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Design and Analysis of a Connecting Rod

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ABSTRACT

The intermediate component between crank and piston is known as connecting rod. The objective of connecting rod is to transmit push & pull from the piston pin to the crank pin and then converts reciprocating motion of the piston into the rotary motion of crank. The components are big shank, a small end and a big end. The cross section of shank may be rectangular, circular, tubular, I- Section, + -section or ellipsoidal-Section. It sustains force generated by mass & fuel combustion. The resulting bending stresses appear due to eccentricities, crank shaft, case wall deformation & rotational mass. FEA approach deals with structural analysis along with various parameters which affects its working & define best solution to overcome the barriers associated with it. This thesis describes designing and Analysis of connecting rod. Currently existing connecting rod is manufactured by using Carbon steel. In this drawing is drafted from the calculations. A parametric model of Connecting rod is modelled using CATIA V5 R20 software and to that model, analysis is carried out by using ANSYS 13.0 Software. Finite element analysis of connecting rod is done by considering the materials, viz... For C70 Steel, Belgium. The best combination of parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS software.

Structural steel has more factor of safety, reduce the weight, increase the stiffness and reduce the stress and stiffer than other material like carbon steel. With Fatigue analysis we can determine the lifetime of the connecting rod.

1. INTRODUCTION

The intermediate component between crank and piston is known as connecting rod**.** The objective of C.R. is to transmit push & pull from the piston pin to the crank pin and then converts reciprocating motion of the piston into the rotary motion of crank. The components are big shank, a small end and a big end. The cross section of shank may be rectangular, circular, tubular, I- Section, + -section or ellipsoidal-Section. It sustains force generated by mass & fuel combustion. The resulting bending stresses appear due to eccentricities, crank shaft, case wall deformation & rotational mass. FEA approach deals with structural analysis along with various parameters which affects its working & define best solution to overcome the barriers associated with it. The structural analysis allows stresses &strains to be calculated in FEA, by using the structural model. The structural analysis performed to create high & low stresses region from the input of the material, loads, boundary condition. FEA approach was adopted in structural analysis to overcome the barriers associated with the geometry & boundary condition. It is used to improve optimize design.

The main objective of this work is to determine shear stresses and optimization in the existing connecting rod, which are in different cross-section as plus (+) section, I-section and ellipsoidal section. The failures of existing design suggest the minimum design changes in the existing connecting rod.

Fig.1.1 Main components of spark ignition reciprocating engine

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1.1 Small end and big end

The **small end** attaches to the piston pin, gudgeoned pin or wrist pin, which is currently most often press fit into the connecting rod but can swivel in the piston, a "floating wrist pin" design. The **big end** connects to the bearing journal on the crank throw, in most engines. Running on replaceable bearing shells accessible via the connecting rod bolts which hold the bearing "cap" onto the big end. Typically there is a pinhole bored through the bearing and the big end of the connecting rod so that pressurized lubricating motor oil squirts out onto the thrust side of the cylinder wall to lubricate the travel of the pistons and piston rings. Most small two-stroke engines and some single cylinder four-stroke engines avoid the need for a pumped lubrication system by using a rolling-element bearing instead, however this requires the crankshaft to be pressed apart and then back together in order to replace a connecting rod.

1.6 Engine specification

The specifications are taken at a Temperature 60F

- Engine type Air cooled 4- stroke
- Bore 57 mm
- Stroke 58.6 mm
- Displacement 149.5cc
- Maximum power 13.8 at the rate of 8500rpm
- Maximum torque 13.4Nm at the rate of 6000rpm
- Compression ratio 9.35/1
- Density of petrol 737.22kg/m3

1.9 Specification of connecting rod (All dimensions are in mm**)**

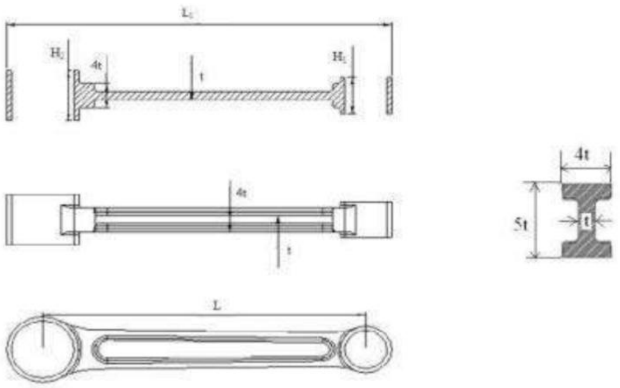

Fig. 1.6 Specifications of connecting rod

1 Thickness of the connecting rod (t) = 3.22
2 Width of the section (B = 4t) = 12.8
3 Height of the section (H = 5t) = 16
4 Height at the big end = (1.1 to 1.125) H = 17.6
5 Height at the small end = (0.9 to 0.75) H = 14.4
6 Inner diameter of the small end = 17.94
7 Outer diameter of the small end = 31.94
8 Inner diameter of the big end = 23.88
9 Outer diameter of the big end = 47.72; Fillet Round = 4; Chamfer=0.75

2. Literature Survey

Leela Krishna Vegiet.al. [1] In his paper theydesigning and Analysis of connecting rod. currently existing connecting rod is manufactured by using Carbon steel.**A.Premkumaret.al. [2]** In their research paper theyhad manufactured using carbon steel and in recent days aluminium alloys are finding its application in connecting rod. **Mohamed AbdusalamHussinet.al. [3]** In their research they had designing and Analysis of connecting rod.**G. Naga Malleshwara Rao [4]** In their research paper they have explore weight reduction opportunities in the connecting rod of an I.C. engine by examining various materials such as Genetic Steel, Aluminium, Titanium and Cast Iron. **Deepak G. Gotiwale et.al. [5]** In their research paper they presents an overview of design of connecting rod for its weight reduction. During its operation it undergoes various types of loads. **S.Vijaya Kumar et.al.[6]** in their modeling and analysis of connecting rod. In this project connecting rod is replaced by chrome steel and titanium for Yamaha Fz-s motorbike. **G.M Sayeed Ahmed et.al. [7]** In their paper theyhad conducted experiments on existing connecting rod made of forged steel which is broken for LML Freedom with the aluminium connecting rod. **K.Karthick et.al. [8]** This research deals with the design and analysis of connecting rod. The existing connecting rod is manufactured using carbon steel. **K. Sudershn Kumar et.al. [10]** In this paper theyhad modelled and analysed of connecting rod. In this project connecting rod is replaced by Aluminium reinforced with Boron carbide for Suzuki GS150R motorbike.

3. METHOLDOLOGIES

3.1 GEOMETRIC MODELLING

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Assault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Assault Systems product lifecycle management software suite.

CATIA competes in the CAD/CAM/CAE market with Siemens NX, Pro/E, Autodesk Inventor, and Solid Edge as well as many others

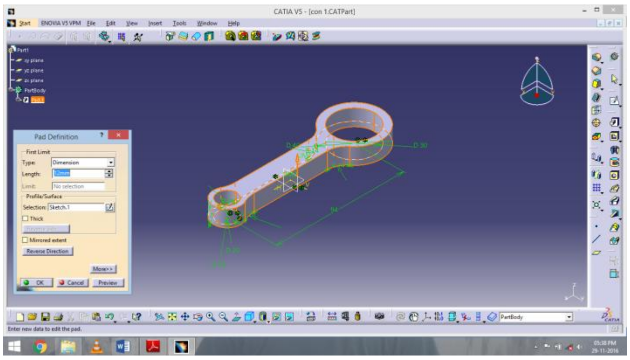

Fig.3.2 Designed CATIA model of connecting rod

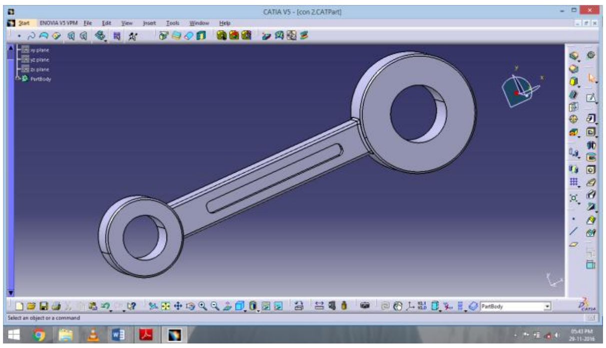

Fig 3.7 Designed CATIA model of Connecting rod with both ends

4 FINITE ELEMENT ANALYSIS

4.1 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 stress, vibration, buckling behaviour, and small or large-scale deflection under loading or applied displacement. It can be also be used to analyze elastic deformation or plastic deformations. Because of the large number of calculations involved and the power and low cost of modern computers, it has become easy to apply Finite Element Analysis to many disciplines.

4.5 Material properties of connecting rod

In this analysis three types of materials are used to reduce its weight. These materials are 1. Structural steel, c-70 steel and beryllium

Material	Densitygram/cc	Young's modulesGPa	Poisons ratio	Yield stressMPa
Structural steel	7.85	200	0.300	250
c-70 steel	7.8	221	0.280	440
Belgium	1.85	287	0.032	240

Fig.4.4 Meshed model of connecting rod

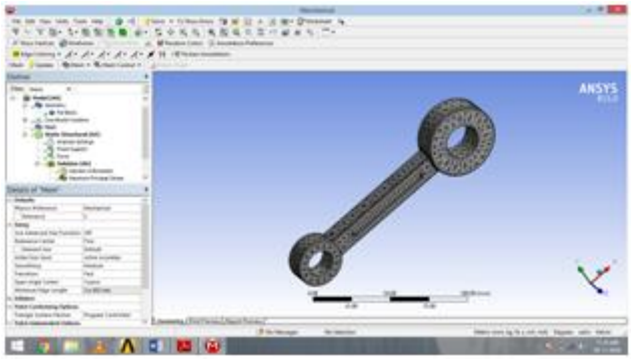

Fig.4.5 Named selections

Fig 4.6 Named selections of connecting rods at ends

4.6.4 Steps involved in analysis using ANSYS

The ANSYS program has many finite element analysis capabilities, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis.

A typical ANSYS analysis consists of the following steps:

Build the model using key points, lines, areas and volume commands.

- Giving material properties.
- Choosing proper element.
- Meshing the model to discritise it into elements.
- Applying the given loads.

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- Applying the boundary conditions.
- Running the solution phase.
- Review the results using the post processor.

5 RESULTS AND DISCUSSIONS

The connecting rod is used to transfer the reciprocating motion to rotary motion. While converting motion the material undergoes stresses and deformations. The stresses and deformations are calculated using finite element method. Here we are considering with and without I section beams and compared for different materials like structural steel, C-70 steel and beryllium.

This is the design model of connecting rod for FEM analysis. Here we have to give the names of various parts and transfer the model for meshing.

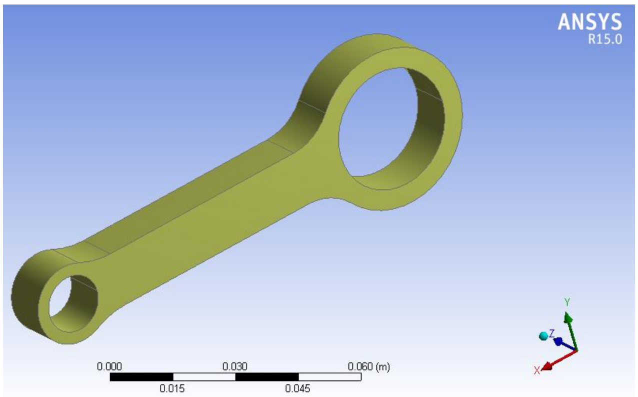

Fig. 5.1 Design model of connecting rod

This is the meshed model of connecting rod. It is used 10 node and 20 node tetra shape of element type solid92 and solid95.This is the input for structural analysis.

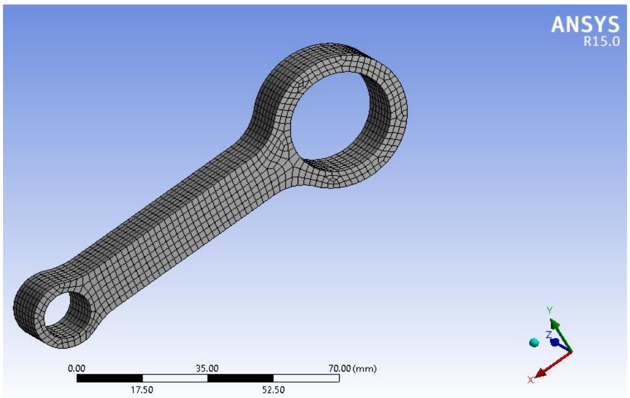

Fig.5.2 Meshed model of connecting rod

Boundary conditions are given to the model**.** First arrest the degrees of freedom of bigger end of the connecting rod. After that apply the loads on the small end of the connecting rod at different areas. Transferring of geometric model in to the FEA (finite element analysis) after solving this model it gives the deflections and von misses stress produced in the connecting rod. Tabulated the results. Various loads are applied on the smaller end to calculate the outputs.

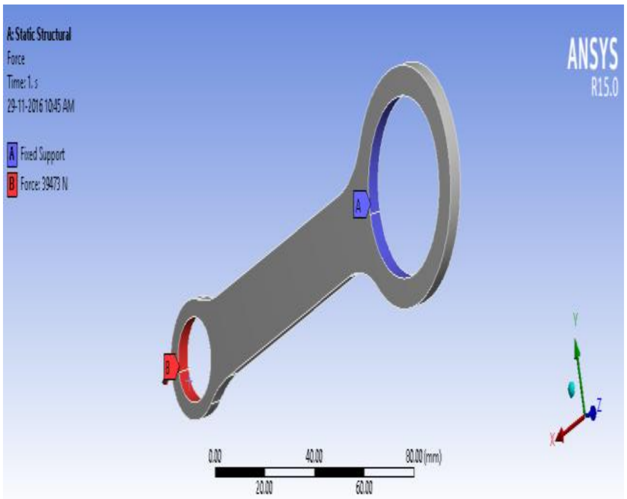

Fig.5.3 Boundary conditions of connecting rod

Fig.5.4 Normal Load on connecting rod

These are the outputs of connecting rod at various loads. The maximum principle stresses and deformations are calculated at different loads. The various outputs are shown below.

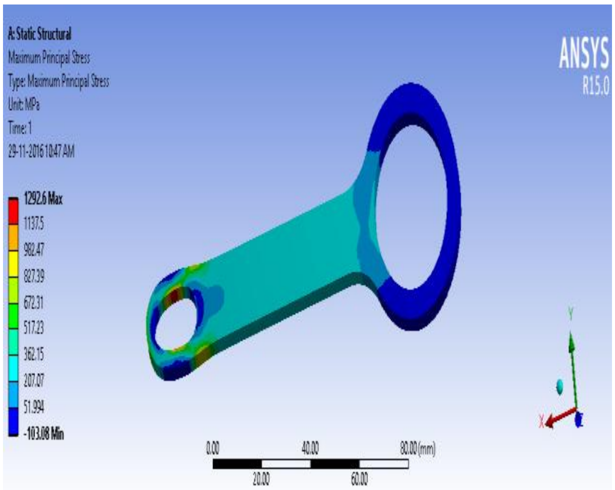

Fig 5.5 Maximum principle stress at 39473.16N

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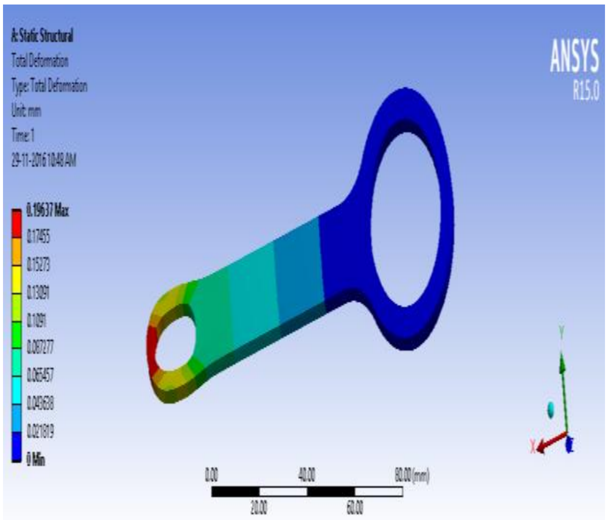

Fig.5.6 Deformation of connecting rod at 39473.16N

5.1 Comparison of results

The connecting rod is analysed by two methods i.e.,

i) Theoretical method.

ii) Numerical method (Finite Element Analysis).

The results obtained by the above two methods are compared at two critical areas of the connecting rod or two different sections of connecting rod where the connecting rod is likely to fail. The two areas or sections of connecting rod where results are compared are:

i) Sec D-D at the Small End.

ii) Sec A-A at the root of Big End.

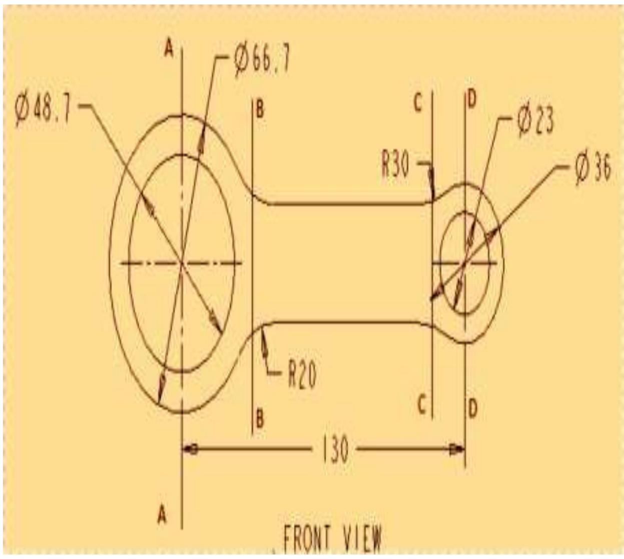

Fig: 5.6.5 Sec A-A, Sec D-D. Considered for analysis.

5.2 Calculations for finding maximum principal stress theoretically

Table 5.1 Theoretical and Fem results at different loads

Load (N)	Theoretical results	FEM based results
39473.16	1312.132N/mm²	1292.6N/mm²
39575	1378.125N/mm²	1296.0N/mm²
39700	1401.257N/mm²	1300.1N/mm²

From the theoretical and Finite Element Analysis it is found that

a) The stresses induced in the small end of the connecting rod are greater than the stresses induced at the big end.

b) Therefore, the chances of failure of the connecting rod may be at fillet section of both end.

B) Consider connecting rod with I section beam for further analysis with different materials. The materials are structural steel, C-70 steel and beryllium are considered for this analysis. In this analysis equivalent stresses, normal stresses in X, Y and Z directions, shear stresses in XY, YZ and ZX planes, total deformation ,deformation in X, Y and Z directions and factor of safety. The results are tabulated and compared each other.

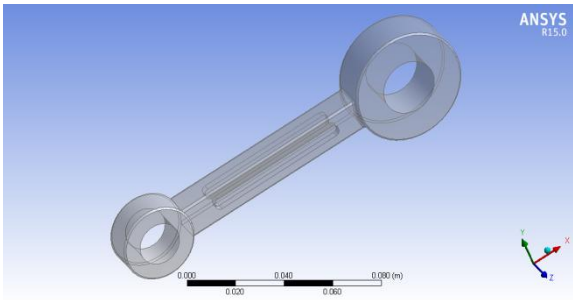

Fig.5.6.6 Design Model of Connecting Rod with I Beam

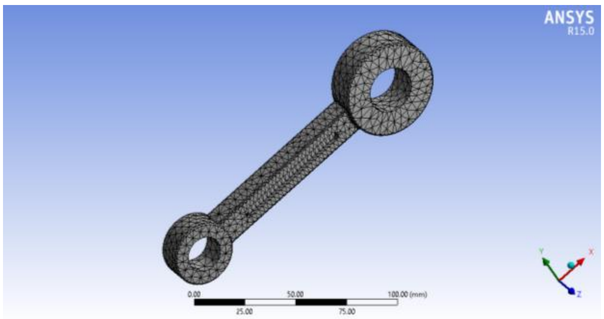

Fig.5.6.7 Meshed Model of Connecting Rod with I Beam

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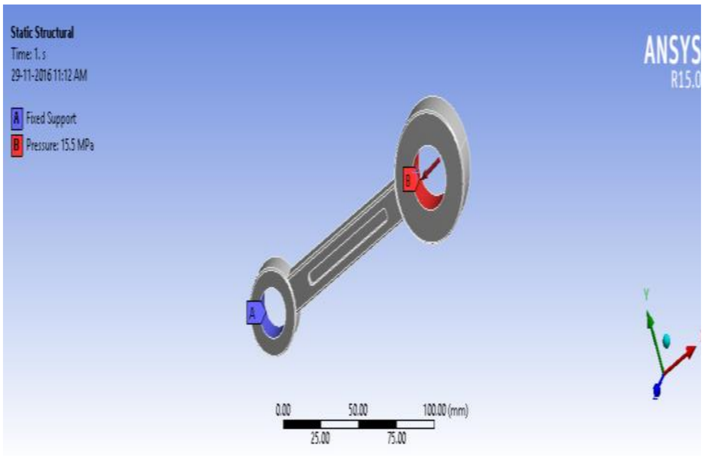

Fig.5.6.8 Boundary Conditions of Connecting Rod with I Beam

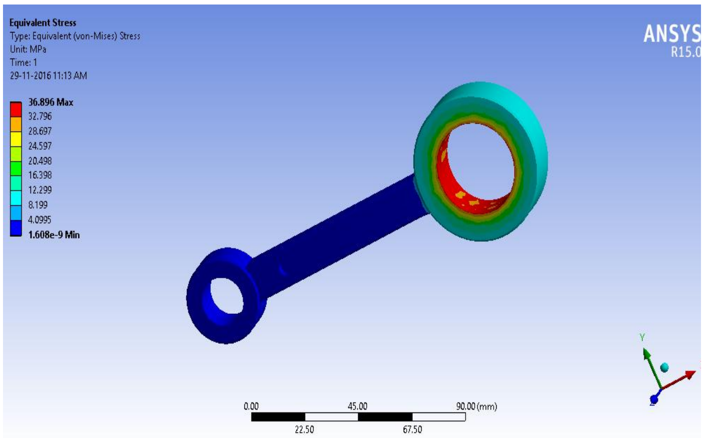

Fig.5.6.9 Equivalent Stress of Connecting Rod with I Beam (Structural steel)

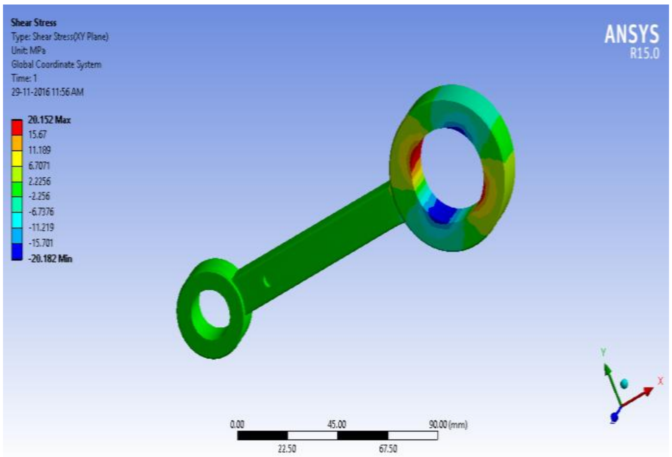

Fig.5.7.3 Shear stress in – XY Plane of Connecting Rod with I Beam (Structural steel)

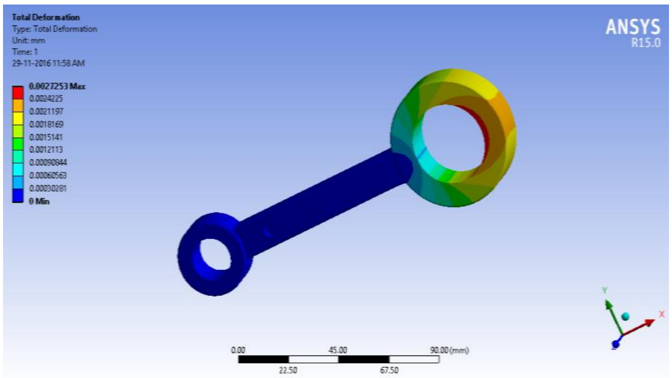

Fig.5.7.6 Total Deformation of Connecting Rod with I Beam (Structural steel)

C-70 STEEL

Here the material for used for this analysis is C70 steel for connecting rod.After applying the same boundary conditions for this material and run the solution. The post processor is used to calculate the equivalent stress along the length of the connecting rod for this material. The equivalent stress indicated in the figure form rod small end to the crank pin.

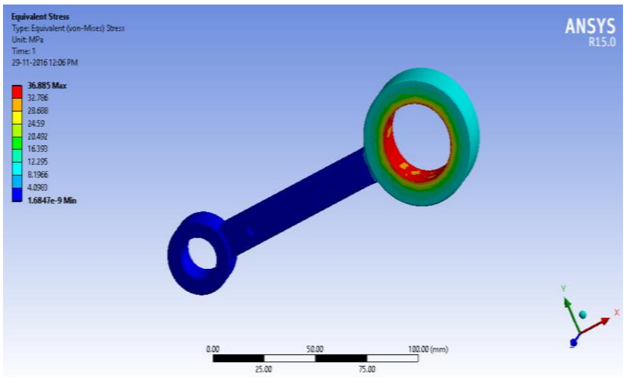

Fig.5.8Equivalent Stress of Connecting Rod with I Beam(C-70 Steel)

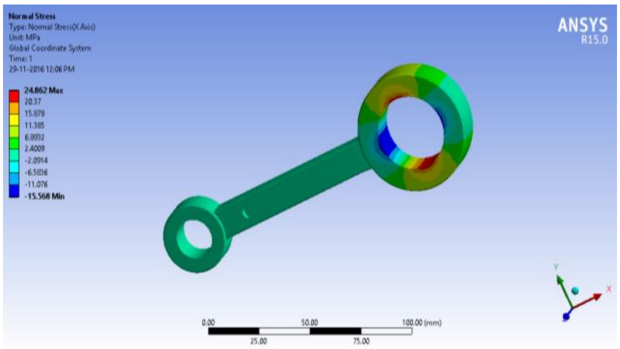

Fig.5.8.1Normal Stress In X Direction of Connecting Rod with I Beam(C-70 Steel)

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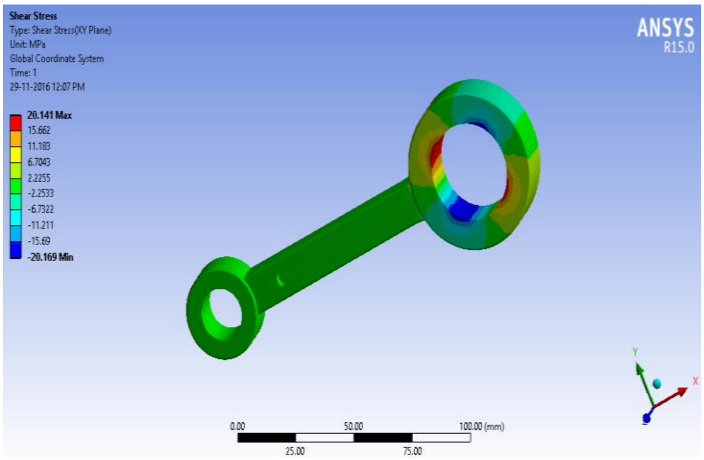

Fig.5.8.4 Shear stress in – XY Plane of Connecting Rod with I Beam(C-70 Steel

Sno	Type	Max(MPa)	Min(MPa)
1	Equivalent stress	36.836	1.608e-9
2	Normal stress(X-axis)	24.877	-15.574
3	Normal stress(Y-axis)	26.591	-15.524
4	Normal stress(Z-axis)	3.4364	-1.8052
5	Shear stress(XY plane)	20.152	-20.182
6	Shear stress(YZ plane)	1.6701	-2.1375
7	Shear stress(ZX plane)	1.8448	-1.5685
8	Total deformation	0.0027253	0.0
9	Directional deformation (X-axis)	0.0027246	-00005984
10	Directional deformation (Y-axis)	0.0017239	- 0.00172210.
11	Directional deformation (Z-axis)	0.0013227	-0.00013331

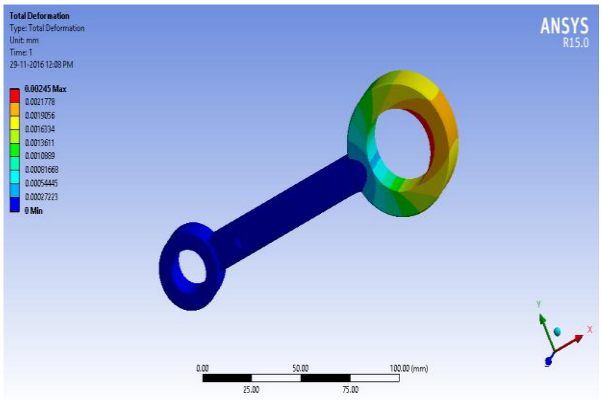

Fig.5.8.7 Total Deformation of Connecting Rod with I Beam(C-70 Steel)

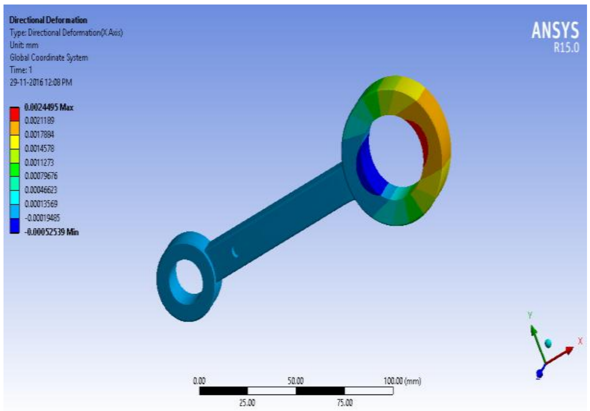

Fig.5.8.8 X- Directional Deformation in of Connecting Rod with I Beam(C-70 Steel)

Table 5.3 Stresses and deformations of C-70 steel

S no	Type	Max(MPa)	Min(MPa)
1	Equivalent stress	36.885	1.6874e-9
2	Normal stress(X-axis)	24.862	-15.568
3	Normal stress(Y-axis)	26.581	-15.537
4	Normal stress(Z-axis)	3.1648	-1.686
5	Shear stress(XY plane)	20.141	-20.169
6	Shear stress(YZ plane)	1.6827	-2.1596
7	Shear stress(ZX plane)	1.7751	-1.5019
8	Total deformation	0.00245	0.0
9	Directional deformation (X-axis)	0.0024495	- 000052539
10	Directional deformation (Y-axis)	0.0015439	-0.0015423
11	Directional deformation (Z-axis)	0.0011183	- 0.00011252

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Belgium

Here the material for used for this analysis is Belgium steel for connecting rod.After applying the same boundary conditions for this material and run the solution. The post processor is used to calculate the equivalent stress along the length of the connecting rod for this material. The equivalent stress indicated in the figure form rod small end to the crank pin.

I – SECTION RESULTS

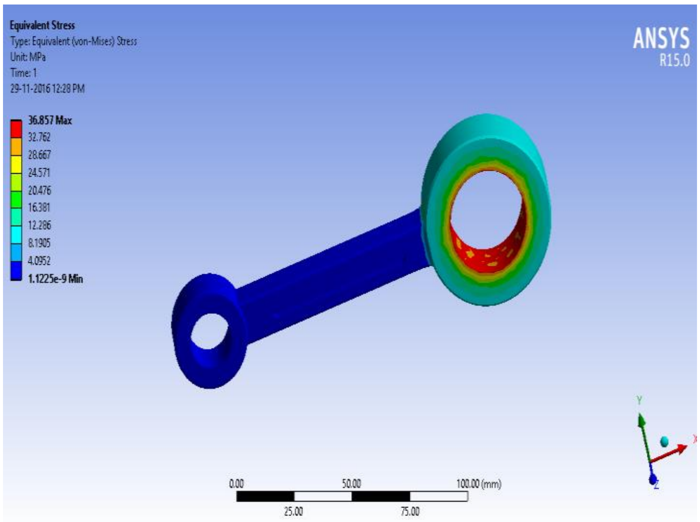

Fig.5.9.2 Equivalent Stress of Connecting Rod with I Beam (Belgium)

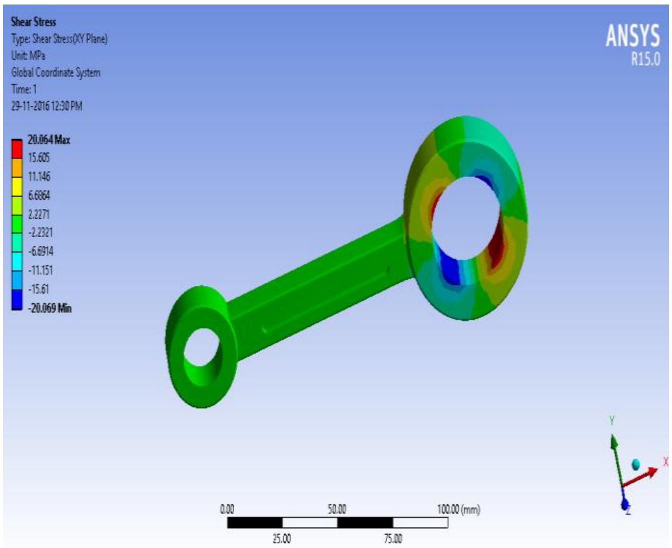

Fig.5.9.6Shear stress in – XY Plane of Connecting Rod with I Beam(Belgium)

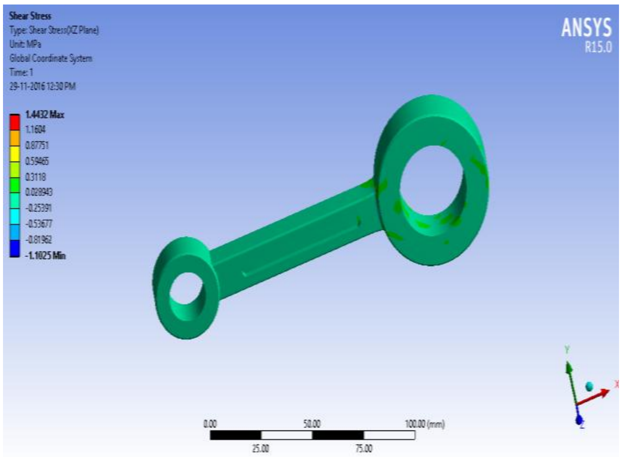

Fig.5.9.6.2 Shear stress in – XZ Plane of Connecting Rod with I Beam(Belgium)

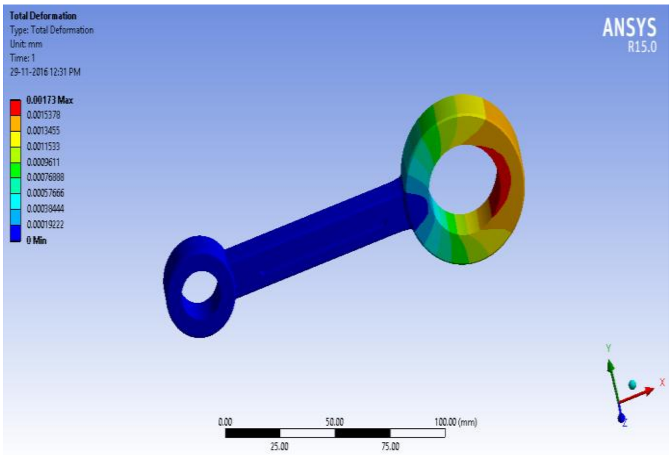

Fig.5.9.6.3 Total Deformation of Connecting Rod with I Beam(Belgium)

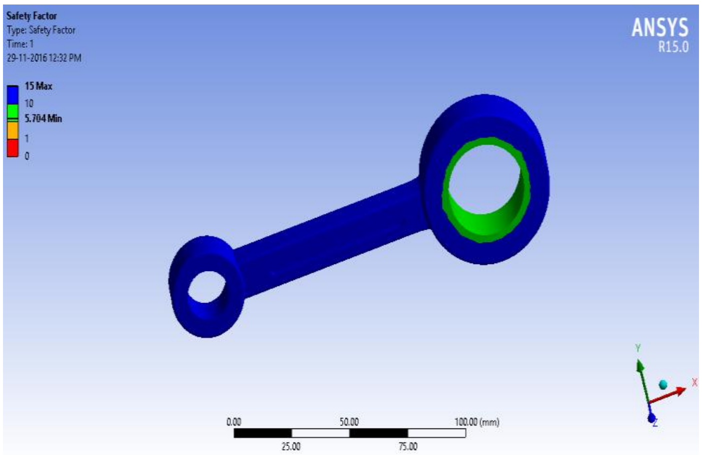

Fig.5.9.6.7 Factor of safety (Belgium)

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Table 5.4 Stresses and deformations of Belgium

S no	Type	Maximum(MPa)	Minimum(MPa)
1	Equivalent stress	36.857	1.125e-9
2	Nomal stress(X-axis)	24.871	-15.549
3	Nomal stress(Y-axis)	26.591	-15.524
4	Nomal stress(Z-axis)	3.4364	-1.8052
5	Shear stress(XY plane)	20.152	-20.182
6	Shear stress(YZ plane)	1.6701	-2.1375
7	Shear stress(ZX plane)	1.8448	-1.5685
8	Total deformation	0.0027253	0.0
9	Directional deformation (X-axis)	0.0027246	-00005984
10	Directional deformation (Y-axis)	0.0017239	-0.00172210.
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CONCLUSION

This thesis describes designing and Analysis of connecting rod. Currently existing connecting rod is manufactured by using Carbon steel. In this drawing is drafted from the calculations. A parametric model of Connecting rod is modelled using CATIA V5 R20 software and to that model, analysis is carried out by using ANSYS 13.0 Software. Finite element analysis of connecting rod is done by considering the materials, viz...

For C70 Steel, Belgium. The best combination of parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS software. Structural steel has more factor of safety, reduce the weight, increase the stiffness and reduce the stress and stiffer than other material like carbon steel. With Fatigue analysis we can determine the lifetime of the connecting rod.

The equivalent stress of C-70 steel is 36.885 MPa
The shear stress XY plane of C-70 steel is 20.141 MPa
The total deformation of C-70 steel is 0.00245
The equivalent stress of Belgium is 36.857 MPa
The shear stress XY plane of Belgium is 20.152 MPa
The total deformation of Belgium is 0.0027253

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