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A STUDY AND ANALYSIS OF DESIGN AND ANALYSIS OF RIGID FLANGE COUPLING

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ABSTRACT

A Coupling is a device which is responsible for the operative power transmission between two shafts rotating at particular RPM. Coupling is used to connect two different shafts at their end and can slip or fail depending upon the torque limit. It is the crucial part of any power transmission and may last for very long time if designed and maintained properly. The present study of this paper is to reduce the stress that acting on the bolts by making it uniform strengthens. The stress in the threaded part of the bolt will be higher than that in the shank. Hence a greater portion of the will be absorbed at the region of the threaded part which may fracture the threaded portion because of its small length. An axial hole is drilled at the center of the bolt through the head as far as thread portion such that the stress in the bolt is uniformly distributed along the length of the bolt. The present study of this paper is to reduce the maximum shear stress by selecting a suitable material for flange coupling. For this purpose, modeling of the rigid-flange coupling is carried out in Uni graphics and analysed in ANSYS Workbench.

KEYWORDS: NX8.0, ANSYS Workbench, Rigid Flange Coupling, Finite Element Method (FEM).

I. INTRODUCTION

Coupling is a device used to connect the shafts together for the purpose of transmitting power and torque. Generally, couplings are used for connection of shafts unit that are manufactured separately. Such as motor and generator; electric motor and centrifugal pump etc. Due to the inconvenience in transportation of shaft of greater length, it becomes necessary to join two or more shafts by means of coupling. The shafts that are connected by coupling should be easy enough to assemble and dismantle for the purpose of repair and alterations .The severe failure due to shearing of bolts head, key head, nuts and other projecting parts may cause accidents. So, it should be covered by giving suitable shape to the flanges or by providing guards. The shaft to be connected by the coupling may have collinear axes, intercepting axes or a parallel axes with a small distance in between them. The flange coupling is further classified into two types; Rigid and Flexible Coupling .Rigid flange coupling consists of two separate grey cast iron flanges. One keyed to the driving shaft and the other to the driven shaft by means of nuts and bolts arranged on a circle concentric with the axes of the shafts. There are two types of rigid flange couplings; Protected and Unprotected rigid flange coupling. In a protected rigid flange coupling, a protective circumferential rim covers the nut and bolt head. So in any case of failure of bolts during operation, broken piece of bolt will dash against this rim and eventually fall down, protecting the operator from any possible injuries. In unprotected rigid flange coupling such protective circumferential rim is absent. So, in any case of failure of bolts, it may hit and harm the operator.

Figure 1 flange coupling

Coupling:

A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. Couplings do not normally allowed is connection of shafts during operation, however of couplings is to join two pieces of rotating equipment while permitting some degree of there are torque limiting couplings which can slip or disconnect when some torque limit is exceeded. The primary purpose misalignment or end movement or both By careful selection, installation and maintenance of couplings, substantial savings can be made in reduced maintenance costs and downtime. Aanalysis of universal coupling under different torque condition Drive shafts are one of the most important components in vehicles. It generally subjected to torsional Stress and bending stress due to weights of components. Thus, these rotating components are susceptible to fatigue by the nature of their operation. Common sign of driveshaft failure is vibration or shudder during operation. Driveshaft mainly involves in steering operation of vehicle. Drivers will lose control of their vehicle if the drive shafts broke during high speed cornering. Because of this human life can be in great danger if we don't know when, where and how the drive shaft will failed.

1.1 **TYPES OF COUPLINGS:**

Sleeve coupling:

A sleeve coupling consists of a pipe whose bore is finished to the required tolerance based on the shaft size. Based on the usage of the coupling a keyway is made in the bore in order to transmit the torque by means of the key. Two threaded holes are provided in order to lock the coupling in position. Bush pin Type flange coupling: This is used for slightly imperfect alignment of the two shafts. This is modified form of the protected type flange coupling. This type of coupling has pins and it works with coupling bolts. The rubber or leather bushes are used over the pins. The coupling has two halves dissimilar in construction. The pins are rigidly fastened by nuts to one of the flange and kept loose on the other flange. This coupling is used to connect of shafts which having a small parallel misalignment, angular misalignment or axial misalignment. In this coupling the rubber bushing absorbs shocks and vibration during its operations. This type of coupling is mostly used to couple electric motors and machines.

Flange coupling:

Coupling is a device used to connect the shafts together for the purpose of transmitting power and torque. Generally, couplings are used for connection of shafts unit that are manufactured separately. Such as motor and generator; electric motor and centrifugal pump etc. Due to the inconvenience in transportation of shaft of greater length, it becomes necessary to join two or more shafts by means of coupling. The shafts that are connected by coupling should be easy enough to assemble and dismantle for the purpose of repair and alterations. The severe failure due to shearing of bolts head, key head, nuts and other projecting parts may cause accidents. So, it should be covered by giving suitable shape to the flanges or by providing guards. The shaft to be connected by the coupling may have collinear axes, intercepting axes or a parallel axes with a small distance in between them.

Alignment: Shaft-alignment is a procedure where two or more machineries, generally a motor and pump, are oriented within a tolerated margin such that at the point of power and torque transfer between the two shafts, the rotational axes of both shafts should be aligned coaxially when the machine is operated under usual condition. While the machine is under running condition, some factors also affect the alignment condition that has been measured before the starting of the machinery. A few of those reasons can be excess piping strain, movement of the foundation, thermal growth of machine parts, bearing load, torque variation of machinery. Also alignment measurement should be done while the shafts are turning in their normal direction of rotation.

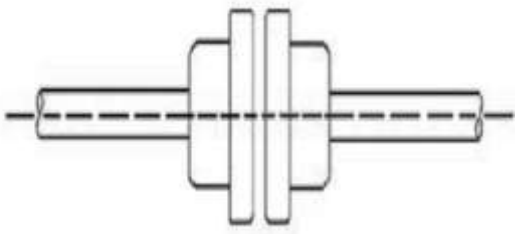

Figure2: Co axial alignment

1.2 Flange coupling is further classified into two types:

1.2.1 Rigid and Flexible Coupling:

Rigid flange coupling consists of two separate grey cast iron flanges. One keyed to the driving shaft and the other to the driven shaft by means of nuts and bolts arranged on a circle concentric with the axes of the shafts. There are two types of rigid flange couplings; Protected and Unprotected rigid flange coupling. In a protected rigid flange coupling, a protective circumferential rim covers the nut and bolt head. So in any case of failure of bolts during operation, broken piece of bolt will dash against this rim and eventually fall down, protecting the operator from any possible injuries.

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In unprotected rigid flange coupling such protective circumferential rim is absent. So, in any case of failure of bolts, it may hit and harm the operator. Coupling maintenance and failure: Coupling maintenance is generally a simple matter, requiring a regularly scheduled inspection of each coupling.

It consists of Performing visual inspections, checking for signs of wear or fatigue, and cleaning couplings regularly checking and changing lubricant regularly if the coupling is lubricated This maintenance is required annually for most couplings and more frequently for couplings in adverse environments or in demanding operating conditions.

Documenting the maintenance performed on each coupling, along with the date. Even with proper maintenance, however, couplings can fail. Underlying reasons for failure, other than maintenance, include:

- Improper installation
- Poor coupling selection
- Operation beyond design capabilities.
- The only way to improve coupling life is to understand what caused the failure
- Abnormal noise, such as screeching, squealing or chattering
- Excessive vibration or wobble

Failed seals indicated by lubricant leakage or contamination Checking the coupling balance: Couplings are normally balanced at the factory prior to being shipped, but they occasionally go out of balance in operation. Balancing can be difficult and expensive, and is normally done only when operating tolerances are such that the effort and the expense are justified. The amount of coupling unbalance that can be tolerated by any system is dictated by the characteristics of the specific connected machines and can be determined by detailed analysis or experience.

1.3 Material Properties:

Rigid flange is usually manufactured by casting as it consists of projection and recess. The commonly used material for flange coupling is grey cast iron which is characterized by graphitic microstructure causing fracture of the material to have a grey appearance. It is one of the most commonly used form of cast iron and the widely used cast material based on casting properties. Most alloys of Ironcontain2.5-4% carbon, 1-3% silicon and the rest is iron by weight proportion. It has less tensile strength and shock resistance as compared to its compressive strength. Its mechanical properties are controlled by the size and morphology of the graphite flakes which deflect a passing crack and initiate counter less new cracks as the material breaks due to which it has good wear resistance and damping capacity. It also experiences less solidification shrinkage than other cast iron that does not form a graphitic microstructure during casting process. The silicon promotes good corrosion resistance and increase fluidity while casting. It also offers good In case of failure of bolts while the machine is being run, the broken piece will dash against this rim and eventually fall down. This protects the operator from injuries.

The construction of unprotected and protected flange coupling is exactly identical except the protective rim.

- It can tolerate 0.5 mm of lateral misalignment and 1.5o of angular misalignment.
- Prevents transmission of shock from one shaft to another Can transmit high torque
- Simple in construction easy to assemble and dismantle Adv. are also associated with this like, the cost of flexible coupling is more, requires more redial distance etc.

1.4 OBJECTIVE:

The objective of this paper is to reduce the shear-stress on the nuts and bolts section of a rigid-flange coupling by carrying out the stress-analysis using FEM. The 3-D NX MODEL model was designed in NX8.0 and the stress analysis was analysed in ANSYS15 workbench.

II. LITERATURE SURVEY

This chapter gives the background for up-coming sections. It is an assessment of the present state of the wide and complex fields of coupling and machine tool chatter. Also, this chapter reviews what has been done in the past in the area of nonlinear dynamics of metal cutting process. This observation leads to the study of mutual dependency among relatively independent components which is referred as coupling. Coupling between signals is quantified by conventional methods such as relative phase relations, coherence analysis, or cross-correlation. However, these tools are linear and assume that individual components have additive mutual influences, rather than nonlinear multiplicative interactions.

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Praveena S,Lava kumar (2014) has conducted a survey in the area of dynamics of coupled rotations and coupled systems. Also, a survey of models and dynamics of coupled systems composed of a number of deformable bodies (plates, beams or belts) with different properties of materials and discrete layer properties is done. The constitutive stress– strain relations for materials of the coupled sandwich structure elements are described for different properties: elastic, viscoelastic and creeping. The characteristic modes of the coupled system vibrations are obtained and analyzed for different kinds of materials and structure composition. Structural analysis of sandwich structure vibrations is done. The author had concluded that coupled rigid and simple nonlinear subsystems in the nonlinear dynamics of the resultant system dynamics introduce hybrid complex nonlinear dynamics with multiplications of the singularity phenomenon.

III. DESIGN AND CALCULATION

This project the evaluation of the influence of two different types of flexible coupling over the vibrational behavior of the engine is executed. These couplings are mounted between the flywheel of the marine diesel engine and the propeller shaft. It is inadequate to carry out a meaningful comparison among couplings spectrum analysis, led in different operating conditions. On the other hand, the use of time-frequency analysis method is well suited. In particular, the application of the wavelet transform is considered in the present work. The high sensitivity of the wavelet transform technique to transient phenomena makes it suitable to provide monitoring features of the couplings. Since, to prove the efficiency of this method, tests were performed by changing the gear repeatedly. Different impulsive phenomena were obtained and the calculation of the mean value of the peaks in time domain is evaluated with the help of such conditions. In order to precisely localize in time-frequency domain these phenomena for monitoring purposes, the wavelet transform amplitude for a frequency range is taken into considerations. In addition the discrete wavelet transform is used in order to point out the impulsive phenomena in signals where the signal to noise ratio is low.

Cconsidering a standard motor with Power = 37.5 kW and RPM = 180 Assuming design torque to be 1.5 times the rated torque

3.1 SELECTION OF MATERIALS:

The shafts are subjected to torsional shear stress. So, on the basis of strength, plain carbon steel of grade 40C8 (Syt = 380 N/mm2) is used as shaft material. The factor of safety for the shafts is assumed to be 2.5.

The keys and bolts are subjected to shear and compressive stresses. On the basis of stress condition, plain carbon steel of grade 30C8 (Syt = 400 N/mm2) is selected for the keys and the bolts. It is assumed that the compressive yield strength is 150% of the tensile yield strength. The factor of safety for the keys and the bolts is also taken as 2.5.

Flanges have complex shape and the easiest method of manufacturing is by casting. Grey cast iron FG 200 (Sut = 200 N/mm2) is selected as the material for the flanges. It is assumed that ultimate shear strength is one half of the ultimate tensile strength. The factor of safety for the flanges is assumed as 6 (higher than nut and bolts), since to make sure that in case of any failure, bolts get fail first than flanges because flanges are costly and hard to manufacture.

IV.ANALYSIS

There are several methods for analyzing. In this project we are using Ansys software for analyzing. Ansys is leading finite element analysis software developed by Ansys inc.it is widely used worldwide graphical user interface package. In a linear static we determine the stresses, displacements, strain. Static analysis deals with computation of displacement and stress due to static loads refers to loading but doesn't cause inertial or damping effects. The material used for coupling is grey cast iron, the Poisson's Ratio of material is 0.28 and the Young's Modulus is 1.1X1011N/mm

4.1 ALUMINIUM ALLOY-STATIC STRUCTURAL:

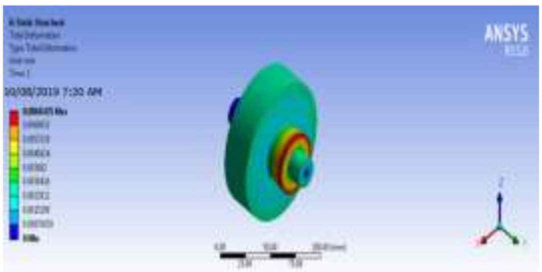

FIGURE.3.TOTAL DEFORMATION

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Details of "Total Deformation"	
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No

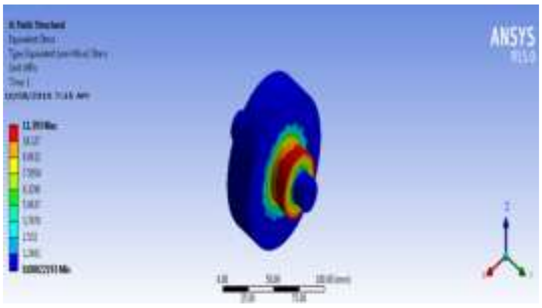

FIGURE: 4. EQUIVALENT STRESSES

Details of "Equivalent Stress"	
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No

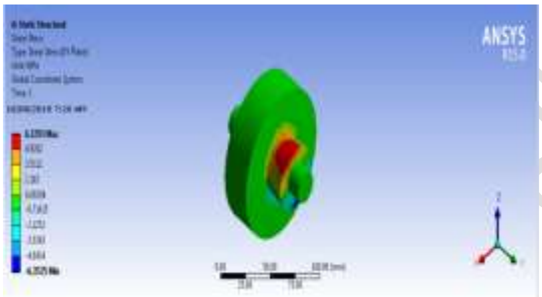

FIGURE:5. SHEAR STRESSES

Details of "Shear Stress"	
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Shear Stress
Orientation	XY Plane
By	Time
Display Time	Last
Coordinate System	Global Coordinate System
Calculate Time History	Yes

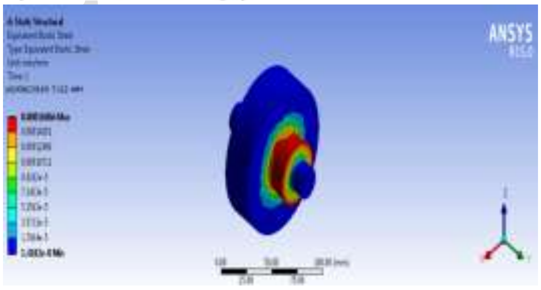

FIGURE 6. EQUIVALENT ELASTIC STRAIN

Details of "Equivalent Elastic Strain"	
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent Elastic Strain
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No

4.2.STRUCTURAL STEEL-STATIC STRUCTURAL:

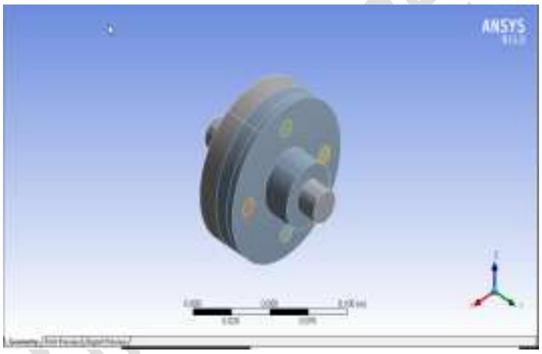

FIGURE:7. STEEL STATIC STRUCTURAL FLANGE COUPLING INTIAL VIEW

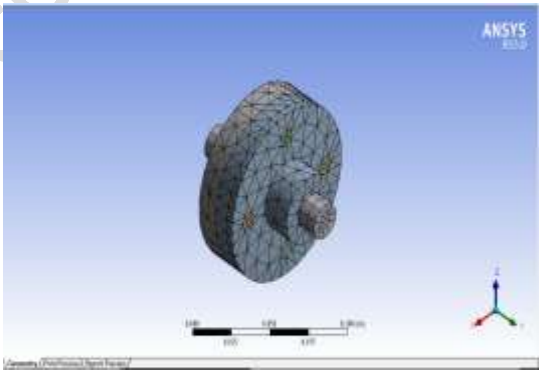

FIGURE:8. STEEL STATIC STRUCTURAL FLANGE COUPLING MESHING MODEL

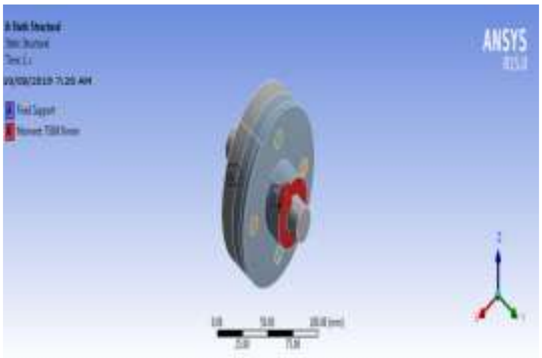

FIGURE:9. STEEL STATIC STRUCTURAL FLANGE COUPLING

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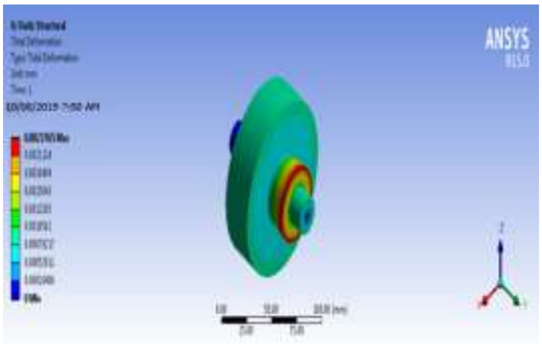

FIGURE .10.TOTAL DEFORMATION

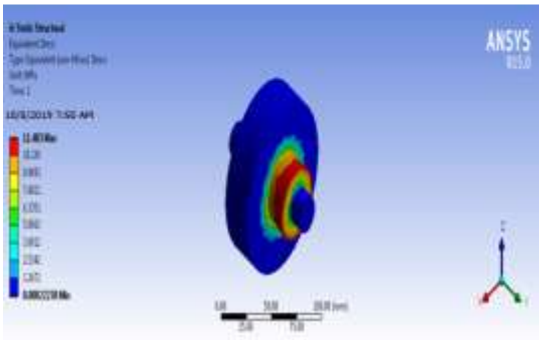

FIGURE: 11. EQUIVALENT STRESSES

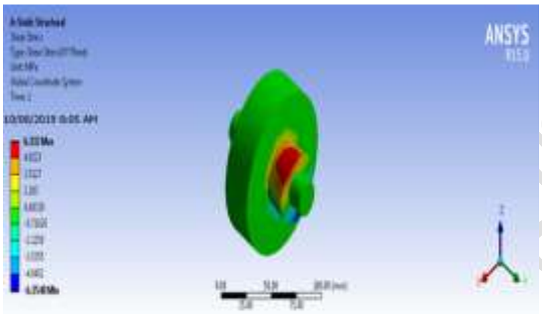

FIGURE:12. SHEAR STRESSES

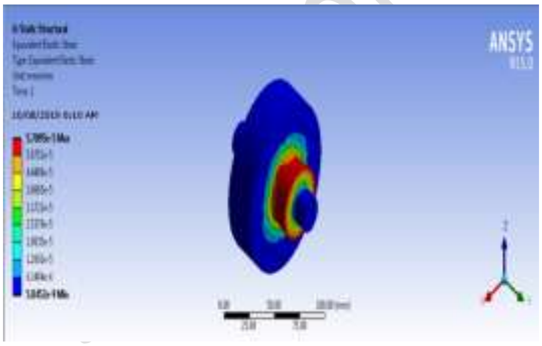

FIGURE.13. EQUIVALENT ELASTIC STRAIN

4.3 TITANIUM ALLOY-STATIC STRUCTURAL

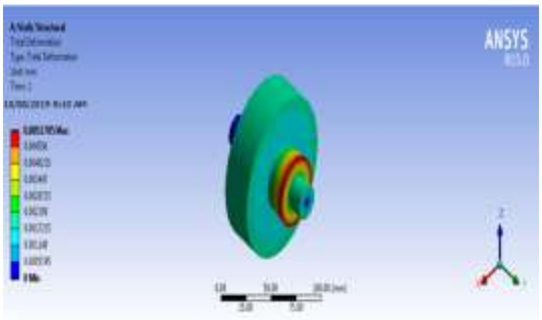

FIGURE .14.TOTAL DEFORMATION

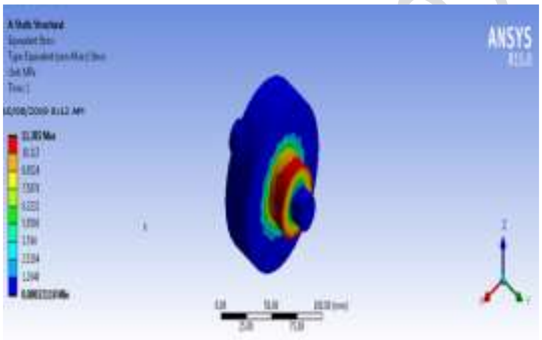

FIGURE: 15. EQUIVALENT STRESSES

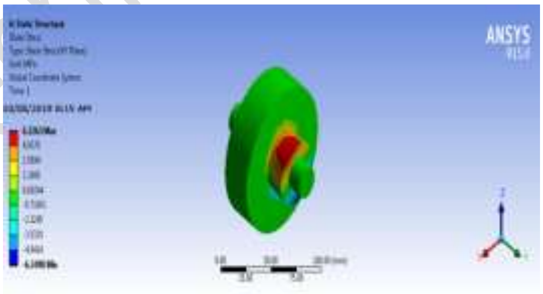

FIGURE: 16. SHEAR STRESSES

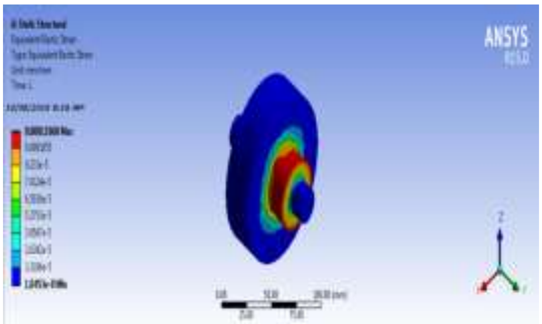

FIGURE.17. EQUIVALENT ELASTIC STRAIN

Table 4.1 Aluminium alloy of flange coupling using different parameters maximum and minimum values

Parameters	Aluminium alloy of flange coupling	
	Maximum	Minimum
Total deformation	0.0068435	0
Equivalent stresses	11.393	0.00022393
shear stress	6.3393	6.2528
Equivalent elastic strain	0.00016086	1.4182E-8

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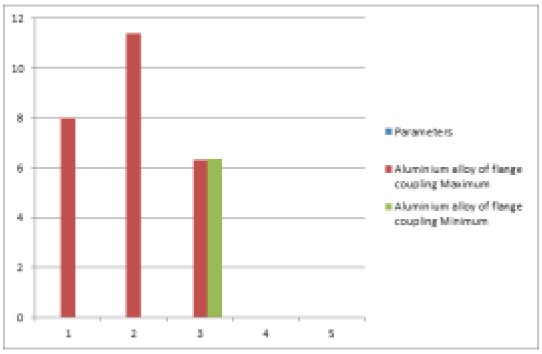
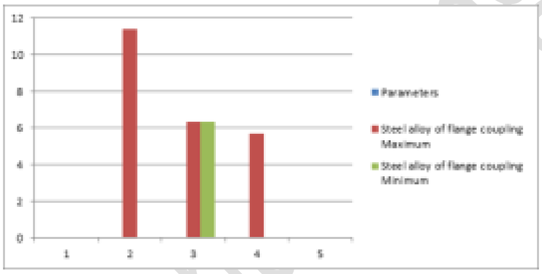


Graph 1 Aluminium alloy of flange coupling using different parameters maximum and minimum values

Table 4.2 Steel alloy of flange coupling using different parameters maximum and minimum values

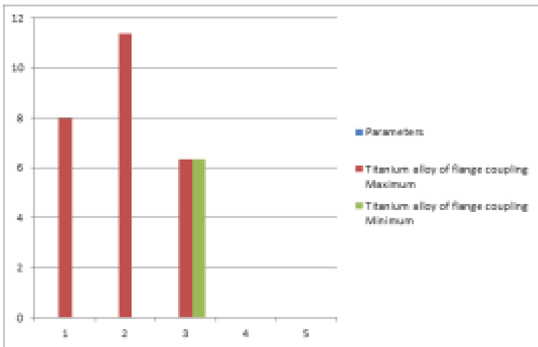
Parameters	Steel alloy of flange coupling	
	Maximum	Minimum
Total deformation	0.0023765	0
Equivalent stresses	11.403	0.00022238
shear stress	6.332	6.3548
Equivalent elastic strain	5.7095	5.0452e-9



Graph .2 Steel alloy of flange coupling using different parameters maximum and minimum values

Table 4.3 Titanium alloy of flange coupling using different parameters maximum and minimum values

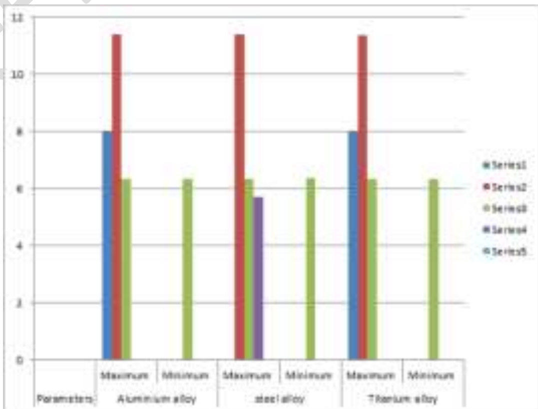
Parameters	Titanium alloy of flange coupling	
	Maximum	Minimum
Total deformation	8.0051705	0
Equivalent stresses	11.382	0.00022118
shear stress	6.3263	6.3498
Equivalent elastic strain	0.00011868	1.0453e-8



Graph 3 Titanium alloy of flange coupling using different parameters maximum and minimum values

Table 4.4 Comparison of Titanium alloy, steel alloy, Aluminium alloy different variations

Parameters	Aluminium alloy		steel alloy		Titanium alloy	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Total deformation	8.0068435	0	0.0023765	0	8.0051705	0
Equivalent stresses	11.393	0.00022193	11.403	0.00022238	11.382	0.00022118
shear stress	6.3293	6.3525	6.332	6.3548	6.3263	6.3498
Equivalent elastic strain	0.00016066	1.4182E-8	5.7095	5.0452e-9	0.00011868	1.0453e-8



Graph:4.Comparison of Titanium alloy, steel alloy, Aluminium alloy different variations

FURTHER ANALYSIS TEST

Failure test by applying high torque at (T = 1000 N.m):

V.CONCLUSIONS

The result obtained from the analysis of the bolts and keys of a rigid-flange coupling using ANSYS workbench is better than that of calculation using analytical method. It was found that the crushing stress for bolts and shear stress in bolts, keys obtained from the Ansys software is slightly less than the crushing and shear stress obtained in the theoretical calculation. Hence the results obtained from Ansys matches theoretical calculations so the design is safe. From this comparison we can conclude that the design of coupling done using nx8.0 is more suitable and safe. Compared with theoretical solution of the problem From the above table it is seen that various stress induced in different parts of the flange coupling are less than the theoretical value. Therefore, in this work, design of flange coupling is in safe mode. Stress in bolt will be modified later.

- Flange coupling is designed and analyzed in step-wise manner
- Flange coupling is modeled in solid works 2014
- The model designed in solid works is imported to ansys workbench
- Analysis is done in ansys work bench
- Different materials are applied
- Such as aluminum silicon carbide, grey cast iron are applied and stress, strain deformations of respective materials is noted
- From the structural analysis results stresses generated in aluminum silicon carbide is high compared to grey cast iron but obtained stress is within the critical stress
- So main advantage of using composite is it reduces the weight of the component and with stand maximum applied loads.

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