OBJECTIVE

Torsion test on metals is a test to find the shear modulus value of (in our case) a steel, aluminium and brass sample. Through this experiment, we can study the deformation of a metal subjected to a torque using a school lab torsion testing machine.

INTRODUCTION

Torsion is defined as the twisting of an object due to the applied torque or moment which will produce rotation along the longitudinal axis of an object. When the applied torque is acted on a member, shear stress and deformation is developed. This applied torque causes a resisting force, this force is known as resisting torque for which is equivalent to the applied torque.

For this experiment, a computerized torsion machine is used to apply an increasing torque to the different samples for some amount of time. As a result the angular displacement is obtained for each different torque. In this particular test, the samples are not tested until failure. However, the maximum torque can be obtained by the machine and thus allowing us to calculate the shear modulus.

Torsion is a concern when designing axles or shafts and would be of interest when structures with circular sections are involved. This test helps us to choose which materials will be suitable for each circumstances. For example, a shaft used in power generation or transmission.

PROCEDURE

Equipments:

- Torsion test machine
- Micrometer
- Computer
- Steel , aluminium and brass sample (1 each)

1. Measure the diameter of each sample (which are already mounted on the testing machines) at 3 different sections and calculate the average diameter for each sample.
2. Take down the length of each sample indicated at the testing machine station.
3. Press on the start button situated on the machine read out indicator to begin the experiment.
4. Wait until the end of the test and the results will show up on the computer connected to the testing machine. Rename the files in which the results are and extract the datas to your personal computer.

Formulas:

$J = (\pi D^4)/32$

$G = (TL)/(\theta J)$

$D = (D1+D2+D3)/3$

Where:

T = Torque (Nmm)

L = gauge length (mm)

θ = angle of twist (radians)

J = polar moment of inertia (mm^4)

G = shear modulus (GPa)

D = average diameter of gauge (mm)

Sample calculations:

$J = (\pi 6.13^4)/32 = 138.6$ mm^4

$G = (5.31 \times 76)/(0.06981 \times 138.6) = 41.7$ Gpa

RESULTS

Sample	Diameter (mm), D=(D1+D2+D3)/3	Gauge length, L (mm)	Polar moment of inertia, J (mm^4)
Steel	6.29	76.0	153.7
Aluminium	5.00	100.0	61.36
Brass	6.13	76.0	138.6

Sample	Maximum Torque (Nm)	Maximum Angle (degrees)	G average (GPa)
Steel	6.88	4.0	49.52
Aluminium	0.38	3.5	18.34
Brass	5.31	4.0	40.28

Steel

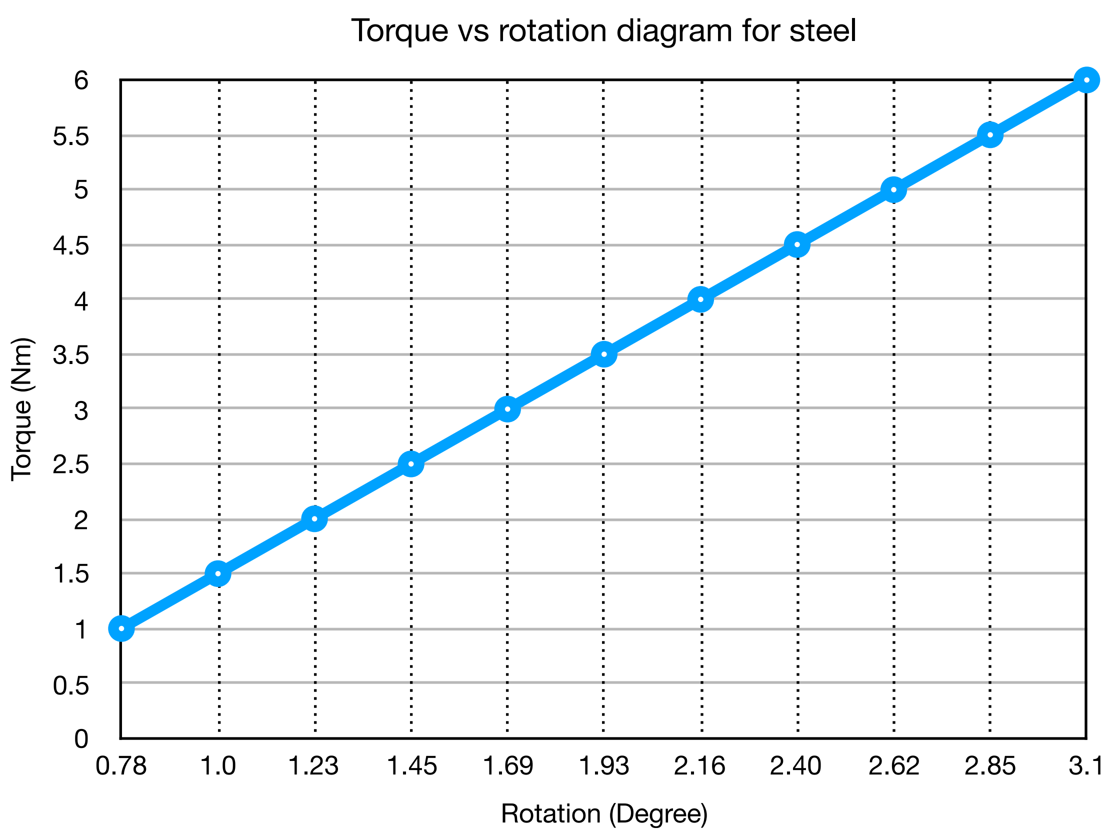
T (Nm)	θ (degrees)	θ (radians)	G (GPa)
1.0	0.78	0.0136	36.36
1.5	1.0	0.0174	42.63
2.0	1.23	0.0215	46.00
2.5	1.45	0.0253	48.86
3.0	1.69	0.0295	50.29
3.5	1.93	0.0337	51.35
4.0	2.16	0.0377	52.46
4.5	2.40	0.0419	53.11
5.0	2.62	0.0457	54.10
5.5	2.85	0.0497	54.72
6.0	3.1	0.0541	54.84

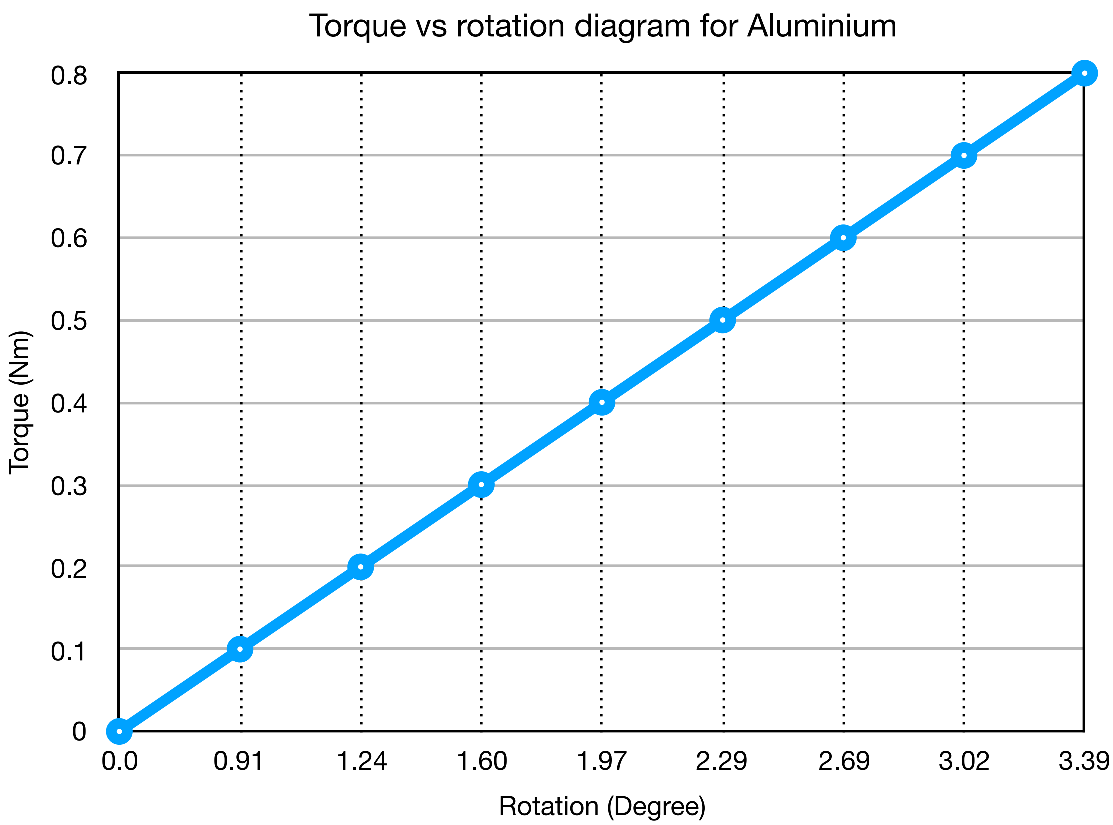
Aluminium

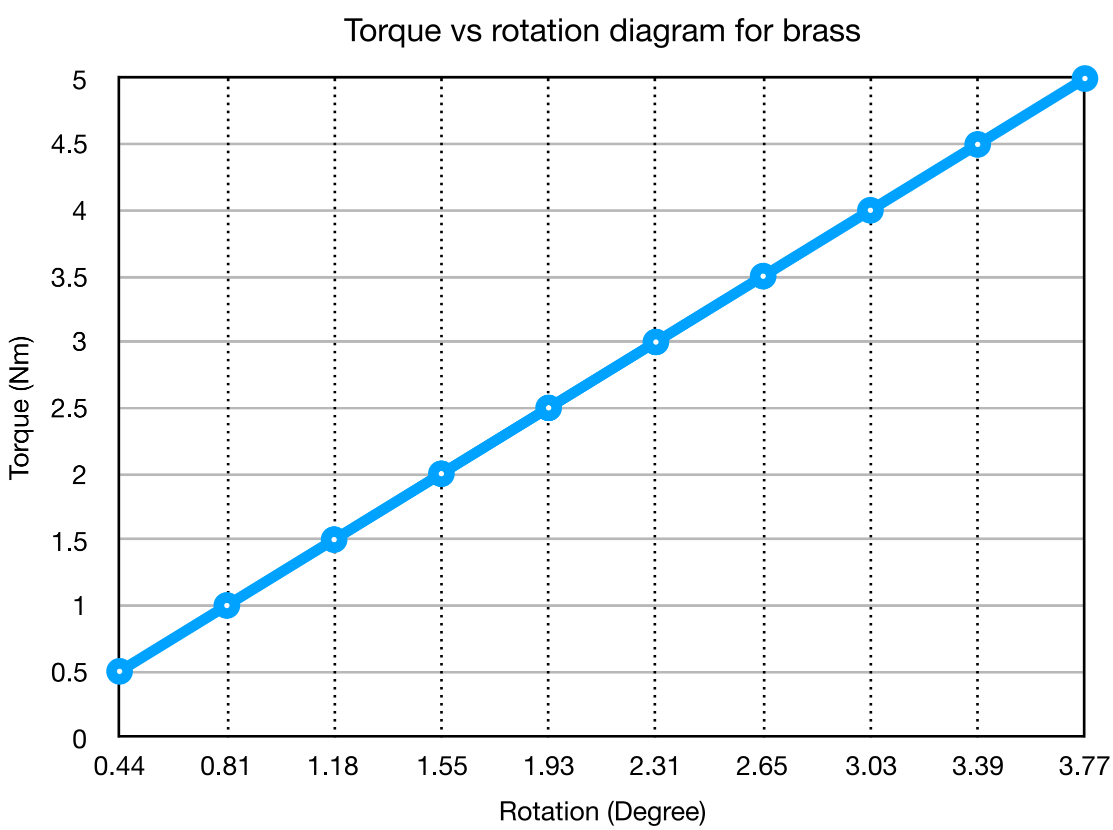
T (Nm)	θ (degrees)	θ (radians)	G (GPa)
0.0	0.0	0.0	0.0
0.1	0.91	0.0159	10.25
0.2	1.24	0.0216	15.09
0.3	1.60	0.0279	17.52
0.4	1.97	0.0344	18.95
0.5	2.29	0.0400	20.37
0.6	2.69	0.0469	20.85
0.7	3.02	0.0527	21.65
0.8	3.39	0.0592	22.02

Brass

T (Nm)	θ (degrees)	θ (radians)	G (GPa)
0.5	0.44	0.00768	35.70
1.0	0.81	0.0141	38.89
1.5	1.18	0.0206	39.93
2.0	1.55	0.0271	40.47
2.5	1.93	0.0337	40.68
3.0	2.31	0.0403	40.82
3.5	2.65	0.0463	41.45
4.0	3.03	0.0529	41.46
4.5	3.39	0.0592	41.68
5.0	3.77	0.0658	41.68




Torque vs rotation diagram for Aluminium
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Torque (Nm)
0.0
0.91
1.24
1.60
1.97
2.29
2.69
3.02
3.39
Rotation (Degree)


Torque vs rotation diagram for brass
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Torque (Nm)
0.44
0.81
1.18
1.55
1.93
2.31
2.65
3.03
3.39
3.77
Rotation (Degree)

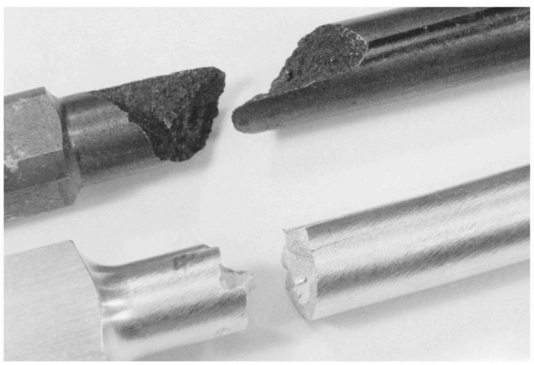
Analysis of results:

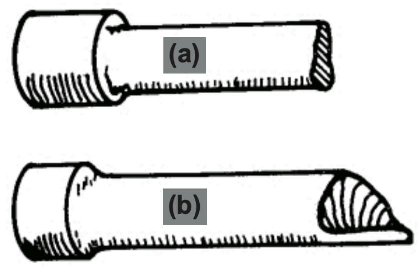
From the results above, (i) we can see that steel is more brittle than aluminium and brass (ii) brass is less brittle than steel but aluminium is more malleable than steel and brass. Compared to the given results in the lab manual, from our experiment, steel and aluminium have a higher shear modulus value. But for brass, it has a lower shear modulus value compared to the results in the lab manual. This is because the type of materials used in our experiments might be different compared to the materials used in the lab manual. In addition, zero error can be a factor affecting the results while measuring the diameters using a micrometer. Hooke’s law is also obeyed by the 3 samples as the graphs show linearity in applied Torque vs. Rotation.

DISCUSSION

1) The advantage of using a tubular cylindrical sample is (i) it's cheaper as less material is used compared to a solid cylindrical sample. (ii) When the surface reaches to elastic limit, the interior will still be in elastic range. Thus, start of yielding at the surface cannot be detected until large amount of plastic deformation occurs. In order to overcome this problem, tubular specimens are used so that shear stress is assumed to be uniform along cross section. The disadvantages of using a tubular cylindrical sample are danger of buckling when using tubular (hollow) specimens if ratios of length to diameter and diameter to thickness are not kept within elastic limits. Moreover, a solid cylindrical sample can be more expensive than a hollow cylindrical solid as more material is used.

2) The torsional fracture is quite distinct from either tension or compression fracture. There is almost no localized reduction or area (i.e. no necking). Possible fractures are as follows: (i) Ductile materials such as aluminium (fig. a) fracture at 90° to the torsional axis in maximum shear plane. (ii) Brittle materials such as cast iron (fig. b) fracture at 45° to the torsional axis in maximum tension plane.





CONCLUSION

For a ductile material, it should have a shear modulus higher than that of a brittle material given the the variables such as gauge length, diameter and experimental conditions approximate each other. Therefore, a ductile material will be able to withstand torque higher than that of a brittle material before reaching its tensile strength and ultimately ruptures.

REFERENCES

https://www.testresources.net/applications/test-types/torsion-test/
https://www.sciencedirect.com/topics/engineering/torsion-testing
https://www.odinity.com/torsion-testing-of-steel-and-cast-iron/