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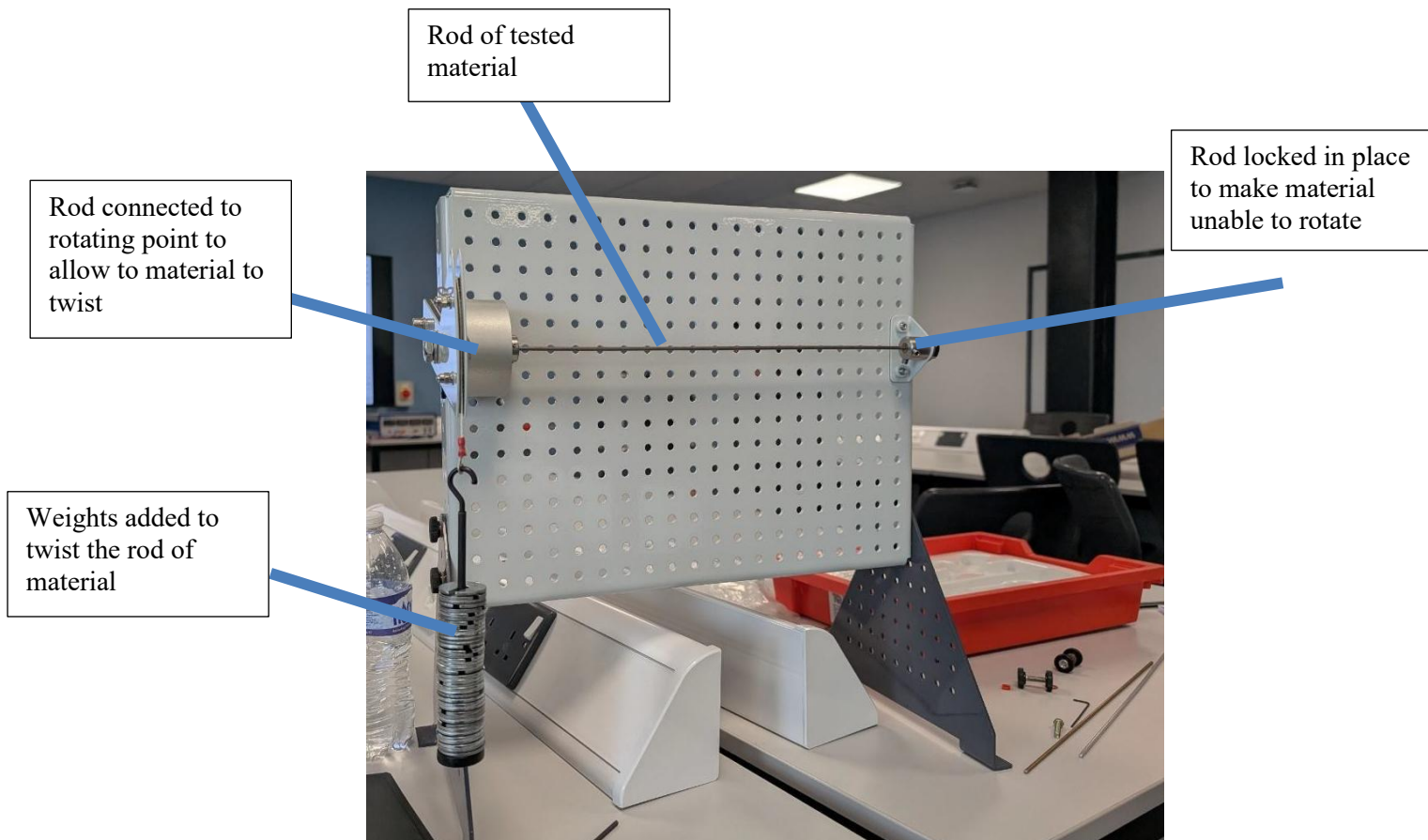
1.0 Introduction

The aims of this experiment is to complete a practical experiment testing torsion and to use the collected data to calculate shear modulus for the materials used within the experiment. This is used to understand the range that each material can withstand torsion forces before becoming elastically deformed. Knowing this limit for material is critical to know when engineering parts, ensuring it is capable of withstanding the forces needed or shearing at the correct time and point. knowing how materials behave in specific conditions can aid in the picking the most suited material for each part. This experiment visually displays these specific properties for the material tested, giving a more comprehensible and understandable example of these properties.

2.0 Experimental procedure

The experiment to measure the torsion of the three different materials, aluminium, brass and steel was done using the apparatus shown in figure 1.:

Figure 1 - The apparatus used to simulate torsion on different materials made by TecQuipment



The first step in the experiment was to measure the original length of each rod, then record the findings. Then secure the rod of material in the fixed chuck on the right and then the rotating chuck on the left (figure 1). This allowed the left side of the rod to twist and create a torsion force on the rod. The force was applied through a lever which weights could be added to. This lever also acted as a ruler to show the angle of twist in the rod. This is shown in figure 2.

The process to taking measurements in this experiment was to ensure the rod is secure and not slipping, add the first set of weight, for this example the first measurement was using 100 grams hanging from the lever. Record the weight used and the angle of twist displayed with the ruler and indicator on the clear plastic in figure 2. This process was repeated until 500g which the final measurements were recorded then the weights were removed along with the rod, to be replaced with the next material. The only exception to this procedure was with aluminium repeating up to 400g as the apparatus was at its limit of measurement.

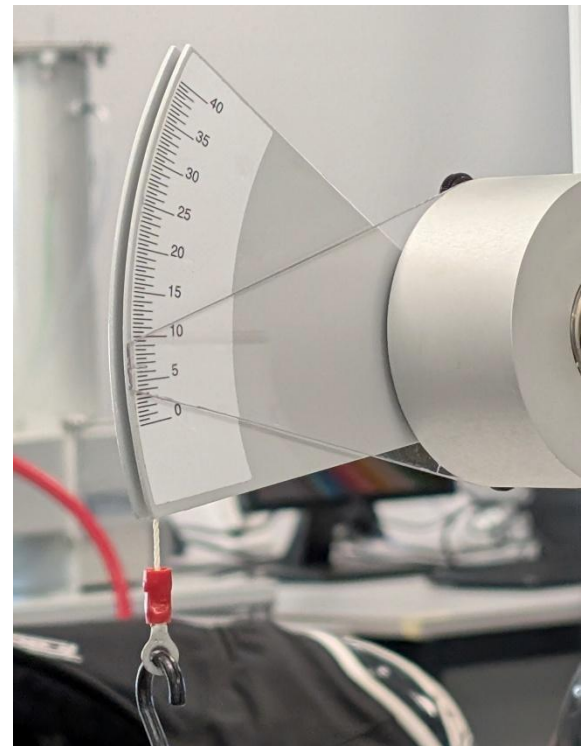


Figure 2 - shows the lever and the ruler showing an angle of twist on the rod

3.0 Results

The raw results of the experiment:

Brass:	
Load in grams	Twist angle in degrees
100g	6.5°
200g	12.5°
300g	18°
400g	24°
500g	30°
Aluminium:	
Load in grams	Twist angle in degrees
100g	8.5°
200g	17°
300g	25.5°
400g	32°
Steel:	
Load in grams	Twist angle in degrees
100g	3°
200g	5.5°
300g	8°
400g	10.5°
500g	13°

Table 1- data collected on apparatus with steel, brass and aluminum

4.0 Analysis

The data from the experiment used to calculate the sheer modulus for each material:

shaft modulus						
Load(m)(g)	load(W)(N)	torque(T)(Nm)	twist angle (degrees)	twist angle (theta)(radians)	TL	Jtheta
100	0.9810000	0.0981	6.5	0.113446401	0.03335	1.02858E-12
200	1.9620000	0.1962	12.5	0.218166156	0.06671	1.97804E-12
300	2.9430000	0.2943	18	0.314159265	0.10006	2.84837E-12
400	3.9240000	0.3924	24	0.41887902	0.13342	3.79783E-12
500	4.9050000	0.4905	30	0.523598776	0.16677	4.74728E-12
material: Brass		L=	D= 0.0031		J=	9.06665E-12
		0.34 m				

table 2 this shows the calculations used to find TL* and Jtheta *Torque multiplied by length of the brass rod

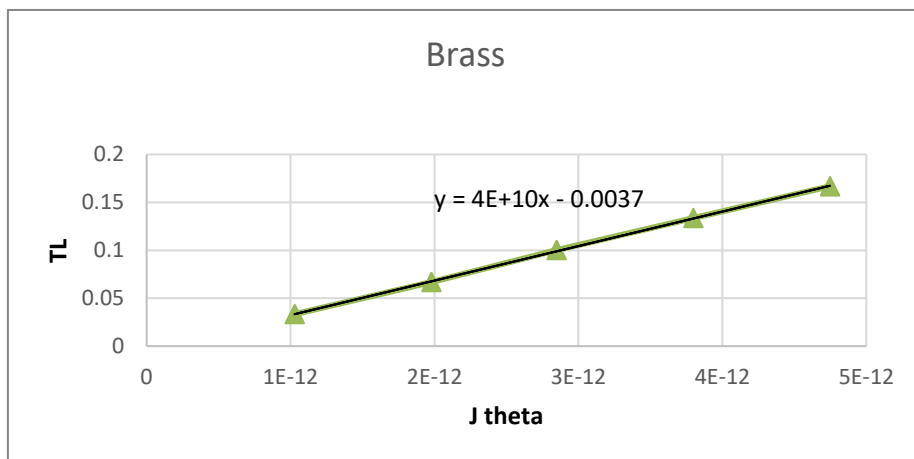


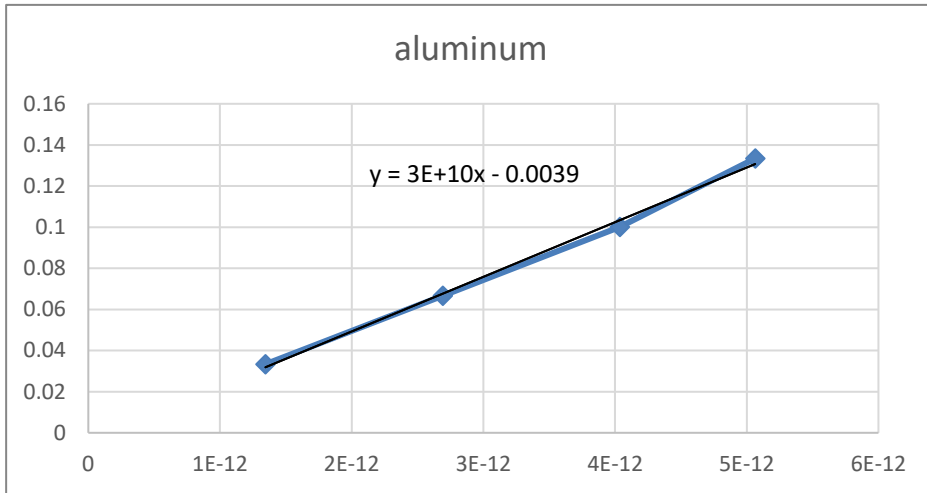
Table 3 this table shows the gradient of the graph and the GPa

gradient of brass graph
36022417390
36GPa

Figure 3 this graph shows the positive correlation of TL increases with Jtheta with the brass rod

shaft modulus						
Load(m)(g)	load(W)(N)	torque(T)(Nm)	twist angle (degrees)	twist angle (theta)(radians)	TL	Jtheta
100	0.9810000	0.0981	8.5	0.148352986	0.03335	1.34506E-12
200	1.9620000	0.1962	17	0.296705973	0.06671	2.69013E-12
300	2.9430000	0.2943	25.5	0.445058959	0.10006	4.03519E-12
400	3.9240000	0.3924	32	0.558505361	0.13342	5.06377E-12
material: aluminum		L=	D= 0.0031		J=	9.06665E-12
		0.34 m				

Table 3 this shows the calculations used to find TL* and Jtheta *Torque multiplied by length of the aluminum rod



gradient of aliminum graph

26578465476

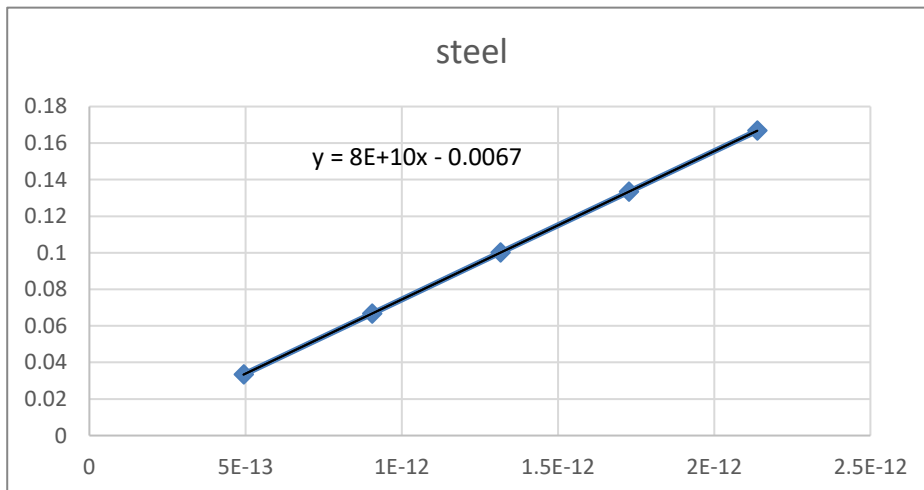
26GPa

Table 4 this table shows the gradient of the graph and the GPa

Figure 4 this graph shows the positive correlation of TL increases with Jtheta with the aluminum rod

shaft modulus						
Load(m)(g)	load(W)(N)	torque(T)(Nm)	twist angle (degrees)	twist angle (theta)(radians)	TL	Jtheta
100	0.9810000	0.0981	3	0.052359878	0.033354	4.93374E-13
200	1.9620000	0.1962	5.5	0.095993109	0.066708	9.04518E-13
300	2.9430000	0.2943	8	0.13962634	0.100062	1.31566E-12
400	3.9240000	0.3924	10.5	0.183259571	0.133416	1.72681E-12
500	4.9050000	0.4905	13	0.226892803	0.16677	2.13795E-12
material: steel		L=	D=	0.00313	J=	9.42274E-12
		0.34 m				

Table 5 this shows the calculations used to find TL* and Jtheta *Torque multiplied by length of the steel rod



gradient of steel graph

81124737324

81GPa

Table 6 this table shows the gradient of the graph and the GPa

Figure 5 this graph shows the positive correlation of TL increases with Jtheta with the steel rod

5.0 Conclusion

Figure 6 shows that the data collected and the calculations used can calculate the sheer modulus. However, the supplied textbook value for brass is 38GPa (*Brass Material Properties*) but the value calculated is 36.01, this difference can be attributed to many different factors. These could range from errors in the calculations, rounding errors to the tested material being damaged from previous experiments. Despite these differences in values researching online shows that they are all within a small difference to their researched values and within the tolerance of these values.

Another odd feature of the data is the small inconsistency on the last plot of the aluminium. This could be a factor if it beginning to fail and elastically deform although it could also be caused by a mistake when reading the degrees of twist on the experiment apparatus. All of the graphs should have linear gradients which can be visually seen to be true with brass and steel.

Steels sheer modulus commonly ranges from 79GPa – 85GPa, which validates my calculations for steel. This is the same with the other materials. The tolerance is mainly due to the different ways to manufacture the material, for example figure 7 shows this difference.

Aluminums sheer modulus commonly ranges between 25GPa and 26GPa (*Properties: What Are the Properties of Aluminum?*).

Structural Steel	79.3
Stainless Steel	77.2
Steel, Cast	78
Steel, Cold-rolled	75

Table 7- a graph showing the different sheer modulus of different types of steel

6.0 Evaluation

The experiment was controlled as errors were removed as all measurements were recorded then the experiment was repeated to check the recorded results are consistent and valid. This removed potential errors with multiple people recording data and potential mistakes from misreading, rounding and misreading the data. By repeating the experiment an extra step of verification was used to ensure all data was correct.

Another potential error that was eliminated was reading errors while the weight levelled out as adding load to the apparatus created a spring like effect. This was eliminated by waiting for the weights to settle for a consistent and reliable reading. If this was not done, then the reading would spoil the data pool. This would offset the result after all calculations are made.

If the material slips within the chucks, the data will be inaccurate and require the experiment to be restarted as all previous data could be false readings. If this error is not caught, the data could result in a curved graph as the more load added to the lever, the more the chuck would slip, creating a significantly larger result for its shear modulus. This was prevented in our experiment by ensuring all bolts are tight using a tool and validating data by resetting up the apparatus and repeating the experiment.

A Possible cause of an error in this experiment could be due to temperature. This will only occur at extreme temperatures; the shear modulus will reduce relatively. Increasing the temperature of the material will slowly reduce the shear modulus, decreasing the materials temperature will not affect the shear modulus, however it will cause its failure to occur at a lower torque. the effect this will have on the data readings will be subtle to irrelevant at small alterations of temperature.

Figure 2 shows the scale on the apparatus. This can be inconsistent and unreliable if read from different angle. This is due to parallax. Because the scale is made of two different parts the measurements and the marked indicator are not flush to one another, changing the viewing angle of the scale will present a different value. This error is prevented by reading the values from straight on and level to the indicator. This was practiced with all the readings taken throughout this experiment. Another way this error can be prevented is by using a digital readout for the scale.

7.0 Further Work

This experiment could have been improved if the data pool was more saturated with multiple rods of the same material to remove any variability in the material, remove defective or damaged material from the data set. This will improve the accuracy of the results and validate the results within the experiment. However, this will require significantly more time to carry out the experiment potentially doubling the time required for the entire experiment.

Another improvement that could be done to improve the results is to validate the weight being added throughout the experiment. This could be done by using a calibrated scale and weighing the weights before use. This will remove inconsistencies in data as if one weight was labelled 50g, but weighed 45g, could drastically reduce reliability in data sets using this weight.

If unlimited resources and time were available, using multiple lengths and diameters of material will improve the accuracy of the data pool. Repeating the experiment with multiple differences in the material, such as length and diameter, will refine the accuracy of the final calculations and allow for a more informed conclusion. With the current data pool, all the lengths of the materials are identical, the brass and aluminium share their diameters. If different length and diameter materials were tested this will show if the calculations are related to diameter and or length of the material, these differences should not affect the results, however proving this with the experiment would improve this experiment

the accuracy of this experiment can be improved if a calibrated digital ruler for the angle of twist. A digital display is much less likely to be misread and data to be recorded incorrectly compared to the physical readout on the apparatus used in the experiment. A digital reading will also be far more accurate as it can display far more decimal places than can be seen with human eye. If errors were made when reading the data the results will be skewed potentially in both directions as there are multiple factors that can cause this error, examples of this are; parallax, the apparatus to not settle after changing the weights, human error and fatigue.

Another potential improvement to this experiment could be using multiple different suppliers for the materials. This will prevent bias to specific types of material as if all the material is supplied from one place, all the steel for example could be manufactured in the same way reducing diversity in the data set. Including these potentially different materials will average out the result allowing for less inconsistency of the material expected is from a different supplier.

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