Analysis of Rigid Flange Couplings

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ABSTRACT: This project deals with stress analysis of rigid flange couplings subjected to torsion using ansys. The theory related to the title will be studied from 'FUNDAMENTALS OF MACHINE DESIGN by T.J.PRABHU, page no-12.3Analytical solution will be obtained. To obtain computer solution ANSYS will be used. A comparison of results obtained from 2 & 3 will be presented.

I.INTRODUCTION

A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. Rigid flange coupling are designed for heavy loads or industrial equipment. When joining shafts within a machine, mechanics can choose between flexible and rigid couplings. The connecting methods for flange couplings are usually very strong because of either the pressure of the material or the sometimes hazardous nature of materials passed through many industrial piping systems.

II.DESIGN AND CALCULATION

Input Parameters

Material: Mild Steel

Power transmit: 80 kw at 200 rpm

Allowable shear stress in shaft: 45 N/mm^2

Allowable shear stress for key material: 45 N/mm^2

Crushing stress for bolt and key: 160 N/mm^2

Shear stress for bolt material: 30 N/mm^2

Shear stress for cast iron: 8 N/mm^2

Calculation

i)Design torque $T_{d=Nominal\ torque \times service\ factor}$

    Service factor is assumed to be 1.25

$$Nominal\ Torque = \frac{power\ in\ watts \times 60}{2\pi \times RPM}$$

$$=\frac{80 \times 1000 \times 60}{2\pi \times 200} = 3819.7 \, Nm$$

$$T_d = 3819.7 \times 1.25 = 4774.65 \, Nm$$

ii) Shaft diameter

Induced shear stress $\tau = \frac{16T_d}{\pi d^3} \leq [\tau]$

$$\frac{16 \times 4774.65 \times 10^3}{\pi d^3} \leq 45 \qquad\qquad [\tau] = 45 \, N/mm^2$$

i.e. d=81.45mm≈85mm

d=85mm

iii) Other dimensions of the coupling

a) Hub diameter D=2d=2×85=**170mm**

b) Hub length l=1.5d=1.5×85=127.5mm≈**130mm**

c) Bolt circle diameter =3d=3×85=**255mm**

d) Key b=22mm,h=14mm from(Fundamentals of machine design by T.J.Prabhu Page No: 12.6 , Table 12.1)

e) Flange thickness $t_f = \frac{d}{2} = \frac{85}{2} = 42.5mm$

iv) Design of hub as a hollow shaft

$$\tau_{hub} = \frac{16T_d}{\pi(D^4 - d^4)}D = \frac{16 \times 4774.65 \times 10^3 \times 170^2}{\pi(170^4 - 85^4)}$$

$$= \frac{5.3N}{mm^2} < [\tau]_{CI} = 8N/mm$$

Satisfactory

v) Design of bolts

4 for shaft diameters from 40 to 100 mm

n = Number of bolts =4 for d = 85mm

$$f_t = \frac{t_d}{radius\ of\ the\ bolt\ circle} = \frac{t_d}{\frac{3d}{2}}$$

$$= \frac{4774.65 \times 10^3}{3 \times \frac{85}{2}} = 37,448.2 N$$

$$Force\ /bolt = F_{tb} = \frac{F_1}{n} = \frac{37,448.2}{4} \approx 9362 N$$

Shear failure of bolts

$$F_{tb} = \frac{\pi d_b^2}{4} \times [\tau]_{bolt}$$

$$9362 = \frac{\pi d_b^2}{4} \times 30, \quad d_b = 19.93 mm \approx 20 mm$$

M20 bolts can be used

Crushing failure of bolts

Check the induced crushing stress.

$$\sigma_c = \frac{F_{tb}}{t_1 d_b} = \frac{9362}{42.5 \times 20}$$

$$= 11\ N/mm^2 < [\sigma_c] = 160 N/mm^2$$

Satisfactory.

vi) Failure of key

Shear failure

Tangential force key=F_{tk}

$$= \frac{T_d}{\frac{d}{2}} = \frac{4774.65 \times 10^3}{85/2} = 112,344.7 N$$

Induced shear stress, $\tau = \dfrac{F_{th}}{b \times l} = \dfrac{112,344.7}{22 \times 130}$

$= 39.3 \; N/mm^2 < [\tau]_{key} = 45 \, N/mm^2$

Satisfactory.

Crushing Failure

Induced contact stress $\sigma_c = \dfrac{F_{th}}{lh/2} = \dfrac{112,344.7}{130 \times 14/2}$

$= 123.5 \, N/mm^2 < [\sigma_c] = 160 \, N/mm^2$

Satisfactory.

vii) Failure of flange by shearing from hub

Tangential force on hub =shearing area$\times \tau$

$\dfrac{T_d}{D/2} = \pi D t_f \times \tau$

$\dfrac{4774.65 \times 10^3}{170/2} = \pi \times 170 \times 42.5 \times \tau$

i.e.
$\tau = 2.47 \, N/mm^2 < [\tau] = 8 \, N/mm^2$

Satisfactory.
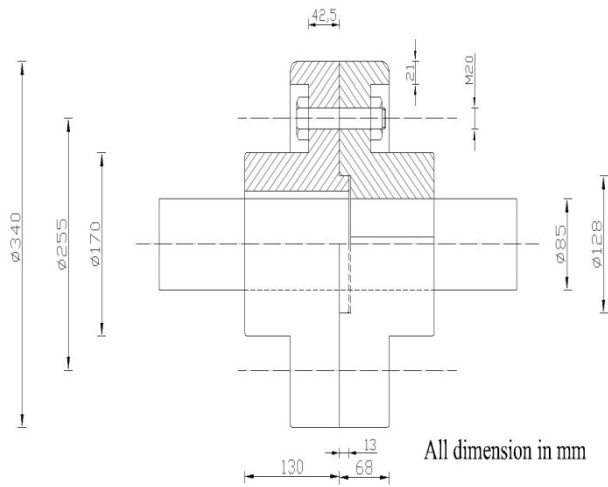
Figure 1 Auto CAD sketch of coupling with calculated dimensions
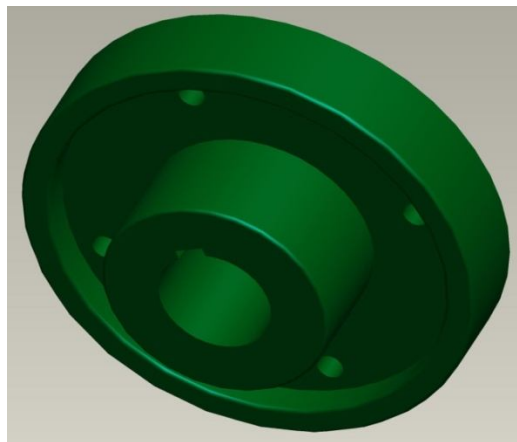
Fig (a) Left flange
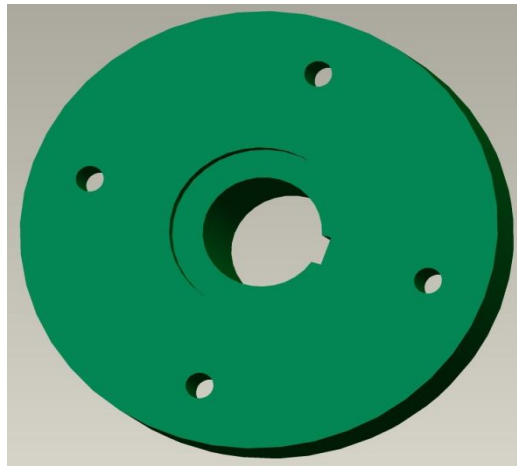
Fig (b) Right flange
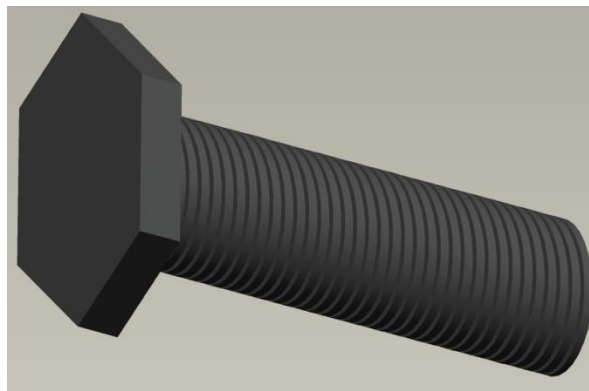
Fig (c)   Bolt
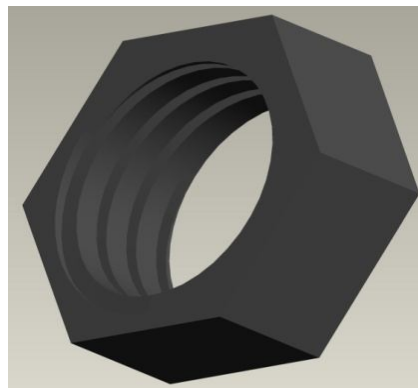
Fig (d) Nut

Fig (e) Shaft

IV. ANALYSIS

There are several methods analysis software's have been used for analyzing. In this project we are using Ansys software for analyzing. Ansys is a leading fini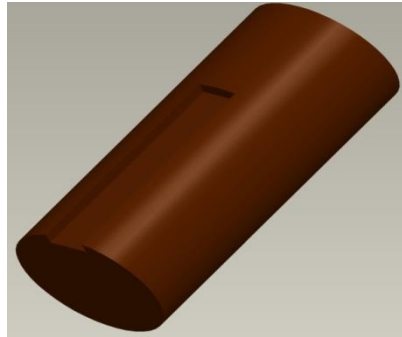te element analysis software developed by ansys inc. it is use friendly graphical user interface package. In a linear static we determine the stresses, displacements, strain and reaction in the fem. Static analysis deals with computation of displacement and stress due to static loads refers to loading but doesn't cause inertial or damping effects to be significant for consideration in the analysis.

The material used here is grey cast iron, the Poisson's Ratio of grey cast iron is 0.28 and the Young's Modulus is 1.1e+005 Mpa

Material	Grey cast iron
Nodes	126611
Elements	66427
Mesh Metric	None
Type of element	Brick 8 node 185

Table 1 Mesh Statistics
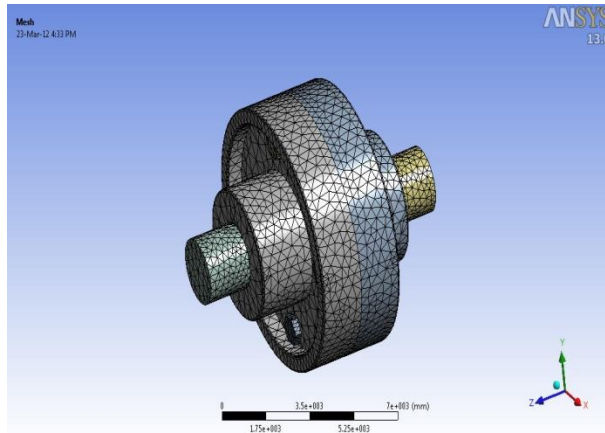
Figure 1 Mesh model of the coupling

Object Name	Fixed Support	Moment
State	Fully defined	
Scoping method	Geometry selection	
Geometry	1 Face	
Suppressed	No	
Coordinate System		Global Coordinate System
X Component		0. N·mm (ramped)
Y Component		0. N·mm (ramped)
Z Component		4.7747e+006 N·mm (ramped)

Table 2   Analysis Settings

S.No	Comparison	Shear stress of bolts	Crushing stress of bolts
1	Theoretical results	30 N/mm^2	160 N/mm^2
2	Analytical results	17.684 N/mm^2	123.24 N/mm^2

Table 3 comparison results of bolts

S.No	Comparison	Shear stress of key	Crushing stress of key
1	Theoretical results	45 N/mm^2	160 N/mm^2
2	Analytical results	11.262 N/mm^2	57.458 N/mm^2

Table 4 comparison results of key

S.No	Comparison	Shear stress in hub flange
1	Theoretical results	8 N/mm^2
2	Analytical results	11.262 N/mm^2

Table 5 Shear stress in hub flange

IV.CONCLUSION

It was found that the stress obtained from the Ansys software is slightly less than the stress obtained in the theoretical calculation. The shear stress and crushing results obtained from Ansys was compared with the theoretical calculation as tabulated. Hence the results obtained from Ansys matches theoretical calculations so the design is safe

REFERENCES

1. T.J.PRABHU ," FUNDAMENTALS OF MACHINE DESIGN",2009
2. PSG College of Technology, "DESIGN DATA BOOK OF ENGINEERS" April 2010