COMPARING THEORETICAL CALCULATION AND FE ANALYSIS OF RIGID FLANGE COUPLING

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Abstract : The purpose of this paper is to compare the result obtained from theoretical calculation and FE analysis of rigid flange coupling. The coupling is used in chemical industry where it is installed in screw conveyer having high torque and slow speed. The material from which coupling is manufacture is EN8 as it has better properties than most of the material from which coupling is manufactured like mild steel, cast iron. The theoretical calculation is done using input data parameters and used to prepare CAD (Computer Aided Design) model using SolidWorks15. Finite element analysis is done using sophisticated FE analysis software workbench 18.1. The result obtained from both the theoretical calculation and finite element analysis is compared to check design is safe against shear failure or not.

***Keywords* – EN8, Ansys 18.1, Rigid Flange Coupling, Solidworks FEM Analysis.**

I. INTRODUCTION

Coupling is device used to transmit motion, particularly rotary motion from one shaft to other. The coupling is fixed at each end of the shaft and mate together by means of nut and bolt. The coupling are strong and made such that they won't disconnect from each other but some time torque limiting coupling are used in industries in which can slip occur when a particular limit of torque is exceeded. The primary function of this device is to connect rotating equipment with some degree of misalignment. They are used to connect driving and driven part and helps in reducing shock loads from one shaft to another. Rigid flange coupling is used were high torque is required at low speed, heavy transmissions of load can be transfer.

Shaft coupling are of two type:-

A. *Rigid type* = in this type of coupling two shafts are perfectly align to each other and it does not permit any misalignment between shaft axis. Following are some types of rigid coupling
   - Flange coupling
   - Sleeve or muff coupling
   - Split muff coupling

B. *Flexible type* = in this type of coupling two shafts are not perfectly align to each other and it permits certain degree of misalignment between shaft axis. Following are some types of flexible coupling
   - Oldham coupling
   - Bushed pin type coupling
   - Universal coupling

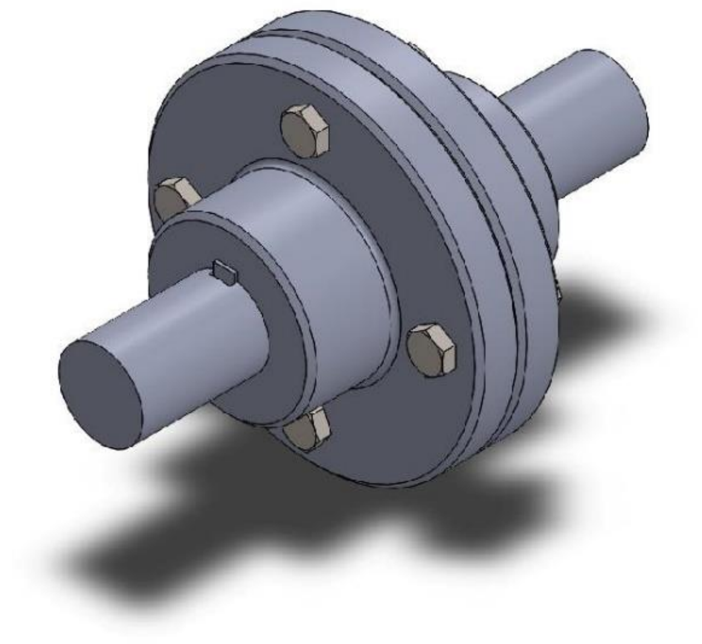

Fig. 1. SolidWorks model of rigid flange coupling

Rigid flange coupling is used were high torque is required at low speed, heavy transmissions of load can be transfer.

II. Objectives

A. Analytical calculation of rigid flange coupling.

B. Design of CAD model using SolidWorks.

C. Analysis of rigid flange coupling using Ansys workbench 18.1.

III. Literature review

A. *Chandra Sekhar Katta, Kamana Srinivasa Rao* – in this paper Chandra sekhar kata shows the structure analysis of rigid flange coupling subjected to load. In this paper it also shows that composite material is not better than cast iron. The cast iron is used for flange in any load condition is way better than other composite material (aluminum, silicon, carbide). SolidWorks and Ansys workbench is used for modelling and analyzing of rigid flange coupling.

B. *Praveen Kumar Sonwane, Prof. K.K. Jain, Asst. Prof. Prateek Yadav* – The main topic of this id paper is to compare the result obtain through analysis to theoretical and analytical result for proving that design is safe the structural analysis of coupling and flange has been carried out in this paper. Catia software is used to design flange coupling. Structural steel and grey cast iron is used for shaft, key, bolt and flange material respectively. The value obtained through stress induced in different part is less than theoretical solution. Hence design is in safe mode.

C. *Chandrakant M Patil* – In this paper external load is applied on flange bolted joint to study its behavior.in this paper the material used the both cast iron and mild steel used for flange and shaft respectively. The allowable shear stress is already given with the diameter of shaft and it is used to design hub, key and bolts circle. Analysis is done using Ansys workbench. As a boundary condition fixed support is used to fix a flange at one end of the shaft and torque is applied at another end of the second shaft. Result is obtained in the post processing phase.

IV. MATERIAL AND METHODOLOGY

Material used is EN8 for flange and shaft for bolt and key C40 material is used.

Table 1. Properties of Material Used

Properties	Material	
	EN8	**C40**
Density	7800 (kg/m^3)	7850 (kg/m^3)
Young Modulus	1.9E+11 (Pa)	1.9E+11 (Pa)
Poisson Ratio	0.3	0.29
Tensile Yield Strength	465 (MPa)	330 (MPa)
Ultimate Tensile Strength	775 (MPa)	630 (MPa)

A. Selection of material-EN8 material for flange and shaft, and material C40 for bolts and key.

B. Analytical design-formulation of rigid flange coupling for finding dimensions and stresses.

C. Cad model-the model is prepared by using SolidWorks software with the help of analytical design.

D. Stress analysis and FEA- by using the design and the material from which the parts of rigid flange coupling is design for stress calculation using FEA software.

E. Comparing analytical design with Ansys model-comparing the stresses of the analytical design with FEA workbench.

F. Result-the result has taken below by above comparison of stresses between analytical and software.

G. Conclusion-overall conclusion will be taken from above result.

V. CALCULATION

Design parameters:–

1. Power (P) = 3.1125 kW
2. Speed of input shaft (N) = 36 rpm
3. Diameter of shaft (d) =50mm
4. Allowable Shear Stress for key and bolt
   $\tau_{as} = \tau_{ys}$ / FOS = 0.5σyt / FOS
   = 0.5 × 330 / 3
   = 55.0 MPa
5. Allowable Shear Stress for flange and shaft
   $\tau_{ac} = \tau_{uc}$ / FOS = 0.5σut / FOS
   =0.5 × 465 / 3
   = 77.5 MPa

Torque,

$$T_{max} = \frac{P * 60}{2\pi N}$$

=825.616*10^3 N-mm

1) Design of shaft

Shear stress of shaft

$$\tau_{max} = \frac{16T_{max}}{\pi d^3}$$

=33.6386 N/mm2 (shear stress induced in shaft)
Since, the shear stress induced in the shaft is less than 77.5 MPa therefore the design is safe against shear failure.

2) Design of key

Width of the key (w) =12.5mm
Height of the key (h) =8.5mm
Length of the key (L) =77mm

Shear stress of key,

$$\tau_{max} = \frac{2T_{max}}{dwl}$$

=35.226 N/mm2 (shear stress induced in key)
Since, the shear stress induced in the key is less than 55 MPa therefore the design is safe against shear failure.

3) Design of hub

Length of hub (l) =75mm
Outer diameter of shaft (D) =100mm

Shear stress induced in hub,

$$\tau_{max} = \frac{16T_{max}}{\pi D^3(1-K^4)}$$

=4.4851 N/mm2 (shear stress induced in hub)
Since, the shear stress induced in the hub is less than 77.5 MPa therefore the design is safe against shear failure.
Where…….. (K=d/D)

4) Design of flange

Thickness of flange (t) =0.5d=0.25mm
Diameter of bolt circle (D_1) =3d=150mm
Outer diameter of flange (D_2) =4d=200m

Shear stress induced in flange,

$$\tau_{max} = \frac{2T_{max}}{\pi D^2 t}$$

=2.1024N/mm2 (shear stress induced in flange)
Since, the shear stress induced in the flange is less than 77.5 MPa therefore the design is safe against shear failure.

5) Design of bolt

Number of bolts (N) =4
Take, Bolt diameter(d_b) =12mm

Shear stress induced in bolt,

$$\tau_{max} = \frac{8T_{max}}{\pi N D_1 ({d_b}^2)}$$

=24.333N/mm2 (shear stress induced in bolt)
Since, the shear stress induced in the bolt is less than 55 MPa therefore the design is safe against shear failure.

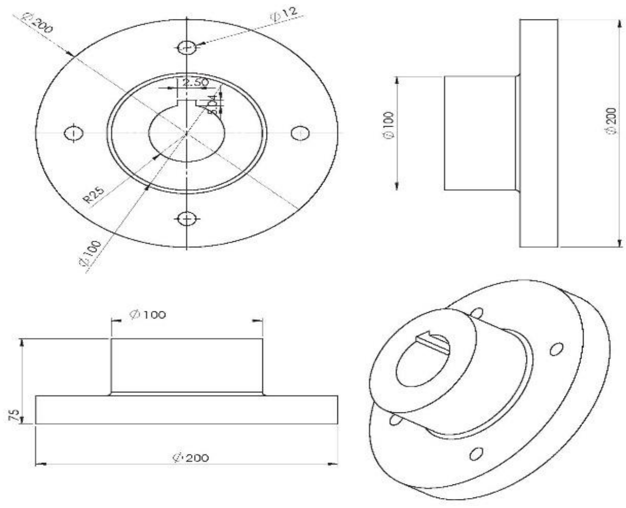

Fig. 2. Dimensions of rigid flange coupling

VI. ANALYSIS OF COUPLING

Ansys workbench18.1 software is used for analysis of complete model.

Below fig 3 which contain following information about meshing are as follows:-

Table 2. No. Of Nodes, Elements Relevance Center Element Size

Nodes	75916
Elements	40858
Relevance Center	Fine
Element Size	Default

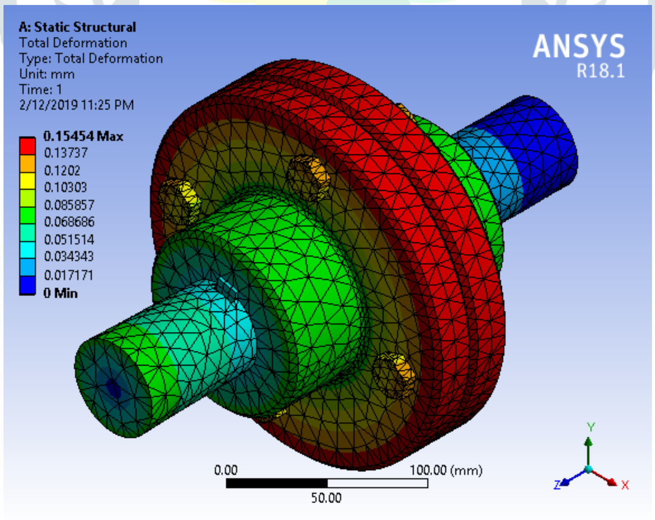

Fig. 3. Total Deformation

Maximum deformation obtain is about 0.15454 mm.

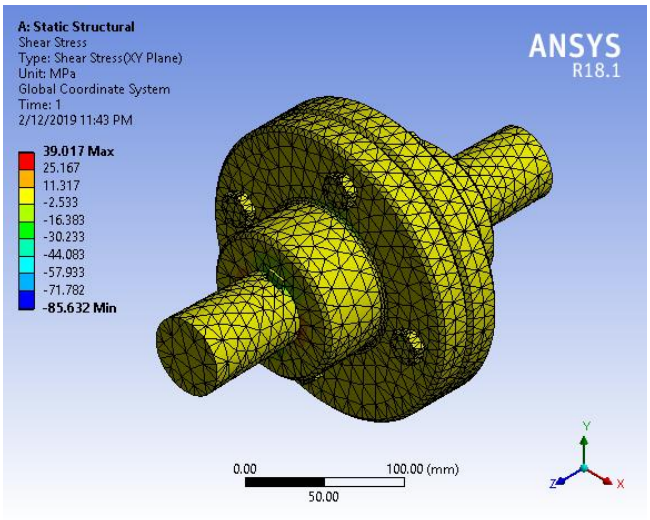

Fig. 4. Shear Stress in Rigid Flange Coupling

Maximum shear stress obtained is 39.017 N/mm2.

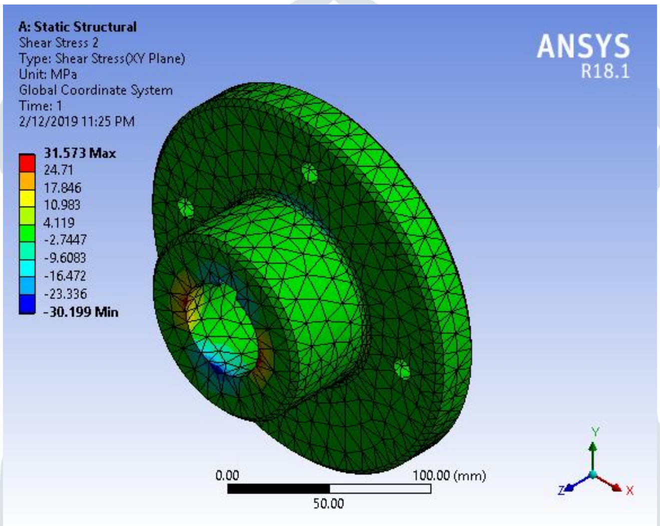

Fig. 5. Shear Stress in Flange

Maximum shear stress obtained is 31.573 N/mm2.

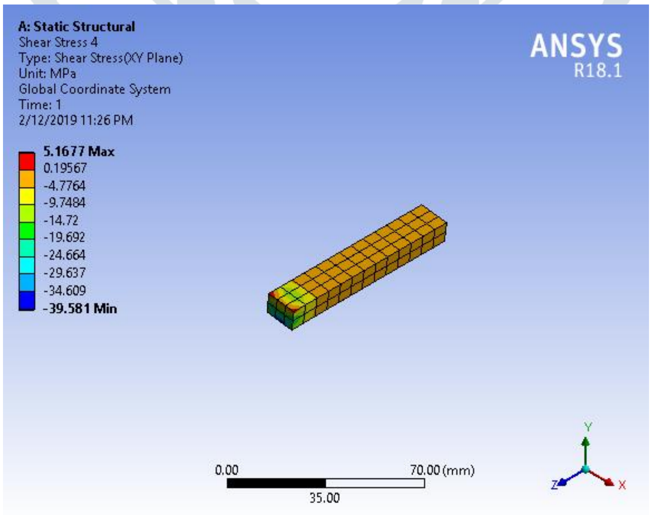

Fig. 6. Shear Stress in Key

Maximum shear stress obtained is 5.1677 N/mm2.

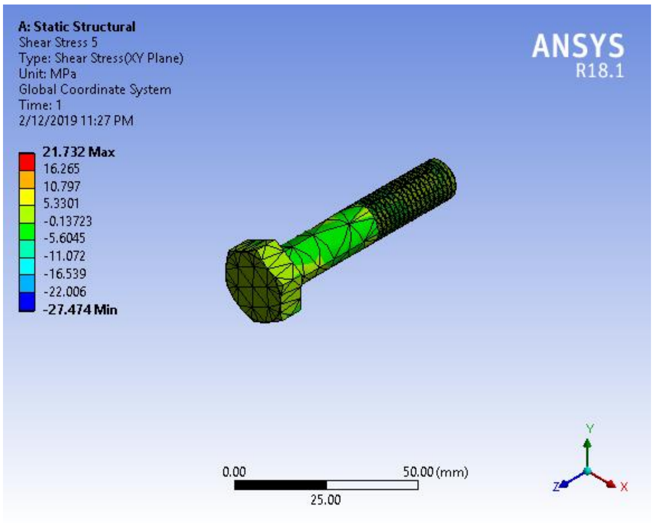

Fig. 7. Shear Stress in Bolt

Maximum shear stress obtained is 21.732 N/mm2.

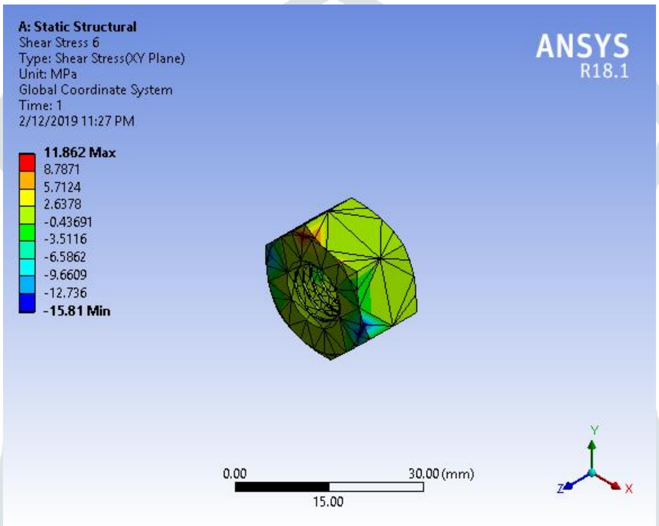

Fig. 8. Shear Stress in Nut

Maximum shear stress obtained is 11.862 N/mm2.

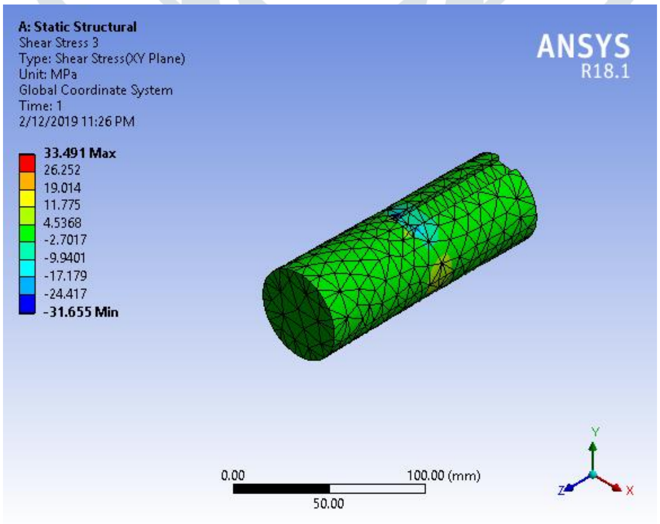

Fig. 9. Shear Stress in Shaft

Maximum shear stress obtained is 33.491 N/mm2.

VII. RESULT

Table 3. Result

Component	Theoretical result (Shear stress)	FEA Analytical result (Shear stress)
Flange	77.50N/mm2	31.573 N/mm2
Bolt	55 N/mm2	21.732 N/mm2
Shaft	77.50N/mm2	33.491 N/mm2
key	55 N/mm2	5.1677 N/mm2

VIII. CONCLUSION

Comparison of results between theoretical calculation and solution from finite element analysis for different parts of rigid flange coupling is shown in above table. From above table it is seen that shear stress induced in different parts of rigid flange coupling are within limit so it's safe against failure. The requirement for safe design is that the result of FE analysis for shear stress is should be under theoretical result of shear stress which is considered as safe from shear.

We can also do FE analysis of coupling with same design but from different materials such as mild steel, aluminum, cast iron to compare their result with result obtain from FE analysis of coupling made from material EN8. We can also manufacture the coupling by using design obtained from theoretical calculation and further we can practically perform the lab test to find the stress induced in on coupling.

Above design is safe as the EN8 material helps to increases the life of coupling and also help from shear failure at maximum possible load induces in coupling. Therefore it is safe design.

REFERENCE

[1] Chandra sekhar katta, kamana srinivasarao, Design and Analysis of flange coupling, International Journal of Professional Engineering Studies Volume VI /Issue 4 / AUG 2016

[2] Praveen Kumar Sonwane, Prof. K.K. Jain, Asst. Prof. Prateek Yadav," international journal of engineering sciences & Research Technology structural analysis of rigid flange coupling by finite element method"

[3] Chandrakant M Patil Int. Journal of Engineering Research and Applications www.ijera.com ISSN: "2248-9622, Vol. 5, Issue 7, (Part - 3) July 2015, pp.89-93