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LOAD ANALYSIS AND MATERIAL OPTIMIZATION OF CONNECTING ROD USING FEA METHODS

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Abstract - Internal combustion engines have at least one connecting rod to transmit the thrust of the piston to the crankshaft, and as the result the reciprocating motion of the piston is translated into rotational motion of the crankshaft. From the viewpoint of functionality, connecting rods must have the highest possible rigidity at the lowest weight capable to withstand varying loads. It has been found that structural failure of various components results in engine missing and starts producing noise and vibration during racing, mileage gets affected and black or white smoke arise; also pickup gets reduced. In automobile industry damaged or broken parts are generally too expensive to replace or repair especially in case of engine. In this concern here we present a review of causes along with preventive maintenance suggestions schedule for better engine life. Later on, finite element modeling and analysis will be performed using ANSYS 12.1 software package to perform a linear static and a coupled thermal-structural contact analysis of the component. A contact analysis is to be carried out to analyze the stresses arising from the interference of the connecting-rod bearing and the piston-pin bushing.

***Keywords*- Internal combustion engine, Connecting rod, Component failure, Finite element analysis, ANSYS**

I. INTRODUCTION TO FINITE ELEMENT METHOD

Finite element method is a numerical technique for tackling issues of designing and scientific material science. In this technique, a body or a structure in which the examination to be completed is subdivided into littler components of Finite measurements called Finite components. At that point the body is considered as a gathering of these components joined at a Finite number of joints called hubs or nodal focuses. The properties of each one kind of Finite component id acquired and amassed together and comprehended as entire to get result.

As such, in Finite element method, as opposed to tackling the issue for the whole body in one operation, we detail the mathematical statements for every Finite component and join together them to get the result of the entire body. Finite element method is utilized to take care of physical issues including muddled geometrics, stacking and material properties which can't be understood by expository technique. This system is widely utilized as a part of the field of structural mechanics, liquid mechanics, hotness exchange, mass exchange, electric and attractive fields issues
Based on application, the finite element problems are classified as follow:

i) Structural problems
ii) Non-structural problems

1. Structural problems: In structural problems, displacement at each nodal point is obtained. By using these displacement solutions, stress and strain in each element can be calculated.

2. Non-structural problem: In non structural problems, temperature or fluid pressure at each nodal point is obtained. By using these values, properties such as heat flow, fluid flow etc, for each element can be calculated.

II. MODELING OF CONNECTING ROD

The model of connecting rod was generated in CATIA V5 R19 on the basis of the specifications given in Fig.2.1. The actual model of connecting rod is shown in Fig.2.2

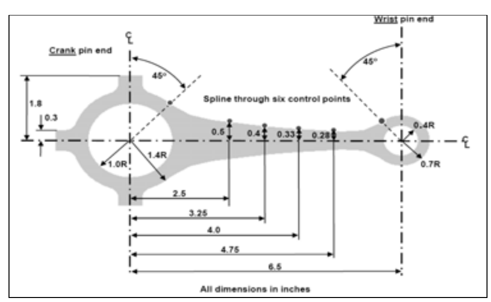

Fig. 2.1 - Specifications of connecting rod.

- Creating the 2D cross section on XY plane using two circle, line and fillets with the help of sketcher option.

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- Fill material in sketch with the help of pad command.
- Creation of hole on piston end and crank end with the help of pocket command.
- Creation of second sketch in shank portion of the connecting rod.
- Pocket the second sketch on both sides of the shank up to desired depth to make the I-section.
- Select an arbitrary rectangle in XY plane at the centre of the crank end in order to make the crank end open.
- Cut half of the crank end with the help of pocket command

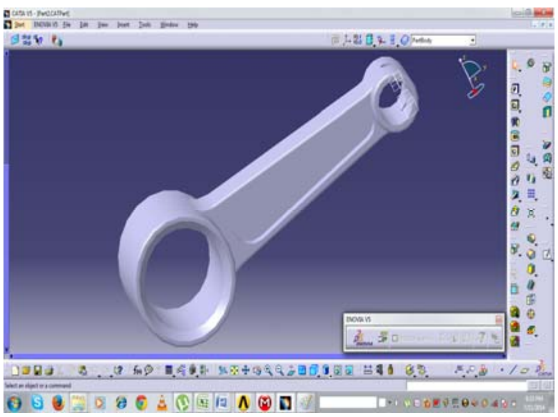

Fig 2.2- Model of connecting rod generated on CATIA

A cylinder of Legend Honda Wonder, market accessible is chosen for the present examination. The measurements of chose cylinder are discovered utilizing vernier caliper, screw gauge and classified in table. As per the measurements of the cylinder is produced utilizing CATIA V5. The model of piston is demonstrated in fig.2.3. It is transported in into outline modeler of ANSYS Workbench.

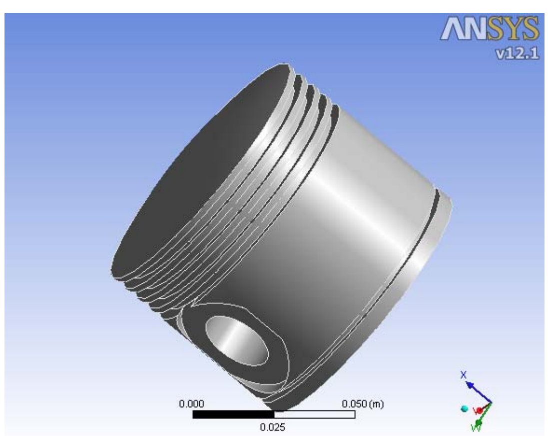

Fig. 2.3- Model of connecting rod generated on CATIA

Selected material	Cast iron
Young's modulus (E)	1.78e+05 MPa
Piossion's ratio	0.3
Density	7.197e+06 Kg/mm^3
Tensile yield strength	110 MPa
Tensile ultimate strength	110 MPa
Compressive yield strength	400 MPa
Compressive ultimative strength	0 MPa

Table 2.1-Mechanical Properties of Cast Iron

III. MESHING

The next stage of the modeling is to create meshing of the created model. The below said parameters are used for meshing. The mesh model of piston is shown in figures given below-

Type of element: Tetrahedron
Number of nodes: 71910
Number of element: 41587

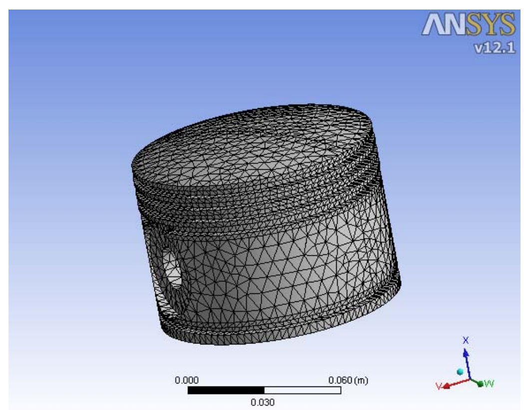

Fig 3.1-Meshing of a piston

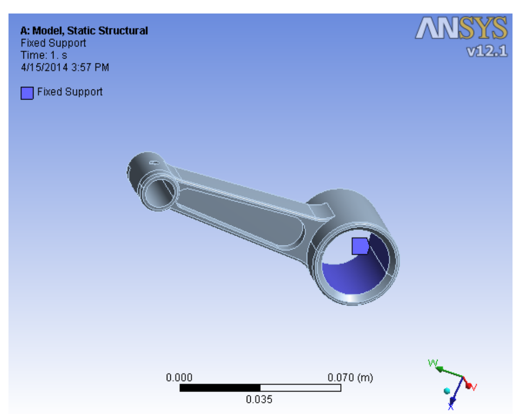

Fig 3.2- Fixed support to the connecting rod

IV. VON- MISES STRESSES

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When, the material used for selected connecting rod is structural steel the result of the von-Mises stresses is shown in the fig.4.1

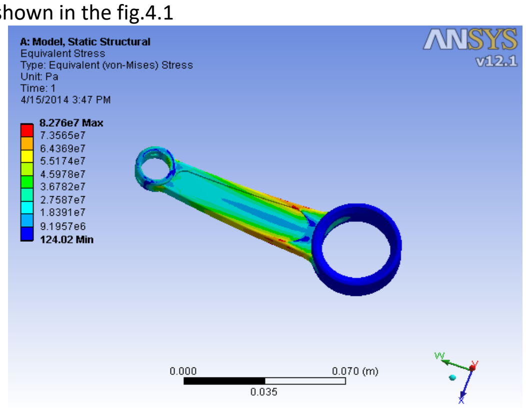

Fig 4.1- Von-Mises stresses in structural steel

When, the material used for selected connecting rod is structural steel en45 and the result of the von-Mises stresses is shown in the fig.4.2

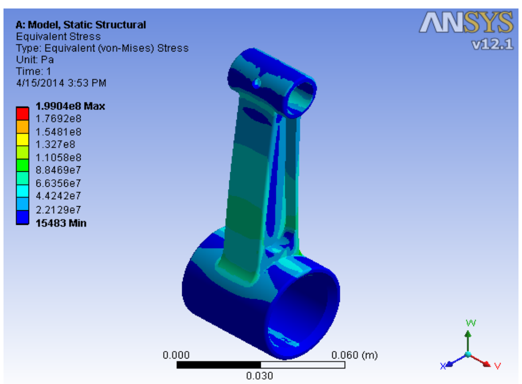

Fig.4.2- Von-Mises stresses in structural steel en45

When, the material used for selected connecting rod is cast iron and the result of the von-Mises stresses is shown in the fig.4.3

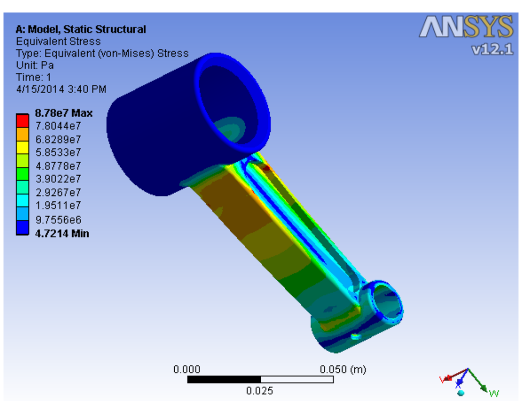

Fig. 4.3 Von-Mises stresses in cast iron

When, the material used for selected connecting rod is aluminum and the result of the von-Mises stresses is shown in the fig.4.4

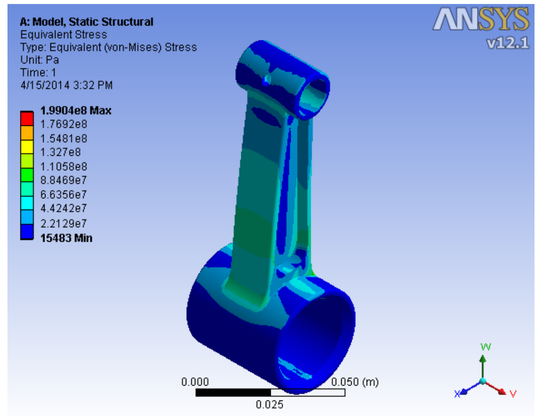

Fig. 4.4 Von-Mises stresses in aluminum

V. EQUIVALENT STRAINS

When, the material used for selected connecting rod is structural steel and the result of the von-Mises strains or equivalent strains is shown in the fig. 5.1

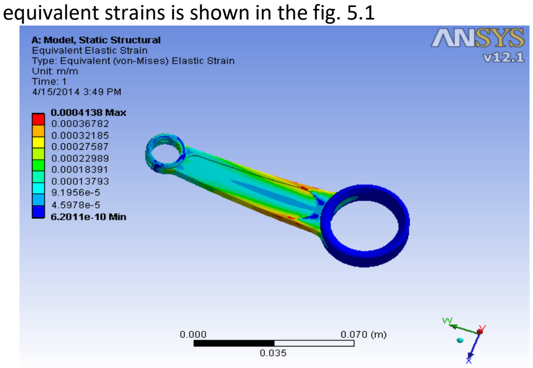

Fig. 5.1- Equivalent or von-Mises strain in structural steel

When, the material used for selected connecting rod is structural steel en45 and the result of the von-Mises strains or equivalent strains is shown in the fig.5.2

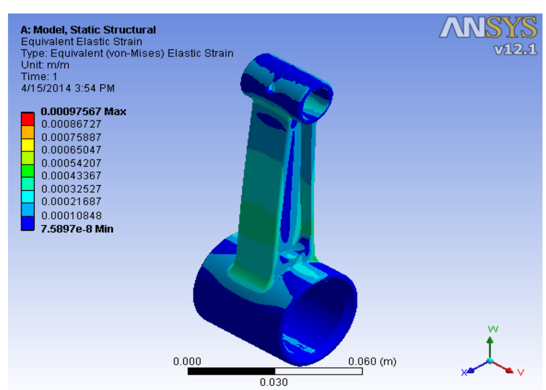

Fig. 5.2- Equivalent or von-Mises strain in structural steel en45

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When, the material used for selected connecting rod is cast iron and the result of the von-Mises strains or equivalent strains is shown in the fig.5.3

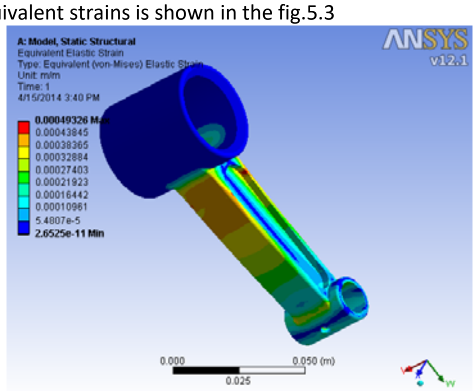

Fig.5.3- Equivalent or von-Misses strain in cast iron

When, the material used for selected connecting rod is aluminum and the result of the von-Mises strains or equivalent strains is shown in the fig.5.4

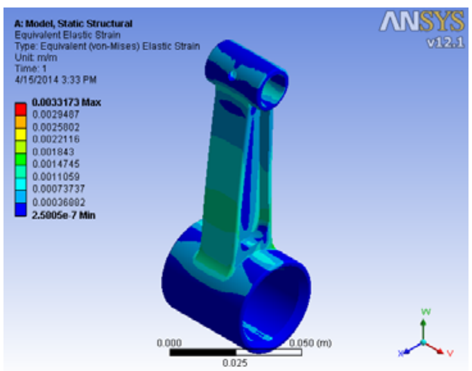

Fig 5.4- Equivalent or von-Mises strain in aluminum

VI. TOTAL DEFORMATION

When, the material used for selected connecting rod is structural steel and the result of the total deformation is shown in the fig.6.1

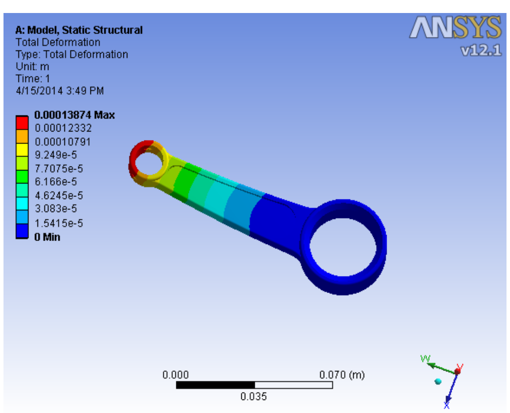

Fig.6.1- Total deformation in structural steel

When, the material used for selected connecting rod is structural steel en45 and the result of the total deformation is shown in the fig.6.2

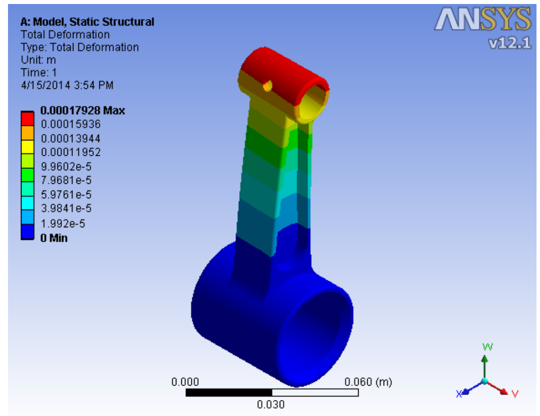

Fig.6.2- Total deformation in structural steel en45

When, the material used for selected connecting rod is cast iron and the result of the total deformation is shown in the fig.6.3

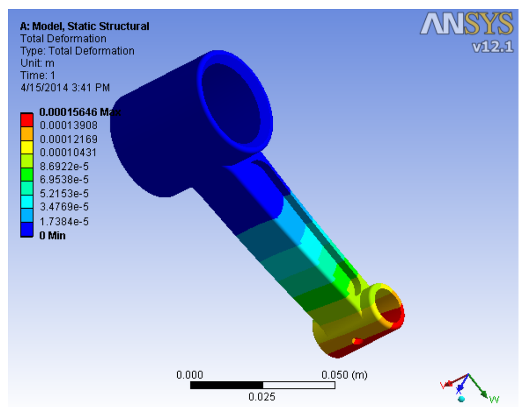

Fig.6.3- Total deformation in cast iron

When, the material used for selected connecting rod is aluminum and the result of the total deformation is shown in the fig.6.4

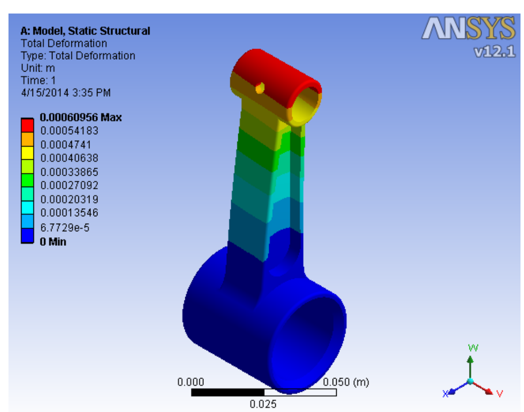

Fig.6.4- Total deformation in aluminum

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VII. RESULTS

Similarly analysis on factor of safety , total deformation and overall life was also done. All the parameters we studied for different materials and their obtained values have been summarized in the table 7.1

S.NO.	NAME OF THE MATERIAL	VON-MISES STRESSES		EQUIVALENT STRAINS		FACTOR OF SAFETY		TOTAL DEFORMATION		LIFE	
		MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.
1	STRUCTURAL STEEL	8.276e7	124.02	0.000413	6.2011e-10	15	1.0416	0.000138	0	1e6	1e6
2	STRUCTURAL STEEL EN45	1.9904e8	15483	0.000975	7.589e-8	15	0.433	0.000179	0	1e6	26093
3	CAST IRON	8.78e7	4.7214	0.000493	2.6525e-11	15	0.981	0.000156	0	1e6	8.995e5
4	ALUMINUM	8.26E+07	15483	0.0011982	2.580e-7	15	0.0011982	0.00040153	0	1e6	1.00E+06

Table 7.1 - Values forVon-mises stresses, strains, factor of safety , total deformation and overall life for chosen materials.

After analyzing all the readings, we found that a big weight reduction can be done using aluminum alloy instead of gray cast iron for manufacturing of connecting rod

$$weigt\ reduction = \frac{mass\ of\ \ using\ gray\ cast\ iron - mass\ of\ usin\ alluminum\ alloy}{mass\ of\ connecting\ rod\ using\ gray\ cast\ iron}$$

$$\%reduction = \frac{0.29054 - 0.10971}{0.29054} * 100$$

= 62.2%

VIII. CONCLUSION

Its been observed that the greater part of the uniting bar of IC Engine are made of Cast iron .Yet on correlation of distinctive materials for comparable limit conditions & stacking conditions its been watched that out of the three materials Aluminum combination is the most suitable material on the premise of Anxiety, Security element, Life, Warm Resistivity, exhaustion & harm on the grounds that such connecting rod does not falls flat even at different burdens not at all like Cast iron bar. What's more by utilizing aluminum compound we can additionally decrease the weight of the connecting rod. Thus improving the outline of the interfacing bar.

Titanium composite are likewise utilized within High velocity engines where expense is not contemplated. As titanium is additionally among the arrangement of better material for connecting rod however it likewise builds the general expense of the outline. From the equal anxiety examination it is watched that the territory near foundation of the more diminutive end is extremely inclined to failure, may be because of higher pounding load because of gudgeon stick get together.

As the anxiety quality is greatest around there and burdens are dreary in nature so risks of exhaustion failure are constantly higher near this locale It is likewise watched that the base hassles among all stacking conditions, were found at wrench end top and also at cylinder end. So the material might be diminished from those segments, in this manner diminishing material expense. For further streamlining of material element dissection of interfacing bar is required.

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