0.4% CARBON STEEL
ORIGINAL CROSS SECTIONAL AREA (M ²)	0.02	0.02	0.02	0.02	0.1
CROSS SECTIONAL AREA AFTER FRACTURE (M ²)	0.008	0.006	0.0056	0.011	0.015
ORIGINAL LENGTH (M ²)	0.025	0.025	0.025	0.025	0.025
TOTAL EXTENTION (M ²)	0.01047	0.019	0.0165	0.0106	0.0043
MAXIMUM FORCE (KN)	8.25	6.9	4.6	8.7	17.5
YIELD FORCE (KN)	5.8	2.2	1	6.2	17
ULTIMATE TENSILE STRENGTH (MN/M ²)	412.5	345	230	435	875
LOWER YEILD STRESS (MN/M ²)	300	110	50	310	850
ELONGATION % AT FRACTURE	42%	76%	66%	42%	17%
REDUCTION AREA % AT FRACTURE	60%	70%	72%	45%	25%

Figure 7 Table of material properties

Discussion of the results

The tensile test is the most simple, popular and widely used mechanical test, as it measures the force required to elongate a test sample until the sample fails and fractures. The test can determine the selection of suitable materials and its mechanical properties needed for its end application and how the material will behave under different loads. The benefit from using the tensile test is that it provides accurate data on the safety of the material by knowing what the maximum load the material can withstand before failing, this data then can be used to ensure the final application of the material is fit for use. The data collected from the test can also be used to aid the design process, reduce costs and aid lean manufacturing. The tensile test can also guarantee quality of materials used in a range of different industries such as aerospace, automotive and health and safety. The main use in aerospace is tensile testing the fasteners used such as nuts, bolts and screws, for the automotive industry to test the fittings such as airbags and seatbelts and, in the health and safety industry its main application is to test the safety of supports.

Comparing the values for the mechanical properties obtained in the class lab to the standard reference values (averages) as shown below for each material tested in the lab carried out in class:

CLASS LAB	ULTIMATE TENSILE STRENGTH (MN/M ²)	LOWER YIELD STRESS (MN/M ²)	ELONGATION % AT FRACTURE
0.4% carbon	875	850	17%
annealed copper	230	50	66%
70/30 annealed brass	345	110	76%
70/30 brass	412.5	300	42%
0.1 normalised carbon steel	435	310	42%

Connect values here -

MATWEB	ULTIMATE TENSILE STRENGTH (MN/M ²)	LOWER YIELD STRESS (MN/M ²)	ELONGATION % AT FRACTURE
0.4% carbon	987	685	18.90%
annealed copper	210	33.3	60%
70/30 annealed brass	110	330	66%
70/30 brass	315	400	35%
0.1 normalised carbon steel	325	425	37%

Figure 8 Comparison of class results and general data

Possible discrepancies for the difference in data could be the machine may have needed to be recalibrated, also the way the test was carried out- the lecturer was reading the results out, when in practise the results would be recorded through a computer to ensure accuracy.

Comparing the properties of 0.4% carbon steel to the properties of the 70/30 annealed brass, the curve of the graph as shown below are very different.

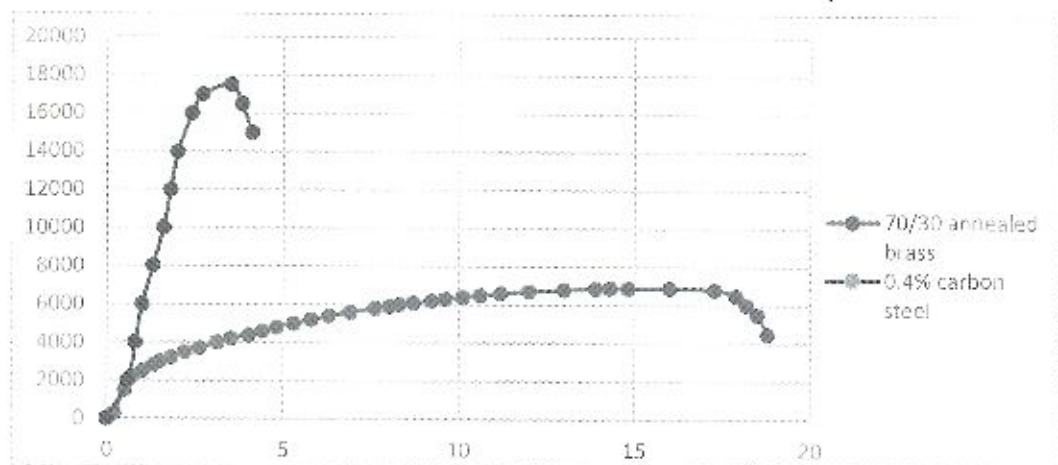


Figure 9 70/30 annealed brass vs 0.4% carbon steel

The annealed brass has an elongation of 76% which is considered to be a very ductile metal, although the UTS is very low and relatively low maximum force of 6.9KN. As stated by S&D non ferrous (<http://www.sdnonferrous.co.uk/70-30-cartridge-brass>) "70/30 cartridge brass is a copper alloy, further categorised as a brass, with the highest ductility out of all the brasses, great strength and impressive corrosion resistance in a number of applications, ideal for use in the automotive, electrical and plumbing industries."

Comparing the annealed brass to the properties of the 0.4% carbon steel, the materials behave very differently when a load is introduced to the material. The carbon steel has a UTS of 875MN/M², a low % of elongation at 17% but can withstand a maximum force of 17.5KN which is almost 3 times more than the brass. As suggested by Adam Rogers (<https://www.metalex.co.uk/carbon-steel-uses/>) the main uses for 0.4% carbon steel also known as "Medium carbon steel is a lot easier to machine and adding small amounts of silicon and manganese improves the quality. Also called mild steel, it's commonly used structurally in buildings and bridges, axles, gears, shafts, rails, pipelines and couplings, cars, fridges and washing machines." Comparing these properties to the 0.1% normalised carbon steel, the 0.1% is less ductile as the more carbon content the more ductile and harder the material is.

I think it would have been good to compare the non-annealed and the annealed brass to highlight the effect of annealing

You could have also discussed the effect of carbon content between the two ferrous metals

As you can see from the image below of the fractured test samples, the 0.4% carbon steel has a brittle fracture as the other materials have a cup and cone like fracture, this is due to the material being very brittle as the % of elongation is very low.

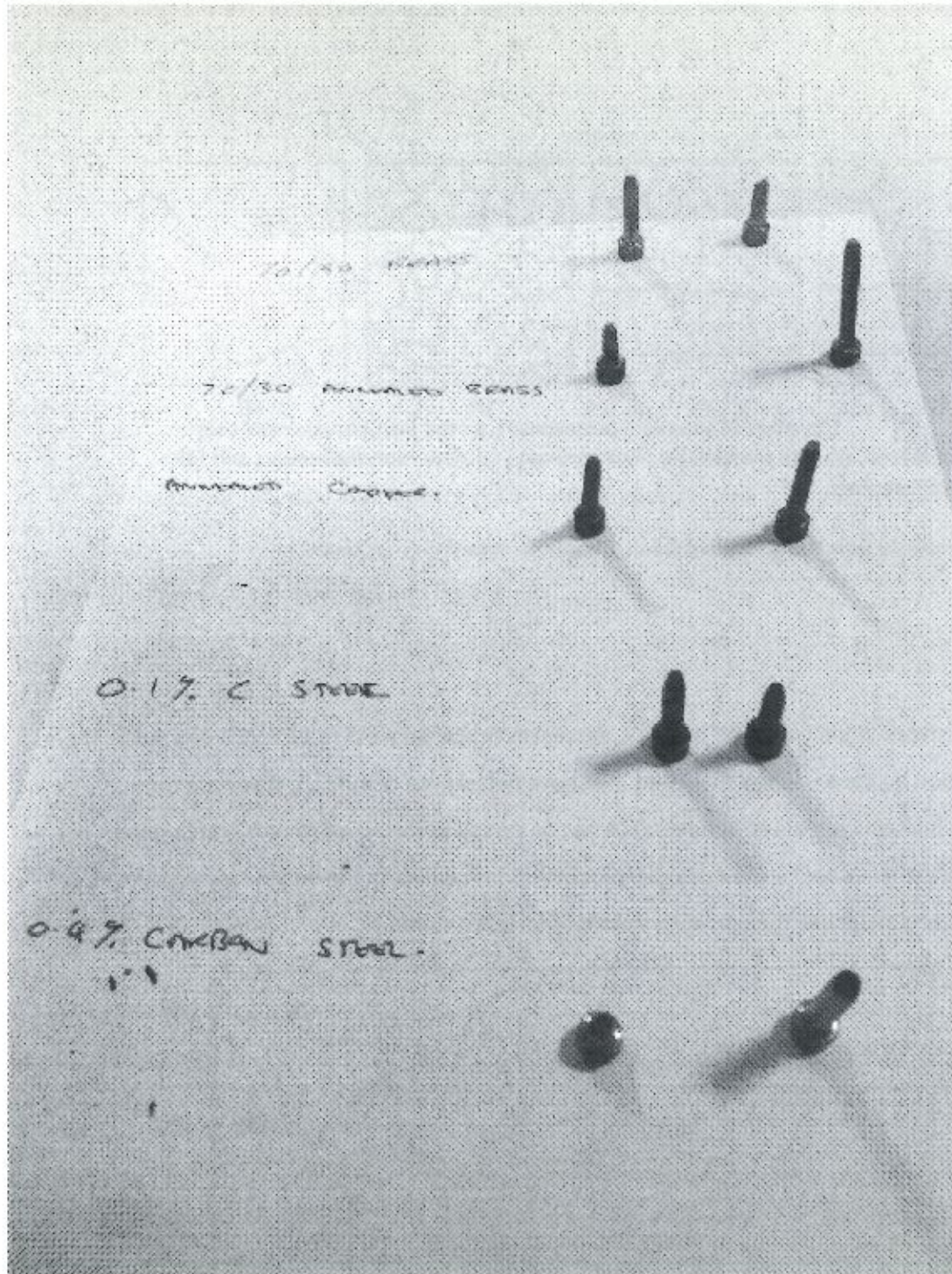
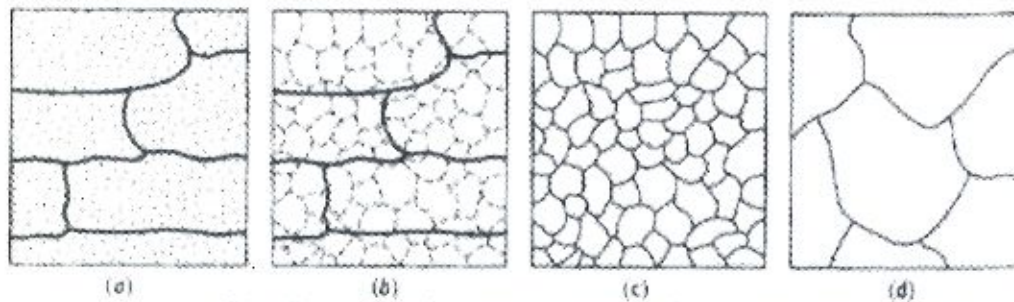


Figure 11 Fractured test samples

Annealing is a process where the material is heated up above its recrystallisation temperature to reduce the number of dislocations in the crystal structure then very slowly cooling the material. This process is usually performed after the material has been cold worked as it prevents the material from being brittle and failing. Below you can see the effect the process has on the materials grain structure:



The effect of annealing temperature on the microstructure of cold-worked metals: (a) cold worked, (b) after recovery, (c) after recrystallization, and (d) after grain growth.

Figure 12 Grain structure source <https://www.slideshare.net/RakeshSingh125/annealing>

Annealing a material increases the ductility, decreases brittleness and reduces the hardness. The recrystallisation process is when the grains that have defects are deformed, these are then transformed into a new grain structure which has no crystal defects. Hot or cold working the material can further enhance the materials properties. As shown in the image below, you can identify the grain structure change when the material is hot rolled.

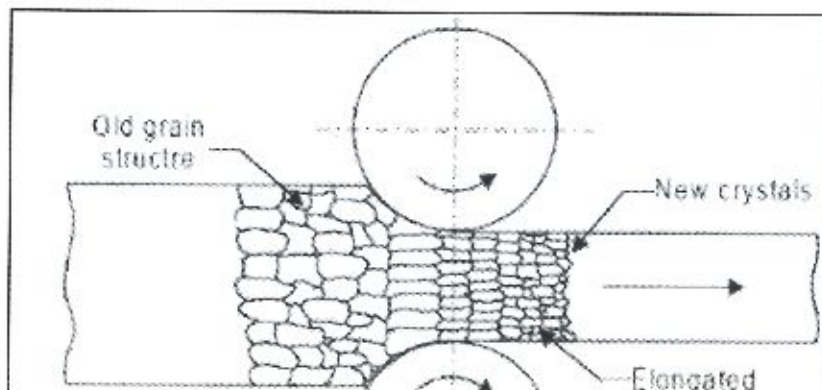


Figure 13 Grain structure when hot rolling source - <http://sainsinechanical.blogspot.com/2011/12/hot-working-of-metals.html>

Conclusion

In conclusion the tensile test is the most commonly used because it's a quick way to test any defects in a material, it aids design engineers if a design needs to have a particular material property and it also determines if a design will fail under a specific load. These factors are important when selecting materials for a specific end use, it will tell you what the maximum force that can be applied to the material, at what point the material will fracture and at what rate will the material deform. From the results of the lab you can also see what benefits annealing can have on enhancing the materials properties as the annealed 70/30 brass had nearly twice as much % of elongation as the non-annealed 70/30 brass, this process will be useful when manipulating the grain structure to make the material more ductile.

Bibliography

- design, s. (2018). stress strain curve: strength of materials. *stress strain curve: strength of materials*, 1. Retrieved from <https://www.smlease.com/entries/mechanical-design-basics/stress-strain-curve-diagram/>
- Howard, P. A. (2018, May 20). *Forms of Crystal Lattice Structures*. Retrieved from coursehero: <https://www.coursehero.com/sg/general-chemistry/lattice-structure-of-crystals/>
- Jumat. (2011, December 09). *Hot working metals*. Retrieved from sainsmechanical: <http://sainsmechanical.blogspot.com/2011/12/hot-working-of-metals.html>
- Khaira, D. H. (2013, November). <https://www.slideshare.net/annealing>. Retrieved from [https://www.slideshare.net: https://www.slideshare.net/RakeshSingh125/annealing](https://www.slideshare.net/RakeshSingh125/annealing)
- Matweb. (2018, June 18). *copper Cu annealed*. Retrieved from matweb: <http://www.matweb.com/search/datasheet.aspx?matguid=9aeb83845c04c1db5126fada6f76f7e>
- Matweb. (2018, June 18). *Data sheet*. Retrieved from Matweb: <http://www.matweb.com/search/DataSheet.aspx?MatGUID=098700ed63b24b14bd3bfdbec937489f&hx0026%3bckck=1&ckck=1>
- metalsupermarkets. (2018, August 2018). *what is annealing?* Retrieved from metalsupermarkets: <https://www.metalsupermarkets.co.uk/what-is-annealing/>
- P.Phule, D. R. (2006). *Science and engineering of materials*. Brooks-Cole.
- Rogers, A. (2016, August 20). *Carbon Steel, Metal Definitions, Metal Uses, Steel*. Retrieved from metalex: <https://www.metalex.co.uk/carbon-steel-uses/>
- Şakar, B. (2017, June 29). *Importance Behind the Tensile Test*. Retrieved from medium: <https://medium.com/@behicsakar/importance-behind-the-tensile-test-3730def3d4ab>