DESIGN AND ANALYSIS OF FLANGE COUPLING

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Abstract

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. This project deals with stress analysis of rigid flange couplings subjected to Static loads using ansys. The design of flange coupling will be done in SOLID WORKS PREMIUM SOFTWARE 2014. To obtain computer solution ANSYS will be used.

Introduction:

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 allowdisconnection 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.

Literature Review:

Siraj MohammadAli Sheikh {1} In this paper titled analysis 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. It is very important to know the accurate prediction for the drive shaft to fail.

N. Cristello and I.Y. Kim (Canada) {2} In this paper titled Design Optimization of an Automotive Universal Joint Considering Manufacturing Cost In this research, universal joint designs are analyzed and compared using a weighted sum of three objective functions: minimization of machining cost, maximization of adjoining shaft joint angle, and minimization of total part volume.

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

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. 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.

Coupling maintainance 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.

Material And Its 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 weldability.

Protected type flange coupling:

In this type of coupling the bolts head and nuts are covered by projecting circumferential rims. 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 has following advantages:-

1. It can tolerate 0.5 mm of lateral misalignment and 1.5o of angular misalignment.
2. Prevents transmission of shock from one shaft to another.

3. Can transmit high torque.
4. 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.

Unprotected type flange coupling:

In an unprotected type flange coupling, each shaft is keyed to the boss of a flange with a counter sunk key and the flanges are by means of bolts. Generally, three, four or six bolts are used. The keys staggered at right angle along the circumference of the shafts in order to divide the by keyways.

The usual proportions for an unprotected type cast iron flange couplings, are as follows: If d is the diameter of the shaft or inner diameter of the hub, then D = 2 d

Length of hub, L = 1.5 d Pitch circle diameter of bolts,

Outside diameter of flange, D2 = D1 + (D1 – D) = 2 D

Thickness of flange, tf = 0.5 d

Number of bolts = 3, for d = 4, for d upto 100 mm = 6, for d upto 180 mm

Marine type flange coupling:

In a marine type flange coupling, the flanges are forged integral with the shafts

The flanges are held together by means of tapered headless bolts, numbering from four to twelve depending upon the diameter of shaft. The other proportions for the marine type flange coupling are taken as follows:

Thickness of flange = d / 3

Taper of bolt = 1 in 20 to 1 in 40

Pitch circle diameter of bolts,

D1 = 1.6 d Outside diameter of flange,

D2 = 2.2 d

Advantages:

1. It is cheap
2. It is simple in structure
3. More efficiency
4. Maintainance is not required.

Disadvantages

It cannot be de-engaged in motion.

Flange coupling cannot transmit power between two non linear shafts.

Introduction to composites:

Composite materials have been widely used to improve the performance of various types of structures. Compared to conventional materials, the main advantages of composites are their superior stiffness to mass ratio as well as high strength to weight ratio. Because of these advantages, composites have been increasingly incorporated in structural components in various industrial fields. Some examples are helicopter rotor blades, aircraft wings in aerospace engineering, and bridge structures in civil engineering applications. Some of the basic concepts of composite materials are discussed in the following section to better acquaint ourselves with the behaviour of composites.

Basic Concepts of Composite Materials:

Composite materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The constituents are combined at a macroscopic level and are not soluble in each other.

Fibres:

Fibres are the principal constituent in a fibre-reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure.

Matrix:

In a composite material the fibres are surrounded by a thin layer of matrix material that holds the fibres permanently in the desired orientation and distributes an applied load among all the fibres. The matrix also plays a strong role in determining the environmental stability of the composite article as well as mechanical factors such as toughness and shear strength.

Classification of Composites:

A material composed of 2 or more constituents is called composite material.Composites consist of two or more materials or material phases that are combined to produce a material that has superior properties to those of its individual constituents. The constituents are combined at a macroscopic level and or not soluble in each other.

Advantages Of Composites:

The advantages of composites over the conventional materials are: High strength to weight ratio, high stiffness to weight ratio, high impact resistance, better fatigue resistance, Improved corrosion resistance, Good thermal conductivity, Low Coefficient of thermal expansion. As a result, composite structures may exhibit a better dimensional stability over a wide temperature range, high damping capacity.

Limitations Of Composites:

The limitations of composites are: Mechanical characterization of a composite structure is more complex than that of a metallic structure, the design of fiber reinforced structure is difficult compared to a metallic structure, mainly due to the difference in properties in directions, the fabrication cost of composites is high, rework and repairing are difficult, they do not have a high combination of strength and fracture toughness as compared to metals and they do not necessarily give higher performance in all properties used for material selection.

Applications of Composite Materials:

- Aerospace: Drive shafts, rudders, elevators, bearings, landing gear doors, panels and floorings of airplanes,
- payload bay doors, remote manipulator arm, high gain antenna, antenna ribs and struts etc.
- Marine: Propeller vanes, fans & blowers, gear cases, valves &strainers, condenser shells.

Preparation of aluminum silicon carbide

Preparation of Aluminium-Silicon Carbide Composite Casting is probably one of the most ancient processes of manufacturing metallic components. The metal matrix composite used in the present work is prepared by the stir casting method.

For the preparation of the Aluminium silicon carbide composite by using stir casting mass basis ratio of 100:2.5, 100:5, 100:7.5, and 100:10 are taken. Fig. 1 illustrates the raw materials and samples of Aluminium Silicon Carbide material. Aluminium alloy in the form of ingots is used. The metal ingots are cleaned and melted to the desired super heating temperature of 750o C in graphite crucibles. Fig. shows schematic set up for stir casting technique.

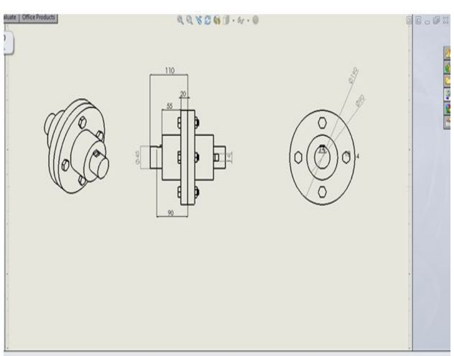
Raw materials and Samples of Aluminium Silicon Carbide material

Introduction to solid works

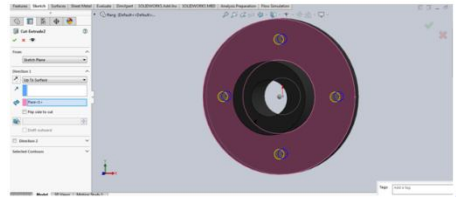
Solid works mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows ™ graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent.

Modeling of flange coupling in solidworks

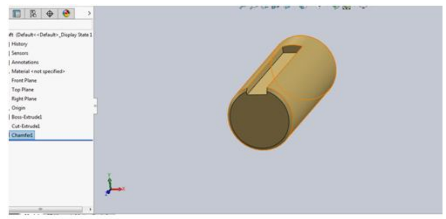
Desining dimensions



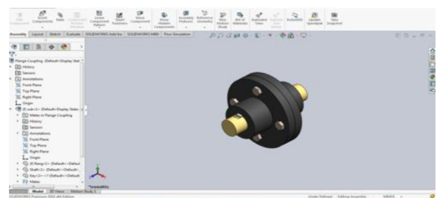
Flange:



Shaft:



Flange coupling:



Finite Element Analysis

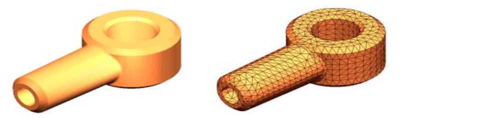
Introduction

Finite Element Analysis (FEA) is a computer-based numerical technique for calculating the strength and behaviour of engineering structures. It can be used to calculate deflection, stress, vibration, buckling behaviour and many other phenomena. It also can be used to analyze either small or largescale deflection under loading or applied displacement. It uses a numerical technique called the finite element method (FEM).

Basic Concepts of Analysis:

Meshing:

The software uses the Finite Element Method (FEM). FEM is a numerical technique for analyzing engineering designs. FEM is accepted as the standard analysis method due to its generality and suitability for computer implementation. FEM divides the model into many small pieces of simple shapes called elements effectively replacing a complex problem by many simple problems that need to be solved simultaneously.



CAD model of a part   Model subdivided into small pieces (elements)

Analysis of flange coupling:

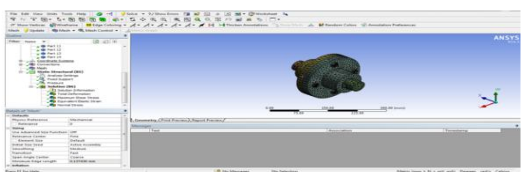
Material properties of grey cast iron

Property	Value	Units
Elastic Modulus	66178.1	N/mm^2
Poisson's Ratio	0.27	N/A
Shear Modulus	50000	N/mm^2
Mass Density	7200	kg/m^3
Tensile Strength	151.66	N/mm^2
Compressive Strength	572.17	N/mm^2
Yield Strength		N/mm^2
Thermal Expansion Coefficient	1.2e-005	/K
Thermal Conductivity	45	W/(m·K)
Specific Heat	510	J/(kg·K)
Material Damping Ratio		N/A

Material properties of aluminium silicon carbide composite

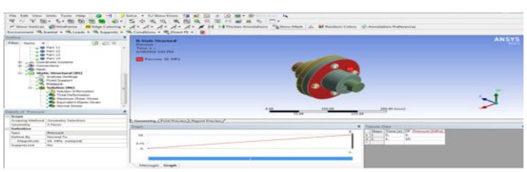
Property	Value	Units
Elastic Modulus	115000	N/mm^2
Poisson's Ratio	0.27	N/A
Shear Modulus	318.9	N/mm^2
Mass Density	2880	kg/m^3
Tensile Strength	680	N/mm^2
Compressive Strength		N/mm^2
Yield Strength	340	N/mm^2
Thermal Expansion Coefficient		/K
Thermal Conductivity	0.2256	W/(m·K)
Specific Heat	1386	J/(kg·K)
Material Damping Ratio		N/A

Meshing:



Boundary conditions:

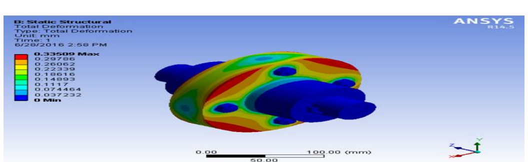
10 MPa Pressure is applied at both ends of the flange to find out the stresses and deformations in flange coupling



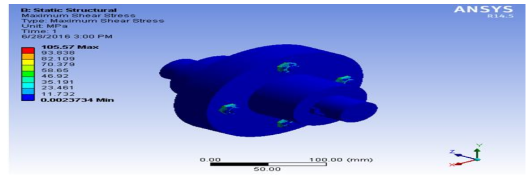
Results:

Material: aluminum silicon carbide

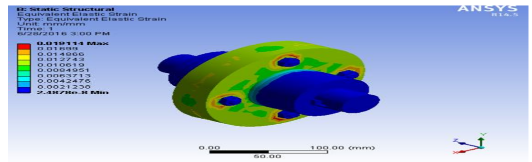
Total deformation



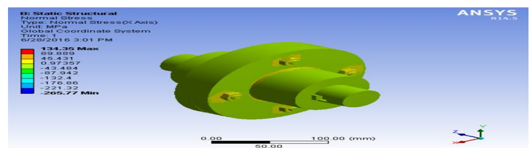
Maximum shear stress



Shear strain

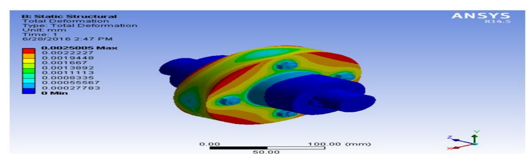


Normal stress

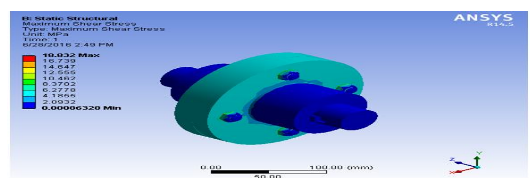


Material: grey cast iron

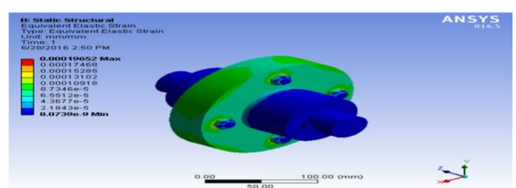
Total deformation



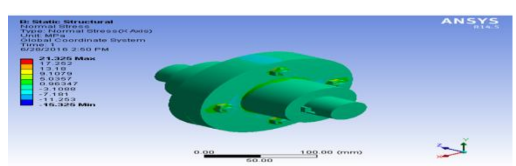
Max shear stress



Shear strain



Normal stress



Results table:

	deformation	stress	strain	Normal stress
Aluminum silicon carbide	0.33509	105.57	0.019	134.35
Grey cast iron	0.0025	18.832	0.00019652	21.325

Conclusion:

- 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 reduce the weight of the component and withstand maximum applied loads.

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(978-93-5134-284-7) Chapter 9.6 Coupling

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