Modeling and Analysis of Cotter Joint

Ashokrao Shinde
Department of Mechanical Engineering,
DKTE'S Textile and Engineering Institute,
Ichalkaranji.

Omkar Chandrakant Vibhute,
Department of Mechanical Engineering,
DKTE'S Textile and Engineering Institute,
Ichalkaranji.

Abstract: **The subject of this project is the modeling and analysis of cotter joint. Cotter joint is used to connect two rods subjected to axial tensile or compressive loads. Cotter joint is widely used to connect the piston rod and cross head of the steam engine, so as a joint between the piston rod and the tailor pump rod, foundation bolt etc. Failure of cotter joint may causes accident, so it is necessary to design cotter joint to withstand under tension without failure the effective design of mechanical device or assembly demand the predictive knowledge of its behavior in working condition. In this project we use theoretical method for finding dimensions of cotter joint. After the design of cotter joint, The modeling of cotter joint is done by using 3D software. Here we will be using CATIA V5R19 for modeling. After modeling on CATIA, we will analyze cotter joint on software named as "ANSYS V15".**

Keywords— Cotter joint, Design, Modeling, Analysi , CATIAV5R20, ANSYS R15.

1. INTRODUCTION

The Failure of cotter joint may causes accident so it is necessary to design cotter joint to withstand under tension without failure. The effective design of mechanical device or assembly demand the predictive knowledge of its behavior in working condition. It became necessary for the designer to know the forces and stress developed during its operation. In this project we use theoretical method for finding dimensions of cotter joint. After the design of cotter joint, the modeling of cotter joint is done by using CATIA V5R20. Here we will be using CATIA V5R19 for modeling. After modeling on CATIA V5R19, We will analyze cotter joint on software named as "ANSYS V15".

A cotter is a flat wedge shaped piece of rectangular cross-section and its width is tapered (Either on one side or both sides) from one end to another for an easy adjustment. The taper varies from 1 in 48 to 1 in 24 and it may be increased up to 1 in 8, If a locking device is provided. The locking device may be a taper pin or a set screw used on the lower end of the cotter. The cotter is usually made of mild steel or wrought iron. A cotter joint is a temporary fastening and is used to connect rigidly two co-axial rods or bars which are subjected to axial tensile or compressive forces. It is usually used in connecting a piston rod to the cross- head of a reciprocating steam engine, A piston rod and its extension as a tail or pump rod, Strap end of connecting rod etc. [6]

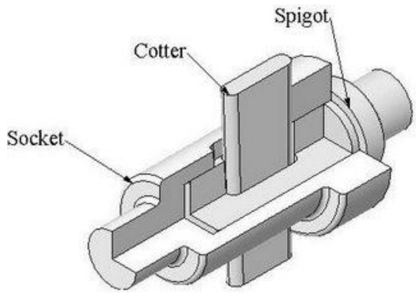

Fig 1: Cotter joint

2. LITURATURE SURVEY

Shaikh J, vanka H, "Modeling and analysis of knuckle joint", International journal & magazine of engineering. They have completed Modeling and analysis by using advanced modeling software system CATIA and ANSYS respectively. The knuckle joint is a type of joint which is used in steering system in between steering rod and steering gear. In this joint is employed here in order to get the maximum productivity and manufacturing technology must not be stiff. FMS (Flexible Manufacturing System) is used in order to gain the advantage over simple manufacturing of knuckle joint. Final dimension from theoretical calculation of knuckle joint. Model of knuckle joint is made in CATIA V5 and that model is taken to ANSYS and stimulated with various material and check for best material which suit for given design load. From result Teflon is best material for design and it close to stress got from stainless steel and cast iron with less manufacturing cost. [1]

Saxena N, Rajvaidya R, "Study and analysis of knuckle joint with the replacement of material by using Teflon", journal of engineering research & application, The objective of this paper is to study the various stresses and strain by replacing of material by using Teflon. In many industries use knuckle joint which is combination of two materials cast iron is stainless steel. In this paper the replacement of cast iron into composite polymer material, Polymer is the most similar to property of metal. Composite polymers are characterized by a high flexibility material they conclusion that the result appropriate equal or closer theoretical and ANYSYS-13. [3]

Ravindra S. Dharpure, Prof D. M. Mate, "Study and Analysis of Pin of Knuckle Joint In Train", The main motive of this paper is to improve the performance of the knuckle pin in the couplings of the railway couplings. The current mechanism of coupling is briefly defined and methodologically treatment is determined for failure of knuckle pin in the coupling. The aim of this chapter is to conceptually define remedy for the failure problem of the knuckle coupling. As per the company's present requirement the cotter joint should be efficiently used to reduce the cost of production, improve the quality of the product, Increase the production rate and Increase the service life of the cotter joint.

3. METHODOLOGY

The main objective of the study is to check whether the cotter joint is withstanding the load applied during the working condition or not.

So the methodology of the study includes

1. CAD Model of cotter joint using CATIAV5R20.
2. Design of cotter joint.
3. CAD Model of cotter joint assembly.
4. Meshing of cotter joint using ANSYS R15.
5. Elemental analysis at various loads.
6. Result and Conclusion.

4. DESIGN OF COTTER JOINT

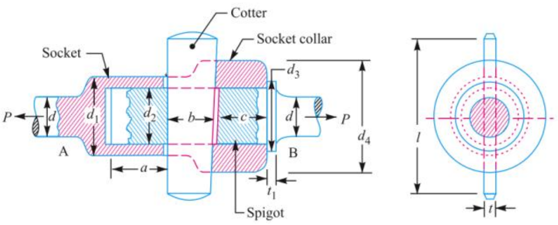

Fig.2: Socket and spigot cotter joint

The socket and spigot cotter joint is shown in Fig 2.

Let,

P= Load carried by the rods,
D= Diameter of the rods,
*d*1 = Outside diameter of socket,
*d*2 = Diameter of spigot or inside diameter of socket,
*d*3 = Outside diameter of spigot collar,
*t*1= Thickness of spigot collar,
*d*4 = Diameter of socket collar,
c= Thickness of socket collar,
b= Mean width of cotter,
t= Thickness of cotter,
l= Length of cotter,
a= Distance from the end of the slot to the end of rod,
σ*t*= Permissible tensile stress for the rods material,
τ= Permissible shear stress for the cotter material,
σ*c*= Permissible crushing stress for the cotter material.

The rods are subjected to tensile force and strength is the criterion for the selection of the rod material. The cotter is subjected to direct shear stress and bending stresses. Therefore strength is also the criterion of material selection for the cotter. On the basis of strength, the material of the two rods and the cotter is selected as plain carbon steel of Grade 30C8 (S_{yt}=400N/mm^2) [7]

To account for these factors, a higher factor of safety is used in the present design. The factor of safety for the rods, spigot end and socket end is assumed as 6, while for the cotter, It is taken as 4 there are two reasons for assuming a lower factor of safety for the cotter.

(1) There is no stress concentration in the cotter.
(2) The cost of the cotter is small compared with socket end or spigot end.

Calculation of permissible stresses

The permissible stresses for rods, spigot end and socket end are as follows-

$\sigma_t = \frac{syt}{fs}$=400/6 = 66.67 N/mm^2

$\sigma_c = \frac{2syt}{fs}$=2*400/6 =133.33 N/mm^2

$\tau = \frac{0.5syt}{fs}$=0.5*400/6 =33.33 N/mm^2

Permissible stresses for the cotter

$\sigma_t = \frac{syt}{fs}$=400/4= 100 N/mm^2

$\tau = \frac{0.5syt}{fs}$=0.5*400/4 =50 N/mm^2

Dimensions of rod

d=32 mm

Thickness of cotter

t=10 mm

Diameter of spigot

d_2=40 mm

Outer diameter of socket

d_1= 55 mm

Diameter of spigot and socket collar

d_3= 48 mm and d_4= 80 mm

a=c= 24 mm

Width of cotter

b= 50 mm

Thickness of spigot collar

t_1= 15 mm

Taper of cotter is 1 in 32 [7]

5. MODELLING OF COTTER JOINT

3D Modeling is used in a variety of applications to make representations of physical objects on the computer. 3D modeling is a subset of Computer Aided Design (CAD), In which you use a computer to assist in the design process for any type of design work. It is used in a variety of applications, Mostly when it comes to designing parts on the computer to assist in the making or visualization of those parts. The computer model is used to communicate dimensions, material types, etc. To anyone viewing the design. CATIA (Computer Aided Three Dimensional Interactive Application) is a multi-platform software suite developed by the French company Dassault Systems. CATIA enables the creation of 3D parts, from 2D sketches, sheet metal, composites, and molded, Forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mould& die. [2]

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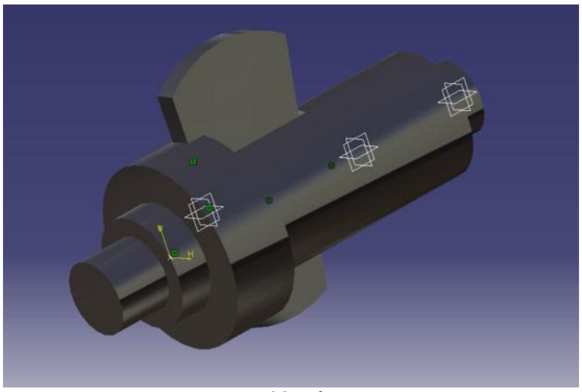

Fig 3: Assembly of cotter joint

6. ANALYSIS OF COTTER JOINT

The finite element method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It is also referred to as finite element analysis (FEA). It subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variation methods from the calculus of variations to approximate a solution by minimizing an associated error function. [1]

The ANSYS program is self-contained general purpose finite component program developed and maintained by Gloria May Josephine Svensson Analysis Systems Iraqi National Congress. The program contains several routines, all reticulated and every one for main purpose of achieving a solution to an engineering drawback by Finite component methodology. ANSYS provides an entire resolution to design issues. It consists of powerful design capabilities like full constant quantity solid modeling, design optimization and automotive vehicle meshing, which provides engineers full management over their analysis.

Analysis of cotter joint

In this paper the cotter joint is analyzed against the tensile force which is applied during the working Condition.

According to the solved problem we can apply the force P = 50 KN on one of its end and other end is fixed. The material selected for cotter joint is plain carbon steel of Grade 30C8 which is having (S_{yt}=400N/mm^2), so that cotter joint will fail above (S_{yt}=400N/mm^2).

By the calculation, we found that maximum force applied is 50KN. By considering Factor of Safety we analyzed the component at various load conditions i.e. at 40KN, 50KN and 60KN.

Static Structural Analysis

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads. The figure shows the deformation and von mises stress diagram at various loads which were applied to the cotter joint assembly.

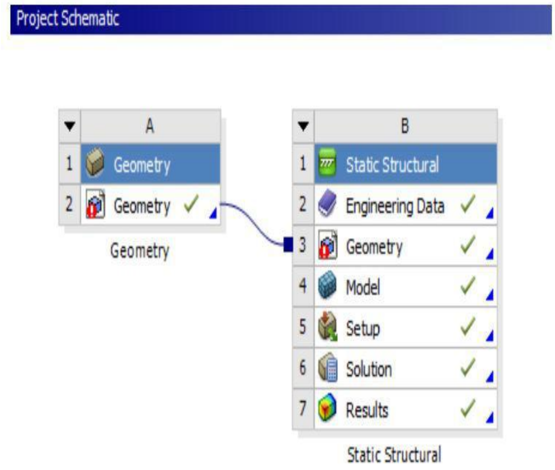

Fig 4: Project Schematic

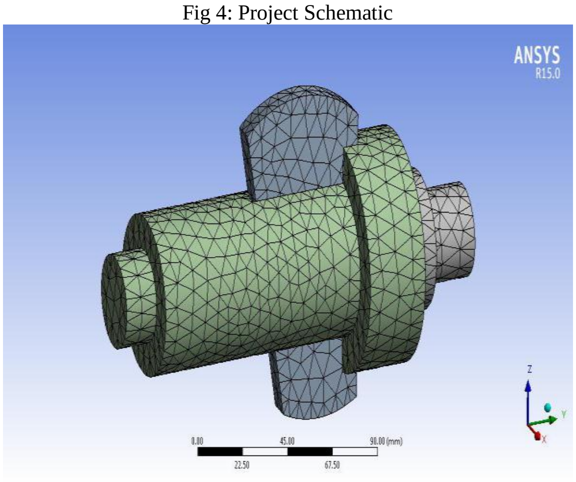

Fig 5: Meshed Assembly

Structural analysis at 40 KN

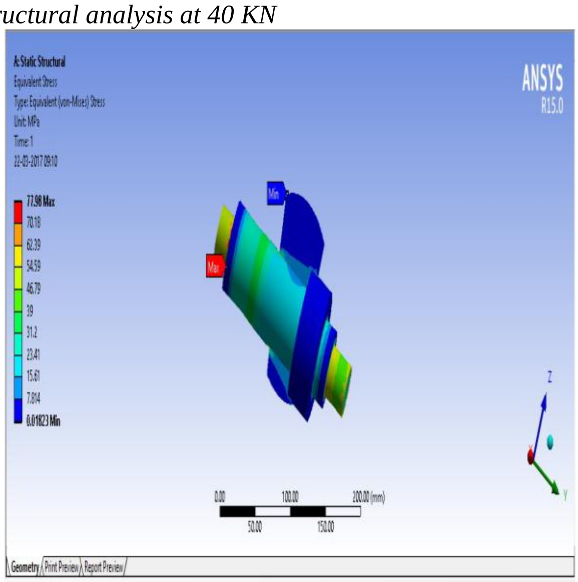

Fig 6: Equivalent (von-mises) stress at 40kN load

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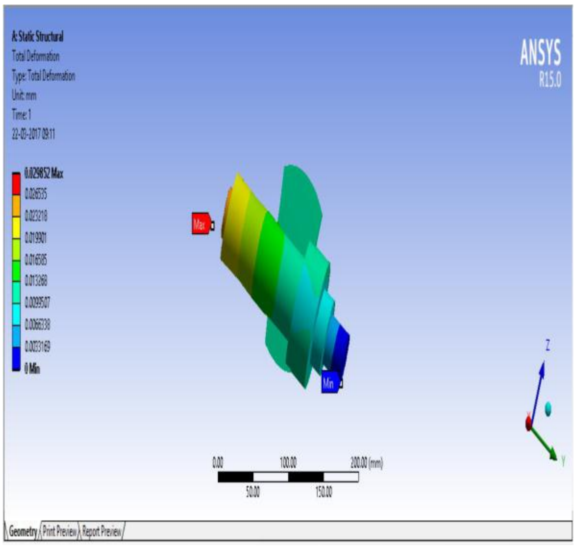

Fig 7: Total deformation at 40KN load

Structural analysis at 50 KN

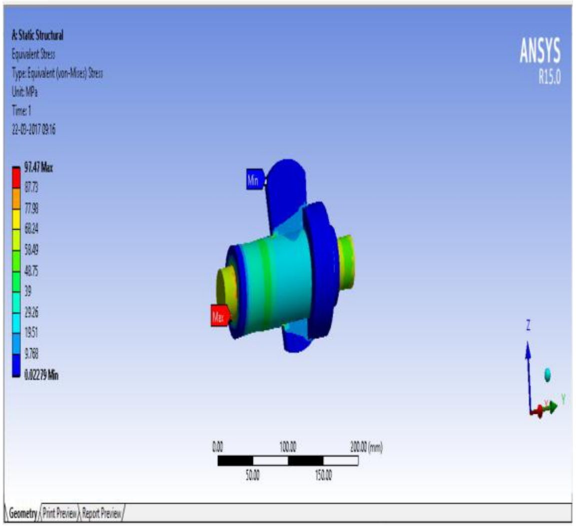

Fig 8: Equivalent (von-mises) stress at 50kN load

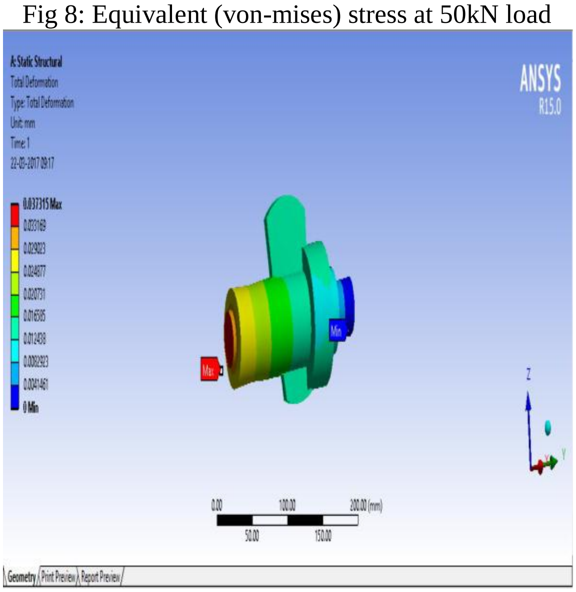

Fig 9: Total deformation at 50KN load

Structural analysis at 60 KN

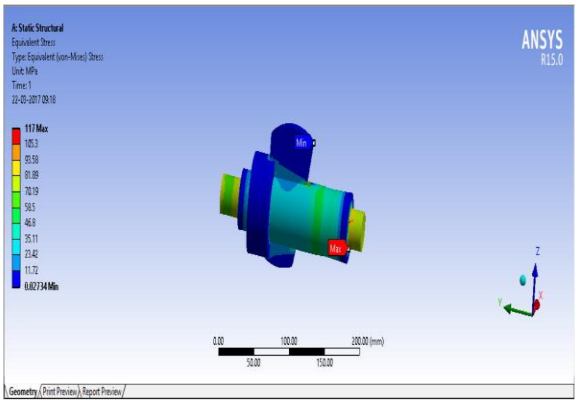

Fig 10: Equivalent (von-mises) stress at 60kN load

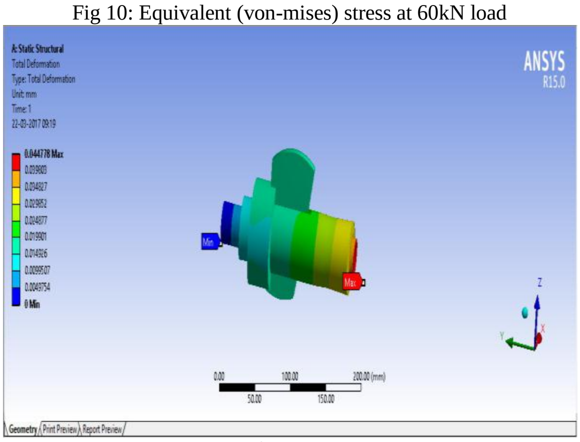

Fig 11: Total deformation at 60KN load

7. RESULT

Load (KN)	Max. Deformation (mm)	Von-Mises Stress (MPA)	Remark
40	0.02998	77.98	SAFE
50	0.03731	97.47	SAFE
60	0.04477	117	SAFE

The maximum permissible value of stress of structural steel is 400 MPA. From this it is clear that the design of cotter joint is safe for 50kN as there is minimum acceptable deflection. The stress is also less than the permissible stress of the material. Hence design of cotter joint Assembly is safe.

8. CONCLUSION

Cotter joint is widely used in application in automobiles and other field. So it should be strong enough so if it can't sustain that amount of load, otherwise there is possibility of accidents. So we designed the cotter joint. Then by CATIA V5R20 we had done the modeling with gives correct design then design we are going to check by ANSYS R15 to find stress in the cotter so we got perfect design of cotter joint.

Based on the analysis results, following conclusion points are summarized,

- The maximum permissible value of stress of 30C8 steel is 400 MPA.
- From the results achieved at loads 40kN, 50kN and 60kN it has given lower stress values and deformation for the 30C8 steel.

9. REFERENCES

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