STRESS ANALYSIS OF THIN WALLED CIRCULAR AND RECTANGULAR TUBES SUBJECTED TO TORSION

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Abstract

The aim of the project is to analyze the stress induced in thin walled circular and rectangular tubes. One end of the tubes are arrested along all axes so that there is no displacement. Torsion is applied to the free end. The analysis is carried out using ansys and theoretically verified for different values of torsion applied.

1. INTRODUCTION

A tube is a cylindrical section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey substances which can flow like liquids and gases (fluids). In common usage the words pipe and tube are usually interchangeable, but in industry and engineering, the terms are uniquely defined. Depending on the applicable standard to which it is manufactured, pipe is generally specified by a nominal diameter with a constant outside diameter (OD) and a schedule that defines the thickness. Tube is most often specified by the OD and wall thickness, but may be specified by any two of OD, inside diameter (ID), and wall thickness. The term "tube" is also commonly applied to non-cylindrical sections, i.e., square or rectangular tubing. In general, "pipe" is the more common term in most of the world, whereas "tube" is more widely used in the U.S.

2. DESIGN AND CALCULATION

Input Parameters

Material: Steel

Torque input for rectangular tube:

840350 N-mm to 1240350 N-mm

Torque input for circular tube:
240350 N-mm to 340350 N-mm

**Shear Stress** \( (\tau) = \frac{T}{2At} \)

Where,

\( \tau \) = Shear stress expressed in N-mm

\( A \) = Area expressed in mm

\( T \) = Torsion expressed in N/mm

\( t \) = thickness expressed in mm

**Area**

Rectangular Tube:

\[ \text{Area} = (L - t) \times (H - t) \]

Where

\( L \) = Length of the outer rectangle in mm

\( H \) = Height of the outer rectangle in mm

\( t \) = Thickness of the rectangle

Circular Tube:

\[ \text{Area} = \pi (R_{\text{med}})^2 \]

Where,

\( R_{\text{med}} \) = Median radius of the tube in mm
1. MATERIAL SPECIFICATION IN ANSYS

Material - Steel

Element Type - Brick 8 Node 45

2. CALCULATION TO BE DONE IN ANSYS

Before entering the torque value, it has to be converted into force and given as input as there in no option in ansys to give torsion directly. On conversion of the torque, it has to be equally distributed on all the nodes of the surface. Hence we divide the total force value by the number of nodes and feed as input.

3. CALCULATION

For Rectangular Tube

Dimensions

$L = 92$ mm $\quad l = 90$ mm

$H = 64$ mm $\quad h = 62$ mm

$t = 2$ mm

where,

$L =$ Length of the outer rectangle in mm

$H =$ Height of the outer rectangle in mm

$t =$ Thickness of the rectangle

Area $(A) = 5580$ mm$^2$

$2At = 22320$

Shear Stress $(\tau) = \frac{T}{2At}$
Case 1

Theoretical Calculation

Applied torque (T) = 1240350 N-mm

Shear Stress ($\tau$) = $\frac{1240350}{22320}$

Shear Stress ($\tau$) = 55.57 N/mm$^2$

Result Through Ansys

Fig. 5.1 Ansys Output of Case 1

Case 2

Theoretical Calculation

Applied torque (T) = 1040350 N-mm

Shear Stress ($\tau$) = $\frac{1040350}{22320}$

Shear Stress ($\tau$) = 46.61 N/mm$^2$
Result Through Ansys

Fig. 5.2 Ansys Output of Case 2

Case 3

Theoretical Calculation

Applied torque (T) = 840350 N-mm

\[ \text{Shear Stress } (\tau) = \frac{840350}{22320} \]

\[ \text{Shear Stress } (\tau) = 37.65 \text{ N/mm}^2 \]

Result Through Ansys

Fig. 5.3 Ansys Output of Case 3
For Circular Tube

Dimensions

\[ \begin{align*}
D &= 50 \text{ mm} & R &= 25 \text{ mm} \\
\bar{d} &= 48 \text{ mm} & r &= 24 \text{ mm}
\end{align*} \]

Where,

‘D’ and ‘R’ are Outer diameter and radius respectively

‘\( \bar{d} \)’ and ‘r’ are Inner diameter and radius respectively

\[
\text{Area} = \pi (R_{\text{med}})^2
\]

\[
\text{Area} = 1661.06 \text{ mm}^2
\]

Shear Stress \( (\tau) = \frac{T}{2At} \)

Case 1

Theoretical Calculation

Applied torque \( (T) = 340350 \text{ N-mm} \)

Shear Stress \( (\tau) = \frac{340350}{6644.24} \)

Shear Stress \( (\tau) = 51.22 \text{ N/mm}^2 \)
Result Through Ansys

![Fig.5.4 Ansys Output of Case 1](image)

Case 2

Theoretical Calculation

Applied torque (T) = 300000 N-mm

Shear Stress (τ) = \(300000 / 6644.24\)

Shear Stress (τ) = 45.15 N/mm²

Result Through Ansys

![Fig.5.5 Ansys Output of Case 2](image)
Case 3

Theoretical Calculation

Applied torque (T) = 240350 N-mm

Shear Stress (τ) = \frac{240350}{6644.24} = 36.174 \text{ N/mm}^2

Result Through Ansys

![Ansys Output of Case 2](image.png)

Fig. 5.5 Ansys Output of Case 2
3. OBSERVATION

Table 6.1 - Rectangular Tube

<table>
<thead>
<tr>
<th>Sno</th>
<th>Applied Torque N-mm</th>
<th>Theoretical Stress N/mm²</th>
<th>Stress Value In Ansys N/mm²</th>
<th>Difference Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1240350</td>
<td>55.57</td>
<td>55.774</td>
<td>0.204</td>
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<tr>
<td>2</td>
<td>1040350</td>
<td>46.61</td>
<td>46.781</td>
<td>0.171</td>
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<tr>
<td>3</td>
<td>840350</td>
<td>37.65</td>
<td>37.787</td>
<td>0.137</td>
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</tbody>
</table>

Table 6.2 - Circular Tube

<table>
<thead>
<tr>
<th>Sno</th>
<th>Applied Torque N-mm</th>
<th>Theoretical Stress N/mm²</th>
<th>Stress Value In Ansys N/mm²</th>
<th>Difference Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>340350</td>
<td>51.22</td>
<td>52.7308</td>
<td>1.510</td>
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<tr>
<td>2</td>
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<td>1.420</td>
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<tr>
<td>3</td>
<td>240350</td>
<td>36.174</td>
<td>37.143</td>
<td>0.967</td>
</tr>
</tbody>
</table>
4. **CONCLUSION:**

    The stress analysis was carried out for thin walled circular and rectangular tubes and the theoretical values were calculated and were compared with the values obtained under virtual conditions. The differences in values have been found to be in allowable limits.

5. **REFERENCES**

   2. Joseph E. Shigely, Charles R. Mischke ‘Mechanical Engineering Design’
   3. Ansys Tutorial from official website of University Of Alberta