"Analysis of Knuckle Joint used in Mahindra 575 DL"

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ABSTRACT

Tractor-trailer finds widespread use as a means of transportation in rural like agriculture field and in urban like goods transport as it is often cheaper. The effective design of any mechanical device or assembly demands the predictive knowledge of its behavior in working condition. It becomes a dire necessity for the designer to know the forces and stresses developed during its operation. In this project the stresses on the knuckle joint and to improve the performance of knuckle joint to a certain extent is going to be studied by using CATIA V5 and FEM will be use in analysis.

Keyword: - *CATIA V5, ANSYS Work Bench 15.*

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1. INTRODUCTION

In mechanical & automobile domain the joints play very crucial role, depending upon the application the joints are used may be temporary or permanent. For power transmission or motion transfer application we generally use temporary joints like screwed joint, cotter joint, sleeve cotter joint, universal joint or knuckle joint. Tractor trailer is useful equipment used in agriculture field or construction for carrying heavy goods. To connect trailer to the tractor flexibly, a knuckle joint is used which consist of forks and a pin, a fork is attached to tractor rigidly and another fork is attached to the trailer by a pin. During transportation variable stresses act on knuckle joint which causes failure of joint.

1.1 Introduction to Knuckle Joint

Knuckle joint is a joint between two parts allowing movement in one plane only. It is a kind of hinged joint between two rods, often like a ball and socket joint. There are many situations where two parts of machines are required to be restrained, for example two rods may be joined coaxially and when these rods are pulled apart they should not separate i.e. should not have relative motion and continue to transmit force. Similarly if a cylindrical part is fitted on another cylinder (the internal surface of one contacting the external surface of the other) then there should be no slip along the circle of contact. Such situations of no slip or no displacements are achieved through placing a third part or two parts at the jointing regions. Such parts create positive interference with the jointing parts and thus prevent any relative motion and thus help transmit the force.

Knuckle joint is another promising joint to join rods and carry axial force. It is named so because of its freedom to move or rotate around the pin which joins two rods. A knuckle joint is understood to be a hinged joint in which projection in one part enters the recess of the other part and two are held together by passing a pin through coaxial holes in two parts. This joint cannot sustain compressive force because of possible rotation about the pin. There are most common in steering and drive train applications where it needs to move something but also need to allow for offset angles. A knuckle joint is used when two or more rods subjected to tensile and compressive forces are fastened together such that their axes are not in alignment but meet in a point. This type of joint allows a small angular movement of one rod relative to another. The joint can be easily connected and disconnected. Knuckle joint is found in valve rods, braced girders, links of suspension chains, elevator chains, etc. The knuckle joint assembly consists of following major components:

1. Single eye.

2. Double eye or fork.

3. Knuckle pin.

4. Key pin.

2. PROBLEM STATEMENT

Knuckle joint is one of the most important components in tractor trailer. Thus, the parts of this joint are susceptible to fatigue by the nature of their operation. Common sign of knuckle pin failure is bending during operation. Knuckle joint mainly used in joining of tractor and trailer. During running condition of vehicle due to unevenness of road the pin get sudden impact which leads to bending of pin. Because of this we have to change pin again and again which is uneconomical for the person who buys it. It is very important to know the accurate prediction for the knuckle pin to fail. For this purpose to check the stress induce in pin, different methods are been carried out that is theoretical and F.E. analysis by using various parameters. Failure analysis is the process of collecting and analysing data to determine the cause of a failure and how to prevent it from recurring. Failure analysis and prevention are important functions to all of the engineering disciplines.

Fig.2.1 failure of knuckle pin in Mahindra 575DL

A component or product fails in service or if failure occurs in manufacturing or during production processing. In any case, one must determine the cause of failure to prevent future occurrence, and/or to improve the performance of the device, component or structure. It is possible for fracture to be a result of multiple failure mechanisms or root causes. A failure analysis can provide the information to identify the appropriate root cause of the failure. Fig.1.8 failure knuckle pin in Mahindra 575DL the problem for this analysis was taken under consideration from the given fig. the knuckle joint is considered the component made up to ASTM grade 20 grey cast iron (ISO grade150, EN-JL1020), which is a material in the low grade grey cast iron group of density 7200 Kg/m3 the model was analyzed in ANSYS 15.0 considering the mechanical properties as ultimate tensile strength 150 MPa and Shear strength as 180 MPa.

2.1 Causes of Failure

Failure analysis is the process of collecting and analysing data to determine the cause of a failure and how to prevent it from recurring. Failure analysis and prevention are important functions to all of the engineering disciplines. A component or product fails in service or if failure occurs in manufacturing or during production processing. In any case, one must determine the cause of failure to prevent future occurrence, and/or to improve the performance of the device, component or structure. It is possible for fracture to be a result of multiple failure mechanisms or root causes. A failure analysis can provide the information to identify the appropriate root cause of the failure.

3. WORK DONE

- The different theoretical stresses are calculated for various components of knuckle joint by applying force of 50 KN. For this study the model was replicated for the same force and the design, results were been tabulated for theoretical and FE analysis.
- For the further analysis of knuckle pin different materials like grey cast iron grade 35, grey cast iron grade 60, Stainless steel and Titanium Alloy were considered with same load condition and diameter.
- Again the ANYSIS results were analyzed by increasing dia.0.5mm for range 35 to 40mm for same load condition and for same material i.e., grey cast iron grade 20. Results of Equivalent von mess stress, Equivalent shear stress and Total deformation were tabulated

3.1 CAD MODEL OF KNUCKLE JOINT

For analysis, it is intended to design the model of knuckle joint in CAD software. Here, CATIA V5 software is used to create components of knuckle joint.

Part 1: CAD Model of Double Eye

Fig. Shows a model of Double eye having same dimension of theoretical model. The procedure to generate Double eye is given below

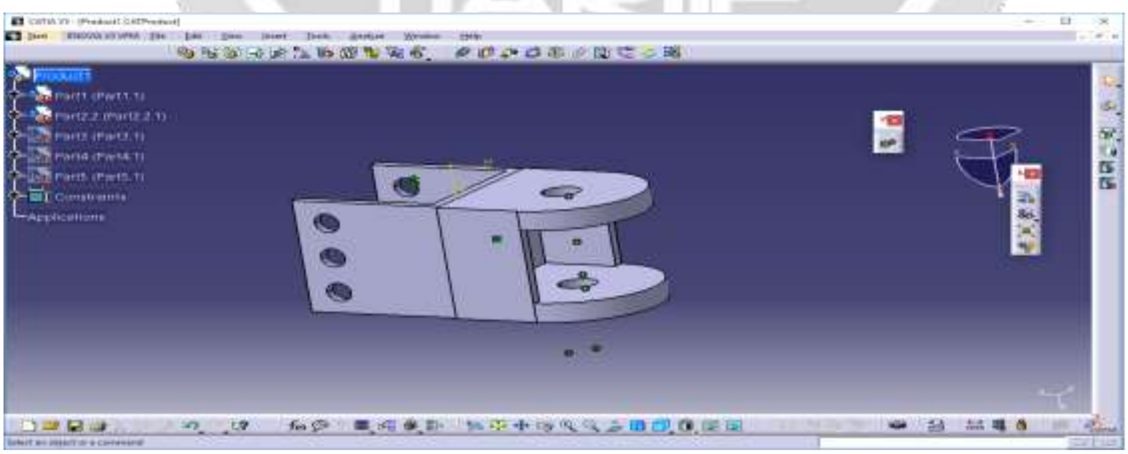

Fig 3.1 CATIA Model of Double Eye

Part 2: CAD Model of Single Eye

Fig. Shows a model of single eye having same dimension of theoretical model. The procedure to generate single eye is given below:

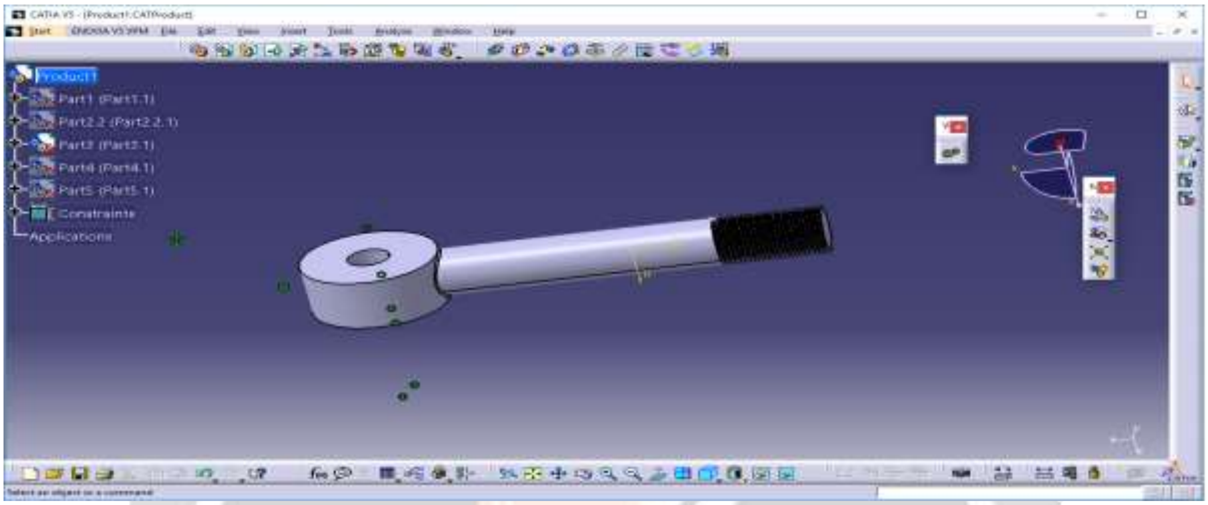

Fig 3.2 CATIA Model of Single Eye

Part 3: CAD Model of Pin

Fig. Shows a model of pin having same dimension of theoretical model. The procedure to generate pin is given below:

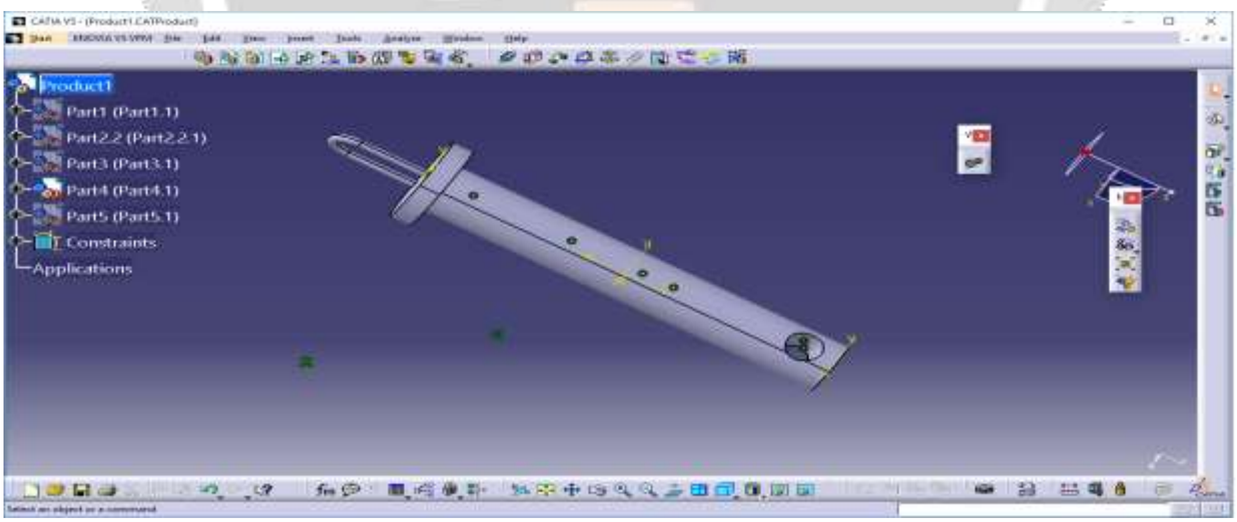

Fig 3.3 CATIA Model of Knuckle Pin

Part 4: CAD Model of Key Pin

Fig. Shows a model of Key pin having same dimension of theoretical model. The procedure to generate Key Pin is given below:

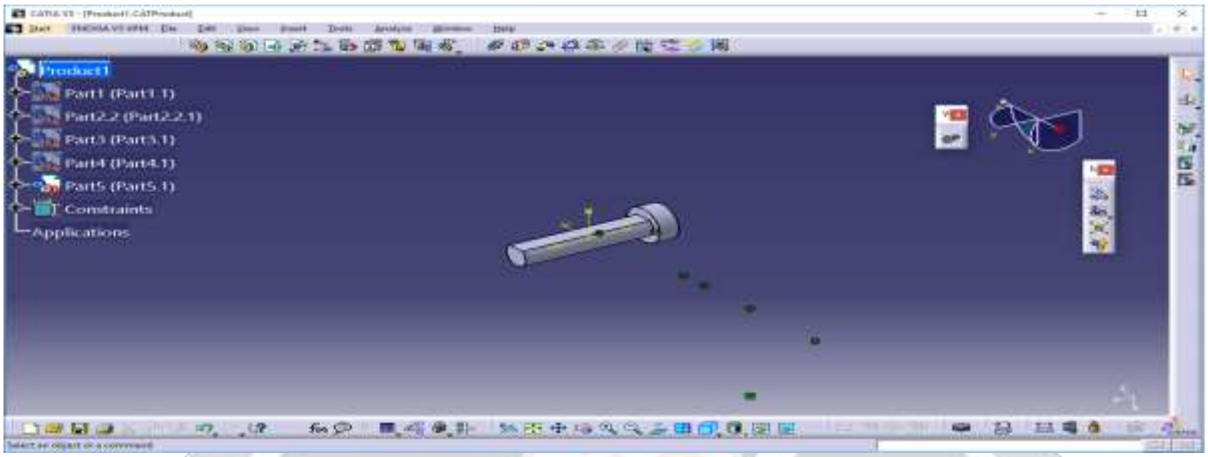

Fig 3.4 CATIA Model of Key Pin

3.2. CAD MODEL ASSEMBLY OF KNUCKLE JOINT

Model of Knuckle joint is created in assembly by calling part

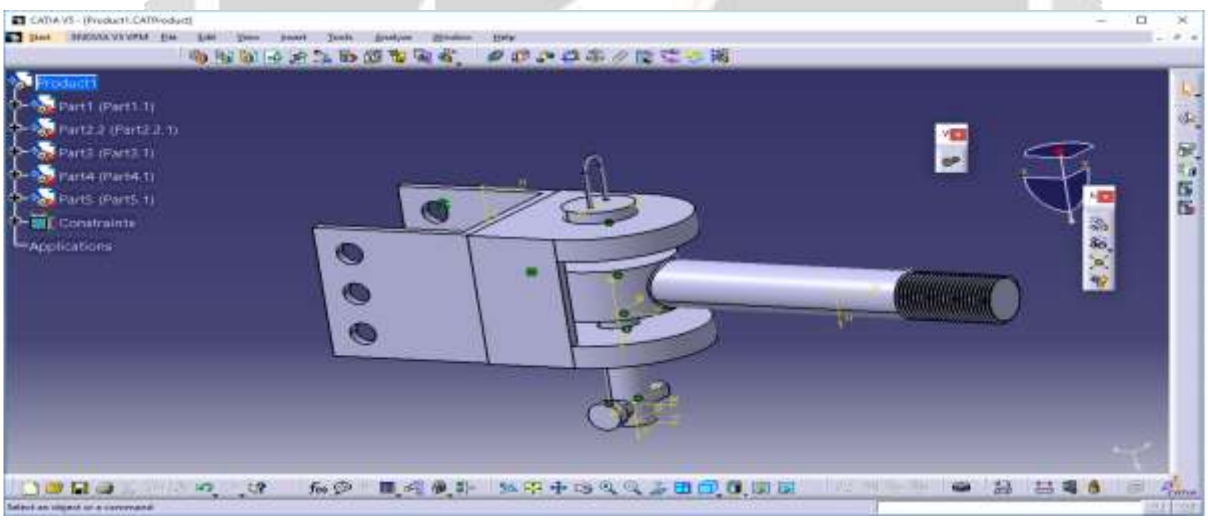

Fig 3.5 CATIA Model of Assembly of Knuckle Joint

3.3 CONVERSION OF CAD MODEL INTO NEUTRAL FILE FORMAT (IGES)

Analysis is carried out by developing a model of universal joint in Pro-E then it converted into IGES file and then it imported to FEA software ANSYS. Fig. 3.6 shows the model of universal joint after imported in ANSYS. The complete procedure for analysis of universal joint is as follows.

File > import > IGES > ok > Brows > part > open > ok

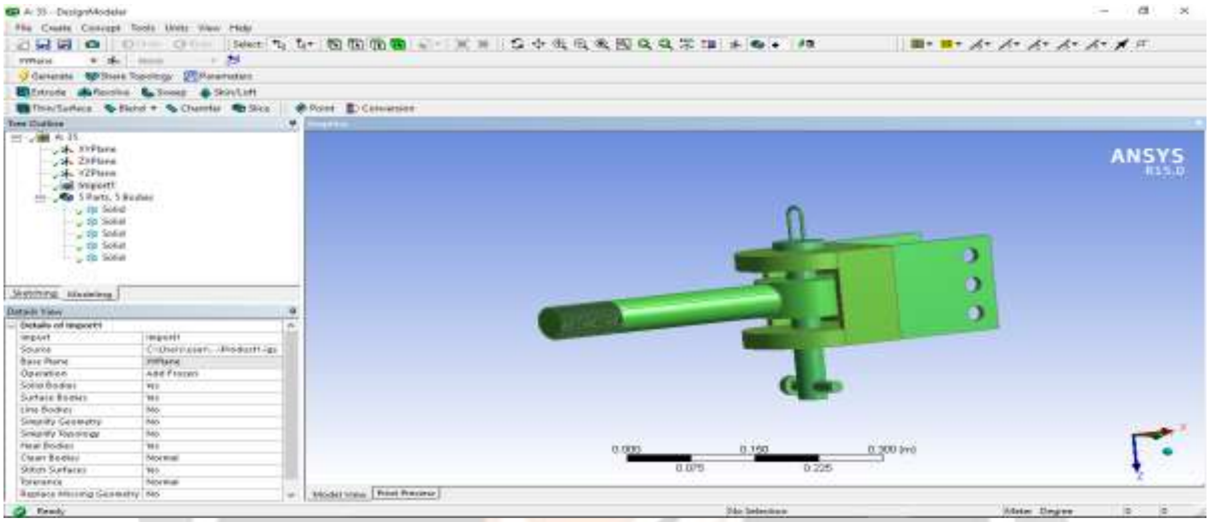

Fig3.6 Model of Knuckle joint after imported in ANSYS

1) ANSYS work bench 15.0

Selection of appropriate analysis system “static structural” static structural > engineering data

2) Define Material

Material properties are specified are as follows.

1) Set Preferences:

Main menu > preferences > structural

2) Defining material properties:

Mechanical properties of material Gray Cast Iron Grade 20

Sr.no.	Symbols	Parameters	Values
1	E	Young’s modulus	82GPa
2	µ	Poisson’s ratio	0.26

Select material > Physical properties > density

Linear elastic> isotropic elastic

Modulus of elasticity (E) = 82GPa

Poisson's ratio = 0.26

3) Define Geometry

Import geometry from source file

Geometry > replace geometry > browse > source file> open > generate

4) Model work bench

Geometry is been provided with define material, fixed support, moment, mesh & solutions as per requirement.

Project> model> geometry > select material > part1, part 2, part 3 ok

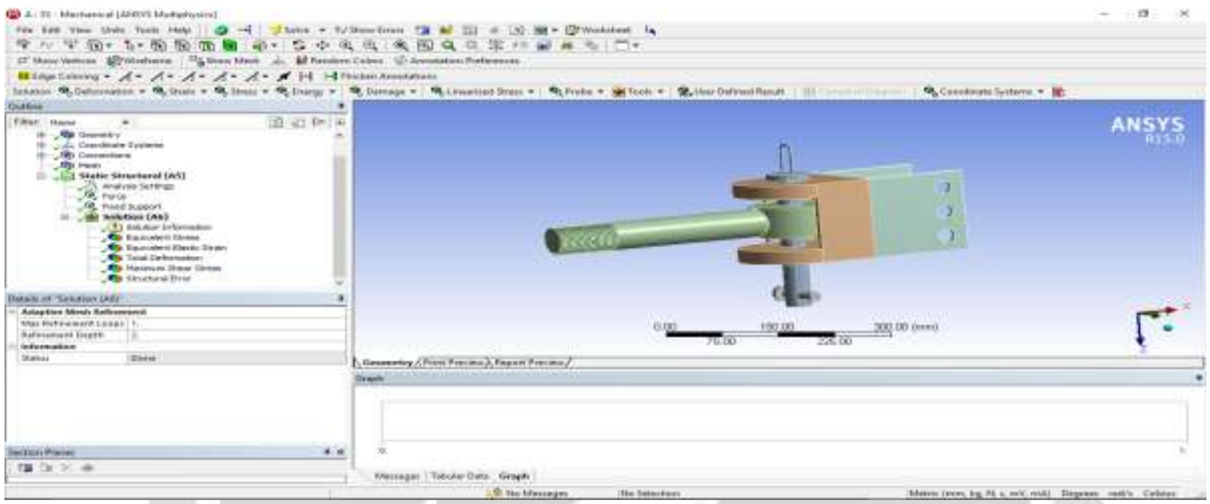

Fig 3.7 Model Work Bench in ANSYS

5) Generating Mesh

There are two types of meshing as triangular and quadrilateral. In this case triangular meshing is chosen.

Mesh >insert> sizing > geometry > apply > generate mesh

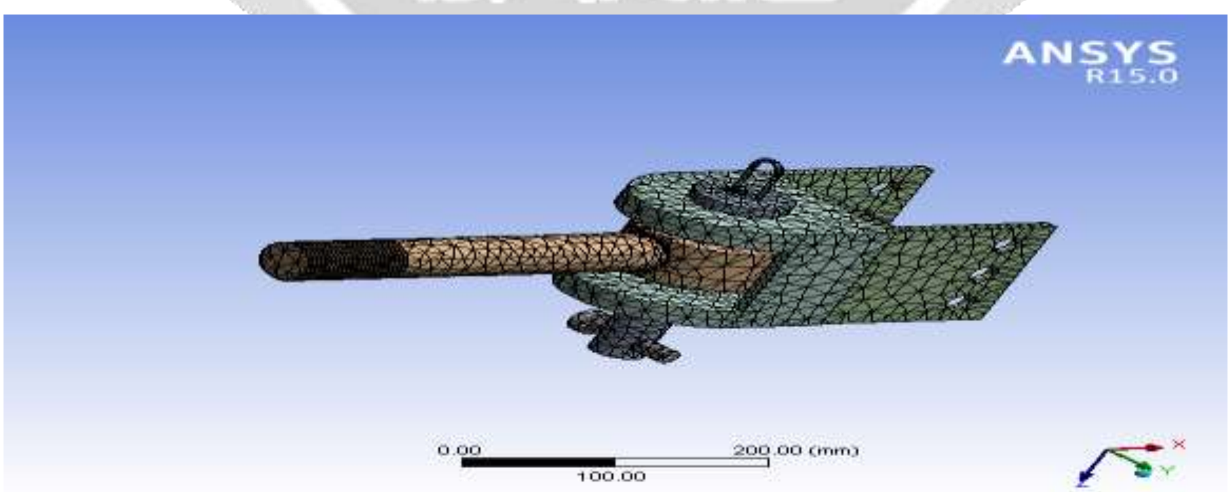

Fig. 3.8 Generating Mesh Model in ANSYS

6) Constraining and loading the model

For constraining

Static structural > fixed support > apply moment > apply

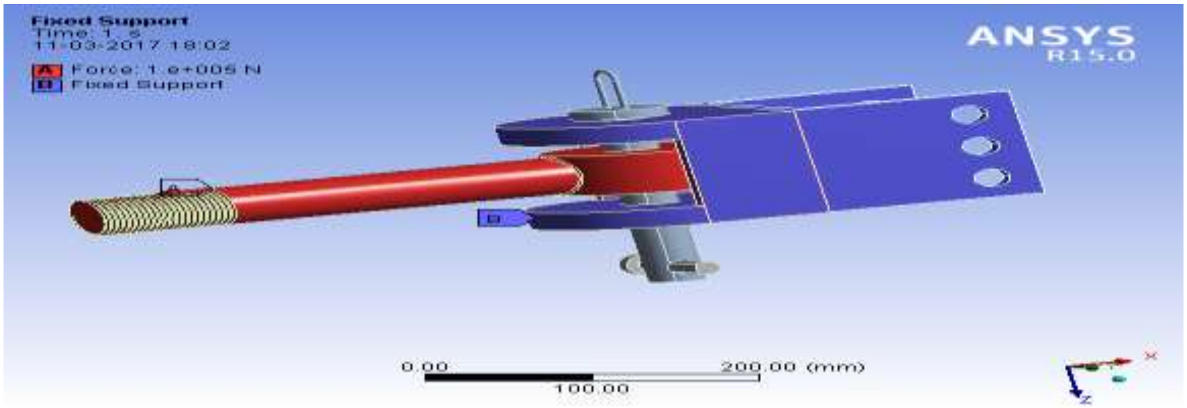

Fig 3.9 Constrain and Load applied Model in ANSYS

3.4 F.E Analysis for Different Materials on 35mm Diameter of Knuckle Pin at 50KN

For the study of Model was replicated for different materials on 35mm diameter at 50KN loading condition is kept same.

3.4.1 F.E. Analysis for Gray Cast Iron ASTM Grade20 (ISO Grade150, EN-JL1020) Material on 35mm Diameter

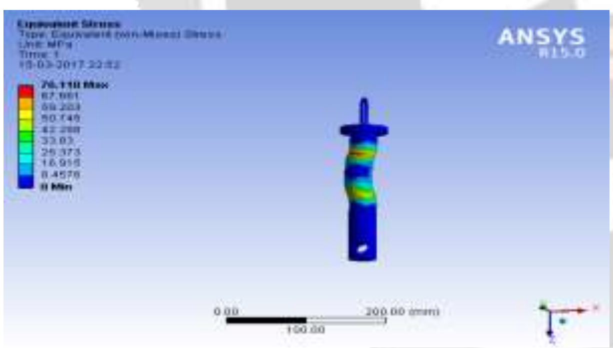

Fig. 3.10 Equivalent stress

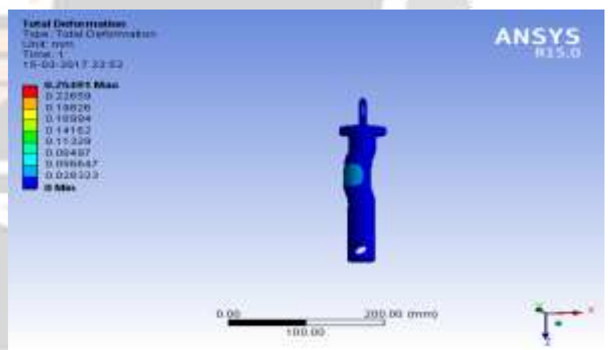

Fig. 3.11 Total deformation

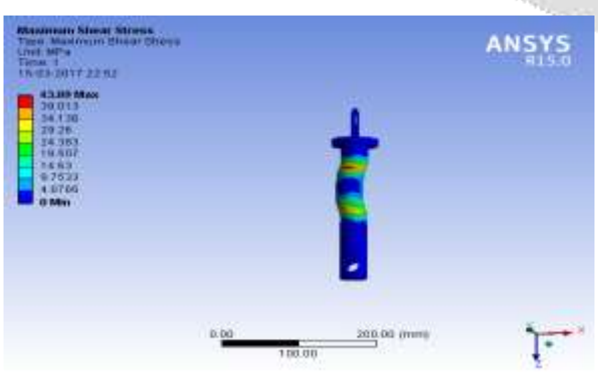

Fig 3.12 Shear stress

3.4.2 FE Result Table for Different Material on 35mm Diameter of Knuckle Pin at 50KN

Materials	Equivalent Stress	Total Deformation	Shear Stress
Grade 20	57.661	0.036647	36.013
Grade 35	52.061	0.022425	32.92
Grade 60	48.023	0.02113	26.697
Stainless steel	40.023	0.017637	22.249
Titanium alloy	37.514	0.023846	21.609

From this table we conclude that mechanical properties of different materials are also responsible for the reduction of total deformation shear stress and equivalent stress accumulated on pin.

3.5 F.E. Analysis for Increasing Diameter by 0.5mm, form 35mm to 40mm Diameter of Knuckle Pin at 50KN and for Gray Cast Iron Grade20

For the study of Model was replicated for different diameter of 35mm diameter at 50KN loading condition and for Gray Cast Iron

3.5.1 F.E. Analysis for 35mm Diameter of Knuckle Pin at 50KN and for Gray Cast Iron ASTM Grade 20(EN-JL 1020)

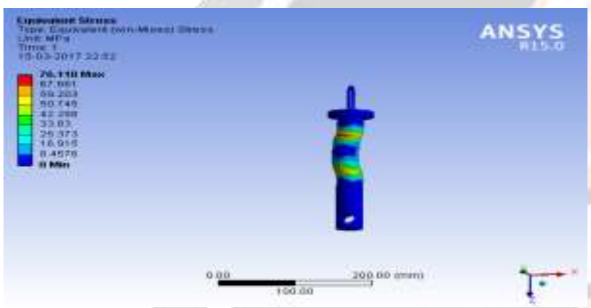

Fig.3.13 Equivalent stress

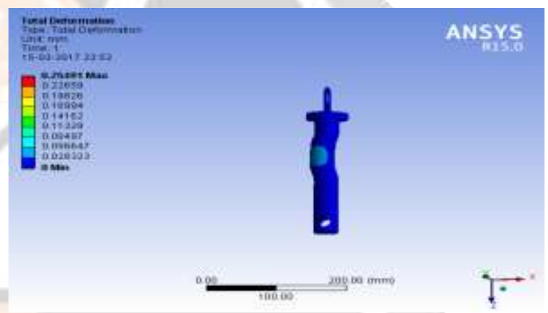

Fig. 3.14 Total deformation

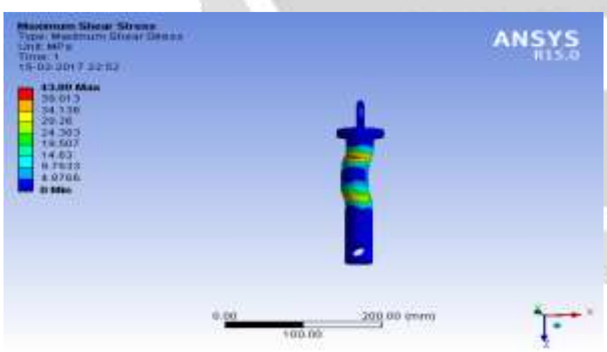

Fig. 3.15 Shear stress

3.5.2 F.E Analysis for 40mm Diameter of Knuckle Pin at 50KN and for Gray Cast Iron ASTM Grade 20(EN-JL 1020)

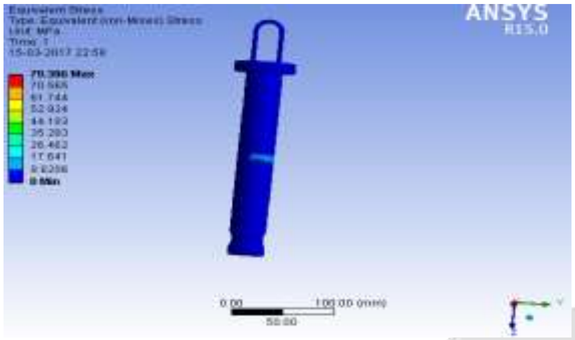

Fig.3.16 Equivalent Stress

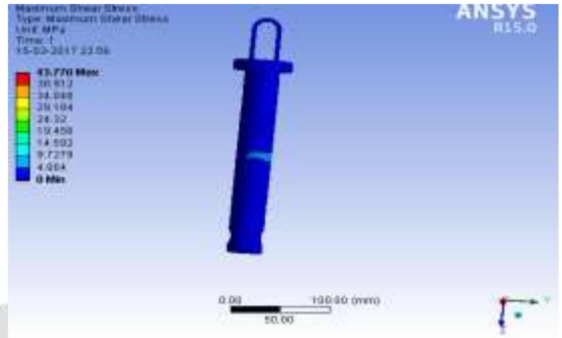

Fig. 3.17 Total Deformation

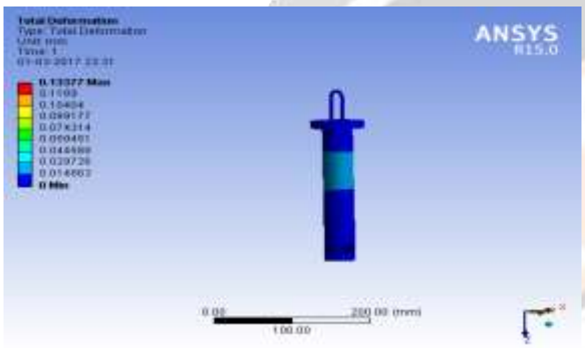

Fig. 3.18 Shear stress

3.5.3 FE Result Table for varying Diameter of Knuckle Pin for Gray Cast Iron ASTM Grade20(EN-JL 1020) at 50KN

Diameter	Equivalent stress	Total deformation	Shear Stress
35	67.661	0.056647	39.013
35.5	59.913	0.051283	34.340
36	56.928	0.038507	31.628
36.5	55.103	0.03724	31.006
37	53.385	0.033443	30.653
37.5	53.092	0.025376	30.056
38	52.058	0.020562	28.888
38.5	47.703	0.018236	26.265
39	45.526	0.017505	24.531
39.5	44.743	0.016995	23.132
40	36.641	0.014853	20.727

From this table we conclude that as we increased the diameter the Total Deformation, Equivalent Stresses and Shear Stresses accumulation on pin get reduced.

4. CONCLUSIONS

After studying knuckle joint used in tractor-trailer and analysis on knuckle pin following conclusion can be drawn.

According to our study Theoretical calculation and FE analysis having around same results on 35 mm Diameter at 50 KN.

Secondly, we also find that material also plays a very important role in stress reduction acting on joint especially on pin. As we change material like grey cast iron (ASTM grade 20 (EN-JL 1020), ASTM grade 35 (EN-JL1040), ASTM grade 60 (EN-JL 1070)), Stainless steel and Titanium alloy; deviations in Equivalent stress (von mises), shear stress and total deformation occurs at same load and diameter in which it has maximum stresses.

As we increase the force the von misses stress get increased on pin and can lead to bending of pin but if we increase pin diameter , it will sustain maximum stress at same force at which it has bend

Not only Varying load on pin and load on trailer can increase stress but sudden impact due to unevenness of road can also cause the failure of pin.

5. ACKNOWLEDGEMENT

We would like to thank my honorable Project Guide Mrs. Swati Datey under whose guidance I have completed our project successfully. Without her unending help, encouragement and motivation this would not have been possible.
Dedication and perseverance when supported by inspiration and guidance leads to success. For me the inspiration and guidance was given by my guide Mrs. Swati Datey who was accessible for us to obviate the darkness with the light of his knowledge of the relevant subject enriched by his hands on experience in the field of technology. I truly feel it was a privilege for me, to have her as my guide. I feel highly honored working under him.
We are also thankful to Prof. D. R. Ikhar (HOD, Mechanical Engineering) and Dr. S. P. Untawale (Principal, D.M.I.E.T.R.) for support and for providing me all the necessary facilities.

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- “STUDY & ANALYSIS OF KNUCKLE JOINT WITH THE REPLACEMENT OF MATERIAL BY USING TEFLON” Nishant Vibhav Saxena Assistant Professor, Department of Mechanical Engineering, MITS, Bhopal, MP Dr. Rohit Rajvaidya Professor, Department of Mechanical Engineering, BUIT, Bhopal, MP.
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