# Green Mechanic

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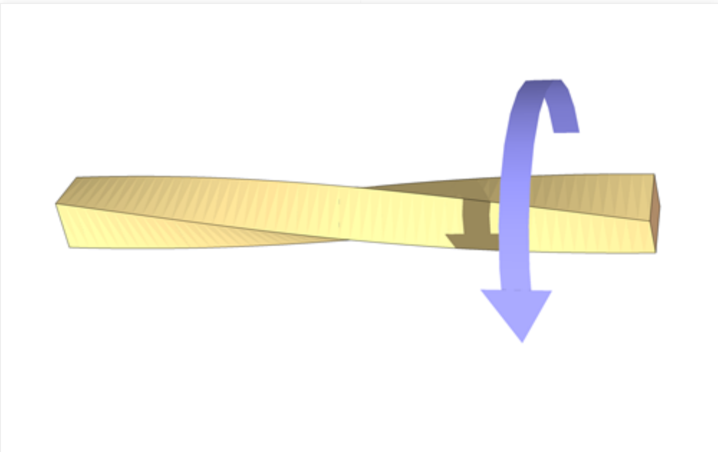
Torsional Testing of Materials, Mechanics of Material Lab Report



### 1.1 Aim

Torsional Testing of Brass, Steel and Aluminum

### 1.2 Objective

- Learn the basics of torsion theory
- Learn and practices the principle of torsion testing,
- Find the maximum shear strain, shear stress and modulus of rigidity
- Establish the relationship degree of rotation and torque applied for the material under observation
- Understand the differences between material properties of different material
- Able to select material for different engineering components which are under torsion

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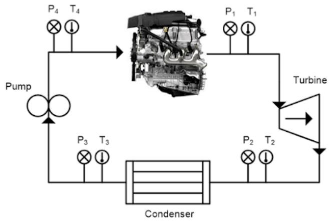


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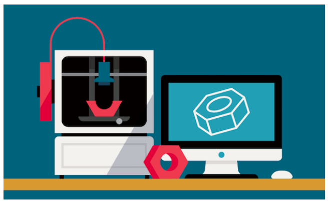

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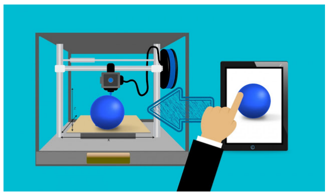

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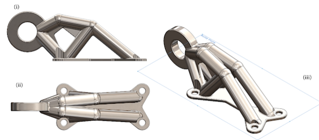


U and Z Type of Flat Plate Heat Exchanger



2.0 Theory

## 2.1 Basic Torsion Theory

R.S. Khurmi & J.K. Gupta (2005) stated that Ii many engineering applications engineering components are subjected to torsion. So it is compulsory for an engineer to understand the basics of torsion theory and learn how a material of engineering component will act under torsion stresses. (pg 120-121)

R.S. Khurmi & J.K. Gupta (2005) stated when an engineering component is subjected to twisting moment or torque then it is said that the engineering component is under torsion. Stress produce as a result of torsion are called torsional shear stress. Torsional shear stresses are maximum at outer surface ad minimum at the central axis. (pg 120-121)



R.S. Khurmi & J.K. Gupta (2005) stated as in our case one end of a shaft is fixed and other is subjected to external torque. As said earlier that stresses produce by the torque will be zero at central axis and maximum at the outer surface. The maximum value of this torsional stress can find out by the following formula

$$\tau/r = T/J$$

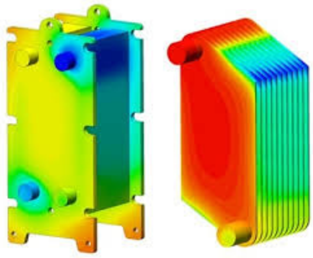
In above equation τ is the torsional stresses produce in the shaft, r is the radius of the shaft, T is the torque applied at the end of the shaft and J is the second polar moment of inertia of the shaft. Second polar moment of inertia of the shaft can be finding out by following formula where D is diameter of the shaft.

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

This first equation can be rewritten in the form of angular displacement, modulus of rigidity and length of shaft and follow.

$$\tau/r = G\theta/l$$

Understanding Finite Element Analysis of Flat Plate Heat Exchanger



Understanding the Spiral Heat Exchanger and its Finite Element Analysis

In above equation G is the modulus of rigidity, l is the length if the shaft and θ is the angular displacement as a result of applied torque. First and third equation can be combined to an equation through which we can find the modulus of rigidity of any material under observation. (pg 509-515)

$$G= T/\theta \times l/J$$

**2.2 Torsion Testing Machine Calibration**

According to T. Udomphol (n.d) follow are the steps that should be followed to calibrate the torsion testing machine

- Take calibrating arm and put in on square end of torque shaft and by adjusting hand wheel level the shaft.
- Set SI unit on digital meter to measure torque
- Adjust the digital meter to zero turning the knob
- Put five kg on calibrating arm and make the dial gauge reading to 0 using hand wheel.
- 24.5 should be reading on the digital meter
- Remove the load and reading should come back to zero
- Plot graph between torque reading and applied torque and calculate slope which have to be 1

3.0 Procedure

According to T. Udomphol (n.d) following is the procedure of operating Torsion Testing machine

- Measure the specimen initial length, initial diameter and initial gauge length and put these values on the provided table shown below.

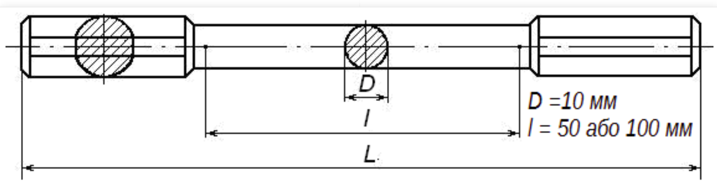



Figure 1 specimen

**Table 1Specimen Dimensions**

| Dimensions | Brass | Steel | Aluminum |
|---|---|---|---|
| Diameter | 6 | 5.53 | 6 |

| | | | |
|---|---|---|---|
| (mm) | | | |
| Length (mm) | 76.5 | 77.09 | 77.15 |

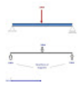
- Mark a line along the length of specimen with the help of permanent pen. This will help us to measure the rotation during twisting.
- Calibrate the torsion testing equipment as explained above
- Use the hexagonal sockets to grip specimen on torsion testing machine
- Fix one end of specimen on input and other end on torque shaft and apply small preload
- Set torque meter to zero
- Start the process and twist the specimen with the strain increment of 0.5 degree until failure of specimen
- Record all experimental data in the provided table
- Note: before taking reading make sure that it’s not fluctuating and leveled off
- Construct relationship between degree and torque
- Establish a relation between shear strain and shear stress
- Calculate the theoretical values of second polar moment of inertia and modulus of rigidity
- While testing, following sequence (as show in table) of applying the angular displacement should be considered.
- Discuss and conclude results

**Table 2angular displacement and torque**

| From | To | Increment |
|---|---|---|
| 0 | 6 | 0.5 |
| 6 | 10 | 4 |
| 10 | 120 | 10 |
| 120 | 420 | 60 |
| 420 | Failure | 120 |

4.0 Results

Experiment was performed according to the steps mentions above and


Report


Engineering Mechanics Statics 13th edition by R.C. Hibbeler Text Book


Torsional Testing of Materials, Mechanics of Material Lab Report

all the data obtain as a result of experiment is arranged in the table below.

Table 3Experimental Results

| **Angular Deflection** | | **Torque Transmitted (Nm)** | | |
|---|---|---|---|---|
| **Degree** | **Radian** | **Brass** | **Steel** | **Aluminum** |
| **0.5** | **0.008727** | **0.81** | **1.2** | **0.06** |
| **1** | **0.017453** | **1.11** | **1.83** | **0.47** |
| **1.5** | **0.02618** | **1.47** | **2.46** | **0.76** |
| **2** | **0.034907** | **1.84** | **3.20** | **1.01** |
| **2.5** | **0.043633** | **2.72** | **3.93** | **1.32** |
| **3** | **0.05236** | **2.70** | **4.72** | **1.65** |
| **3.5** | **0.061087** | **3.11** | **5.54** | **1.99** |
| **4** | **0.069813** | **3.36** | **6.40** | **2.32** |
| **4.5** | **0.07854** | **3.98** | **7.27** | **2.66** |
| **5** | **0.087267** | **4.41** | **8.18** | **3.00** |
| **5.5** | **0.095993** | **4.84** | **9.15** | **3.33** |
| **6** | **0.10472** | **5.27** | **10.05** | **3.64** |
| **10** | **0.174533** | **7.21** | **14.14** | **5.92** |
| **20** | **0.349066** | **9.86** | **15.84** | **7.74** |
| **30** | **0.523599** | **10.76** | **16.32** | **8.07** |
| **40** | **0.698132** | **11.22** | **17** | **8.17** |
| **50** | **0.872665** | **11.48** | **17** | **7.93** |
| **60** | **1.047198** | **11.45** | **17.24** | **8.10** |
| **70** | **1.221731** | **11.88** | **17.06** | **8.2** |
| **80** | **1.396264** | **12.11** | **17.51** | **8.4** |
| **90** | **1.570797** | **12.30** | **17.68** | **8.24** |
| **100** | **1.74533** | **12.48** | **18.00** | **8.7** |
| **110** | **1.919863** | **12.60** | **18.22** | **8.7** |
| **120** | **2.094396** | **12.70** | **18.70** | **8.7** |
| **180** | **3.141594** | **13.47** | **19.10** | **9.02** |
| **240** | **4.188792** | **13.80** | **19.60** | **9.11** |
| **300** | **5.23599** | **14.47** | **19.60** | **9.48** |
| **360** | **6.283188** | **14.98** | **19.60** | **9.51** |
| **420** | **7.330386** | **15.36** | **20.17** | **9.71** |

Graphs

5.1 Angular displacement from 0 to 6 degree

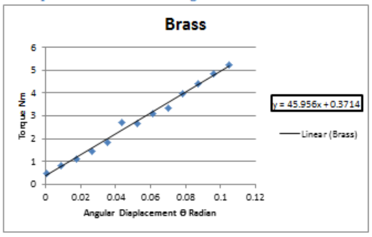



Figure 2 Brass graph (torque vs angular displacement)

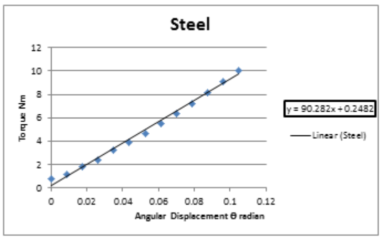



Figure 3 Steel graph (torque vs angular displacement)

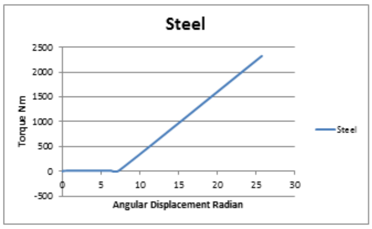



Figure 6 Steel graph (torque vs angular displacement till failure)

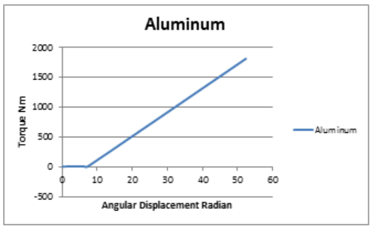



Figure 7 Aluminum graph (torque vs angular displacement till failur)

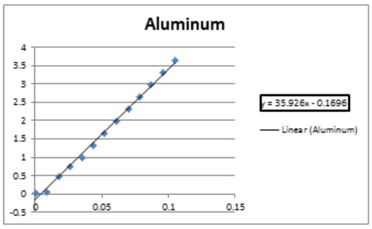



Figure 4 Aluminum graph (torque vs angular displacement)

5.2 Angular displacement from 0 to failure

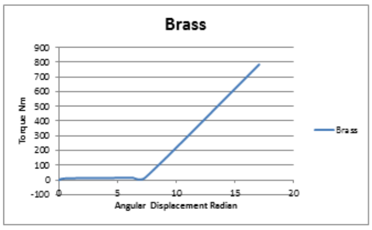



Figure 5 Brass graph (torque vs angular displacement till failure)

6.0 Calculations

### 6.1 Calculation for Brass

Calculating polar moment of inertia

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

$$J = (\pi \times 6^4)/32$$

$$J = 127.17\ mm^4$$

**Calculating Modulus of Rigidity**

$$G = T/\theta \times l/J$$

$$G = 45960 \times 76.5/127.17$$

$$G = 27641.54\ N/(mm^2)$$

**Calculating shear Stresses**

$$\tau/r = G\theta/l$$

$$\tau/r = T/J$$

6.3 Calculation for Aluminum

**Calculating polar moment of inertia**

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

$$J = (\pi \times 6^4)/32$$

$$J = 127.17\ mm^4$$

**Calculating Modulus of Rigidity**

$$G = T/\theta \times l/J$$

$$G = 34566 \times 77.15/127.17$$

$$G = 20970.09\ N/(mm^2)$$

**Calculating shear Stresses**

$$\tau/r = G\theta/l$$

$$\tau/r = T/J$$

7.0 Discussion

1. Sample calculations for the polar moment of inertia of specimen is provided above in calculation section

2. While performing the experiment the human error while calibrating the equipment, applying load and taking reading can cause alter the result. The limitation of the machine can also cause error in the reading

3. The second polar moment of inertia J depends on the diameter of the shaft not on the length of the shaft. So length of specimen have nothing to do with polar moment of inertia and will not affect the calculation

4. While performing the experiment clamping the specimen and applying of preload is done to insure that the specimen is griped tightly in jaws and it is perfectly straight. Lose grip can cause damage to specimen, machine and also to the operator. Torque reading must be taken at the time when scale is stable and is not fluctuating because fluctuating scale is difficult to read and can cause error in reading

5. It is impossible to predict the point where failure will occur as a result of torsion loading. Failure mostly occurs at the point which has any internal defect or cracks; if not the point with highest stress concentration will be the point of failure.

8.0 Conclusion

Torsion test have been perform on three different materials (brass, steel and aluminum) and with the help of experimental data, value of modulus of rigidity and shear stresses is calculated.

- Steel has the maximum value of modulus of rigidity and applied torque at failure which means that it is the strongest material from available three material and so it can withstand higher shear stress stresses than other two materials
- Aluminum came second among the three materials as it can bear more shear stress and applied torque than brass but cannot take as much torque as steel can. It can take more angular displacement other two materials and it is due to material property called ductility.
- Brass has third position among the available materials. Although it modulus of rigidity is greater than aluminum but it fails at lower torque than aluminum. It has the least value of angular displacement at the fracture, this show that it has lowest ductility among the three.

The reason that two values of shear stress obtain are different is that equation one consider the geometric properties like polar moment of inertia and equation two use material properties like modulus of rigidity. On the bases of these calculations we can now differentiate between the properties of different materials and can predict their behavior under torsional stress.

on September 28, 2016

Labels: lab report

2 comments:

Unknown December 20, 2019 at 7:42 PM

very usefully thanks

Reply

Unknown May 1, 2020 at 6:44 PM

how to get the value of 45960 in the equation T/0?

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