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Design & Analysis of Marine Ship Connecting Rod

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ABSTRACT

The connecting rod is the intermediate member between the piston and the crankshaft. Its primary function is to transmit the push and pull from the piston pin to the crank pin, thus converting the reciprocating motion of the piston into rotary motion of the crank. Existing connecting rod is manufactured by using iron. This project describes modeling and analysis of connecting rod. In this project connecting rod is replaced by chrome steel and titanium for Yamaha Fz-s motorbike. A 2d drawing is drafted from the calculations. A parametric model of connecting rod is modeled using creo parametric 2.0 software. Analysis is carried out by using ansys software. Connecting rod can be designed for weight and cost reduction also to increase the life time of connecting rod. Upto some level of extent the weight of the connecting rod is lighter and having more strength as compared to the original design. The maximum stress is within the allowable stress limit for chrome steel and titanium.

Keywords : Connecting Rod, Static Analysis, Creo Parametric 2.0 Software, Chrome Steel, Titanium

Normenclature:

A = cross sectional area of the connecting rod.
L = length of the connecting rod.
C = compressive yield stress.
Wcr = crippling or buckling load.
Ixx = moment of inertia of the section about x-axis
Iyy = moment of inertia of the section about y-axis respectively.
Kxx = radius of gyration of the section about x-axis
Kyy = radius of gyration of the section about y- axis respectively.
D = Diameter of piston
r = Radius of crank

I. INTRODUCTION

The connecting rod is the intermediate member between the piston and the Crankshaft. Its primary function is to transmit the push and pull from the piston pin to the crank pin, thus converting the reciprocating motion of the piston into rotary motion of the crank. 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 modeled using CATIA V5 R19 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... Forged steel. 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. Forged 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.

Tony George Thomas The connecting rod forms an integral part of an internal combustion engine. The connecting rod is acted upon by different types of loads while undergoing its operation. One of the main reasons contributing to its failure is fatigue. The aim of this study is to redesign the connecting rod by incorporating the manufacturing process effects into the analysis and obtain a better fatigue performance. The redesign is aimed at reducing the weight of the component. Heavy duty application's connecting rod was selected for the study. The analytically calculated loads acting on the small end of connecting rod were used to carry out the static analysis using ANSYS. A stress concentration was observed near the transition between small end and shank. A piston-crank connecting rod assembly was simulated for one complete cycle (0.02 seconds) using ADAMS to obtain the loads acting on small end of connecting rod. This force vs. time graph was converted into an equivalent stress vs. time graph. This stress vs. time graph was used as loading graph for fe-safe. The fatigue life calculated using fe-safe is 6.94×106 cycles and these results are validated with the help of Palmgren-Miner linear damage rule. The fatigue life of connecting rod can be further enhanced by incorporating manufacturing process effects in the analysis stage. Fatigue life was estimated by incorporating the shot peening process effects. An in-plane residual stress for the selected surface elements were applied for obtaining the beneficial effect of shot peening. There was an increment of 72% in fatigue life cycles). We conclude that shot peening can significantly increase the fatigue life of a connecting rod component.

II. METHOD

Specification Of The Problem

The objective of the present work is to design and analyses of connecting rod made of Forged steel. Steel materials are used to design the connecting rod. In this project the material (carbon steel) of connecting rod replaced with Forged steel .Connecting rod was created in CATIAV5 R19. Model is imported in ANSYS 13.0 for analysis. After analysis a comparison is made between existing steel connecting rod viz., Forged steel in terms of weight, factor of safety, stiffens, deformation and stress.

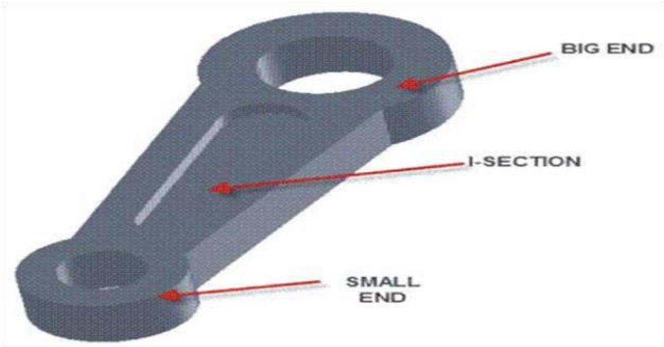

Figure 1. Schematic Diagram of Connecting Rod

Force Due To Gas Pressure And Pistion Inertia:

The direct load on the piston due to gas pressure is transformed to the connecting rod. This force can be calculated with the help of indicator diagram. Otherwise, empirically

Force due to gas pressure, FG = (3.14 $d^2/4$) * gas pressure [ref.PSGDB 7.122]

Force due to inertia of reciprocating parts, Fi = $\frac{R}{g}\omega^2\left[\cos\varnothing + \frac{\cos 2\varnothing}{l/r}\right]$

Where, d= diameter of piston

P=gas pressure

R=weight of the reciprocating Parts

r=radius of the crank

l= length of the connecting rod.

ω = angular velocity

The net force acting on the piston will be algebraic sum of the gas force and the inertia force.

F= FG $\pm$ Fi [ref. PSGDB 7.122]

Design Of Shank Of The Connecting Rod:

The shank of the connecting rod may be of circular section, rectangular section OR I-section. Connecting rods of circular and rectangular sections are generally used in the low speed engines where as in high speed engines connecting rod of I-section is preferred. In high-speed engines, the weight of the connecting rod should be as small as possible, without sacrificing strength, so that the inertia forces remain small. Considering these two aspects, the most suitable section for the shank is the I-section. The usual proportions chosen for the I-section are shown in figure 2 [ref. PSGDB 7.122]

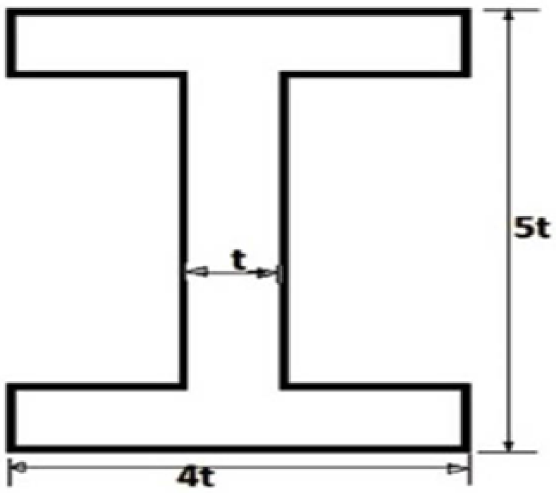

Figure 2

In general

From standards,

Thickness of flange and web of the section = t

Width of the section B = 4t

Height of the section H = 5t

Area of the section $A = 11t^2$

Moment of inertia about x axis $I_{xx} = 34.91t^4$ Moment of inertia about y axis $I_{yy} = 10.91t^4$

Therefore $I_{xx}/I_{yy} = 3.2$

So, in the case of this section (assumed section) proportions shown above will be satisfactory. Length of the connecting rod (L) = 2 times the stroke

L = 117.2 mm

According to Rankine's – Gordon formula,

$F = f_c A/(1+a(1/K_{xx}))$

Let,

A = C/s area of connecting rod, L = Length of connecting rod f_c = Compressive yield stress,

F = Buckling load

I_{xx} and I_{yy} = Radius of gyration of the section about x – x and y – y axis respectively K_{xx} and K_{yy} = Radius of gyration of the section about x – x and y – y axis respectively.

III. MODELLING

Steps Modeling Of Connecting Rod In

Connecting Rod has been modelled with the help of CREO PARAMETRIC 2.0 Software. The Orthographic & final Solid Model of connecting rod is shown in figures below. The following is the list of steps that are use to create the required model.

1. The base feature is created on three orthogonal datum planes.
2. Creating two circular entities on either sides of rod crank and piston pin end (with the help of sketcher Option). 3) Filling the material between the crank and piston pin End (With the help of EXTRUDE Option).
3. The second feature is also created on datum planes.
4. Using the EXTRUDE option the second feature is generated in between the two ends of the connecting rod.
5. Using the Protrude CUT option, the cut feature is generated on the second feature inorder to get the I section.
6. Then the creo file is converted into .iges file for exporting it into the ansys software for further processing.

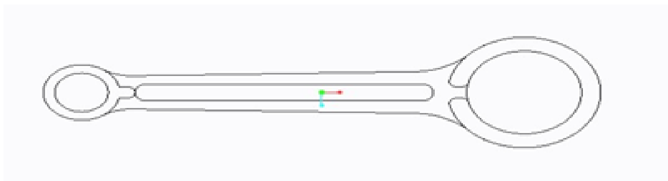

Figure 3. 2D Drawing for Connecting Rod.

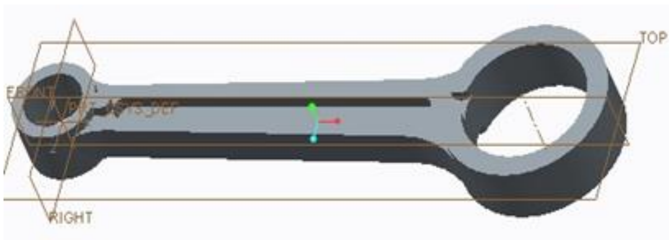

Figure 4. Solid Modelling of Connecting Rod

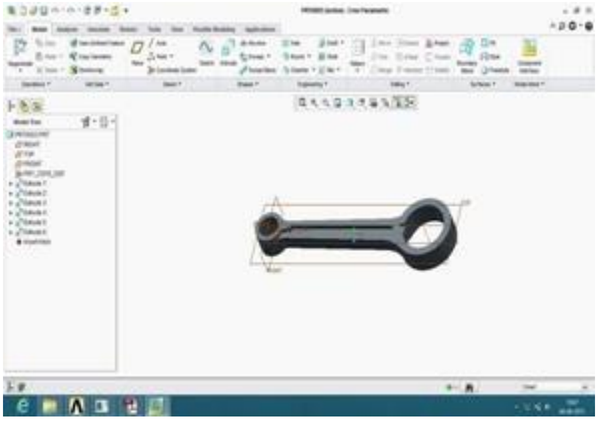

Figure 5. Solid Model of Connecting Rod with Work Sheet

IV. MATERIALS

Materials Used For Connecting Rod

Iron

Figure 5. Structure of Iron

Characteristics:

1) Iron is a ductile, gray, relatively soft metal and is a moderately good conductor of heat and electricity.
2) It is attracted by magnets and can be readily magnetized.
3) The pure metal is chemically very reactive and rusts readily in moist air, forming red-brown oxides.
4) Alpha iron, also known as ferrite, is the stable form of iron at normal temperatures.

Steps Involved In Analysing The Connecting Rod

The analysis is done by using ANSYS software by importing the .iges file from creo parametric. The procedure followed is given below

1) First the .iges file is imported into the ansys, File>Import>IGES>filename.
2) In the Ansys main menu, the Structural analysis is set in the pre-processor section.
3) The appropriate element type is given.
   Solid>Tet 10 node 187
4) The material properties are given.
5) Meshing of model was done.
6) One end of the connecting rod is fixed and the load is applied on the other end(big). 7) The solution was generated for current LS.
7) The result for von mises stress and deformed & undeformed shape was taken.

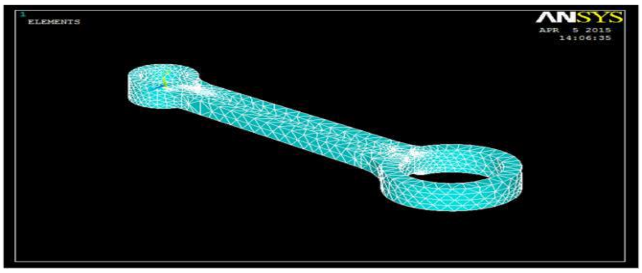

Figure 6.1. Meshing of Connecting Rod

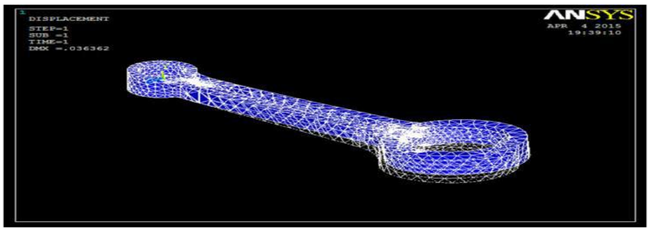

Figure 6.2. Def+undef of Iron

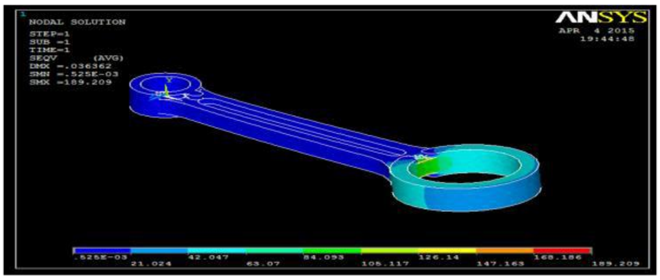

Figure 6.3. Vonmises Stress of Iron

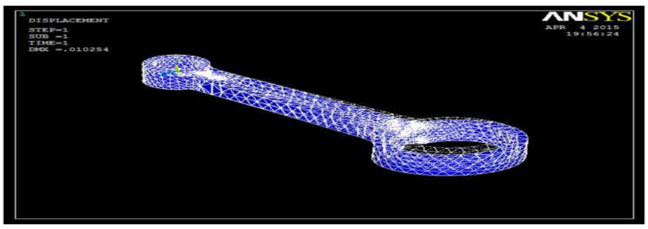

Figure 6.4. Def+undef of Chrome Steel

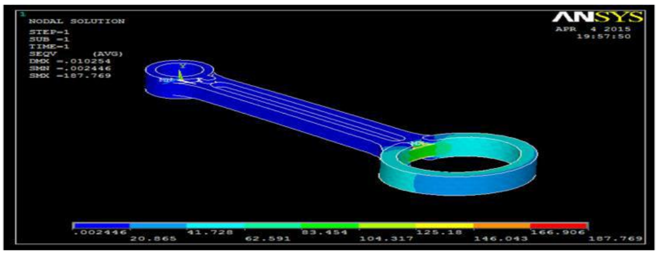

Figure 6.5. Vonmises Stress of Chrome Steel

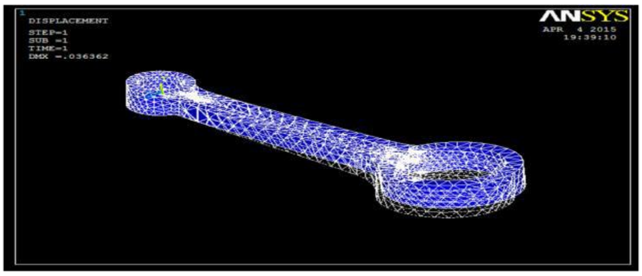

Figure 6.6. Def+undef of Titanium

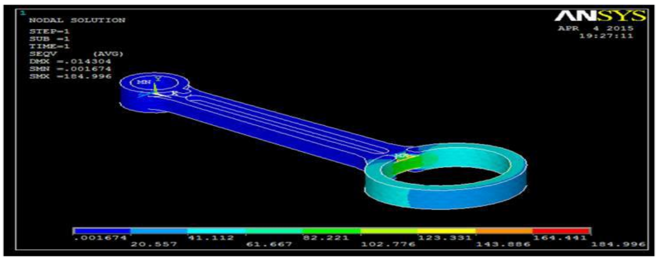

Figure 6.7. Vonmises Stress of Titanium

V. RESULTS AND DISCUSSION

5.1 Results For Weight Of Connecting Rod

IRON

Density of iron = $7.87\text{x}10^{-6}$ Kg/mm^3

Volume of connecting rod = $1.76911\text{x}10^4$mm^3

1)

2) **Vol. 4, Special Issue 6, May 2015**

Weight of connecting rod = Density × Volume

=$7.87\text{x}10^{-6}$ x$1.76911\text{x}10^4$

= 0.1392kg

CHROME STEEL

Density of chrome steel =$7.833\text{x}10^{-6}$ kg/mm^3

Volume of connecting rod =$1.76911\text{x}10^4$mm^3

Weight of connecting rod =Density × Volume

= 0.13857kg

Percentage of reduction in weight

= W of iron-W of chrome steel / W of iron

= 0.1392 - 0.13857 /0.727

= 0.452 kg

Titanium = W of iron - W of titanium / W of iron

=0.1392 - 0.0796 / 0.1392

= 0.42816 kg

5.2 Results For Stiffness Of Connecting Rod

IRON

Weight of connecting rod = 0.1392Kg

Deformation = 0.036362mm

Stiffness = Weight/Deformation

= 0.1392/0.036362 = 3.8221kg/mm

CHROME STEEL

Weight of connecting rod = 0.13857Kg

Deformation = 0.010254mm

Stiffness = Weight/Deformation

= 0.13857/0.010254 =13.5137 kg/mm

TITANIUM

Weight of connecting rod = 0.0796Kg

Table 1. Comparisons of Materials.

MATERIAL PROPERTIES	IRON	CHROME STEEL	TITANIUM
Stress Max.	189.209	187.769	184.996
Stiffness	3.82817	13.5137	5.5648
Deformation	0.036362	0.010254	0.014304

Deformation = 0.014304mm

Stiffness = Weight/Deformation

= 0.0796/0.014304 = 5.5648 kg/mm

VI. CONCLUSION

By checking and comparing the results of materials in above tables, the finalized results are shown below.

It explains about the various stresses to be considered while designing the connecting rod and different materials used and comparing the result of all material.

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