

Static Analysis of Connecting Rod for Weight optimization

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Abstract – The main objective of the paper is to design and optimize the performance of the connecting rod in an I.C. engine by replacing the traditional material with a composite material. This paper deals with the design of a connecting rod for Hero Splendor vehicle using aluminium fly ash silicon composite. The model of the connecting rod is developed using a modeling software. The static analysis of the designed connecting rod is done using FEM software and the results are compared with that of Al360. By using aluminium fly ash silicon composite weight optimization of the connecting rod is achieved. The designed connecting rod is having higher stiffness to weight ratio than the existing connecting rod.

Key Words: connecting rod, aluminium fly ash silicon composite, optimization, FEM

1. Introduction

The internal combustion engine connecting rod is one of the most vital parts of the engine. It converts the reciprocating motion of the piston to rotary motion of the crank shaft. It is subjected to various complex loads due to gas pressure and the inertia forces of the reciprocating parts. The stresses induced into the connecting rod due to the thrust and the pull of the piston are bending stresses, tension and compression in the axial directions. The connecting rod should be able to withstand these forces in adverse environmental conditions. The design and the weight of the connecting rod influence the performance of the engine. In this paper design of the I section of the connecting rod is done for aluminium fly ash silicon composite material for Hero Splendor vehicle.

2. Design of I section of connecting rod

The axial and the bending stresses induced in the connecting rod are due to gas pressure and the inertia forces of the piston. These forces are taken into consideration while designing the I section. I section is selected for the cross section of the connecting rod to provide maximum rigidity with minimum weight.

2.1 Pressure calculation

Consider a 100cc engine :
Engine type air cooled 4-stroke

$$\text{Bore} \times \text{Stroke (mm)} = 52.4 \times 57.88$$

$$\text{Displacement} = 97.2 \text{ c.c}$$

$$\text{Maximum Power} = 5.5 \text{kw at } 8000 \text{rpm}$$

$$\text{Maximum Torque} = 1.05 \text{kgm at } 4000 \text{rpm}$$

$$\text{Compression Ratio} = 9.1:1$$

$$\text{Density of petrol at } 288.855 \text{ K} - 737.22 \times 10^{-9} \text{ kg/mm}^3$$

$$\text{Molecular weight } M - 114.228 \text{ g/mole}$$

$$\text{Ideal gas constant } R - 8.3143 \text{ J/mol.k}$$

From Ideal gas equation,

$$PV = m \cdot R_{\text{specific}} \cdot T$$

Where,

P = Pressure

V = Volume

m = Mass

R_{specific} = Specific gas constant

T = Temperature

But, mass = density * volume m

$$= 737.22 \times 10^{-9} \times 97.22 \times 10^3 = 0.0716 \text{ kg}$$

$$R_{\text{specific}} = R/M \quad R_{\text{specific}} = 8.3143 / 0.11423$$

$$R_{\text{specific}} = 72.787 \text{ Nm/kg}^{\circ}\text{K}$$

$$P = (0.0716 \times 72.786 \times 288.85) / (97.2 \times 10^3 \times 10^{-9})$$

$$P = 15.48 \text{ MPa}$$

Force acting on the Piston F_p

$$F_p = P \cdot A$$

$$F_p = 15.48 \times 10^6 \times 2.1565 \times 10^{-3}$$

$$F_p = 33398.38 \text{ N}$$

2.2. Design of I section

General I section

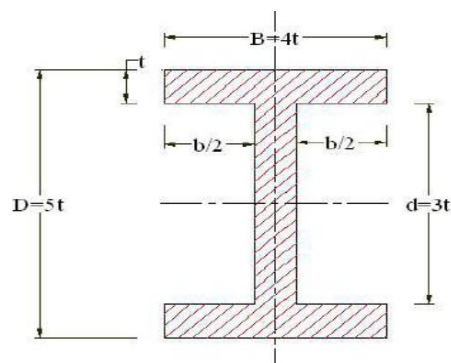


Fig-1 Standard Dimensions of I section

Thickness of the flange and web of the section = t

Width of the section B = 4t

Height of the section H = 5t

Area of the section A = 11t²

Moment of inertia about x axis I_{xx} = 34.91t⁴

Moment of Inertia about y axis I_{yy} = 10.91t⁴

Herefore I_{xx}/I_{yy} = 3.2

According to Rankine-Gordon formula,

$$F = \frac{\sigma * A}{1 + \alpha \left(\frac{L}{K}\right)^2}$$

$$33398.38 = \frac{363 * 11t * t}{1 + 0.0002 \left(\frac{115.76}{1.78t}\right)^2}$$

Let, A = C/s area of connecting rod

L = length of connecting rod

σ = 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

T = 3.023 mm

Therefore

Width B = 4t = 12.092 mm

Height H = 5t = 15.115 mm

Area = 11t² = 100.523 mm²

Height of the piston end H₁ = 1.1H = 1.25H

H₁ = 1.1 * 15.115 = 16.625 mm

Height at crank end H₂ = 0.9H = 0.75H

H₂ = 0.8 * 15.115 = 13.6035 mm

Dimensions of big end

P = D_i * D_o * P_b

D_i = 0.81 * 39 = 31.59 mm

Dimensions of small end

D_o = 17.75 mm

D_i = 0.625 * 17.75 = 11.09375 mm

2.3 Material Properties

Material	Al composite
Ultimate Tensile Strength	422MPa
Yield Strength	363MPa
Young's Modulus	70GPa
Poisson's Ratio	0.33
Density	2611.61kg/m ³

3. Model of Connecting Rod

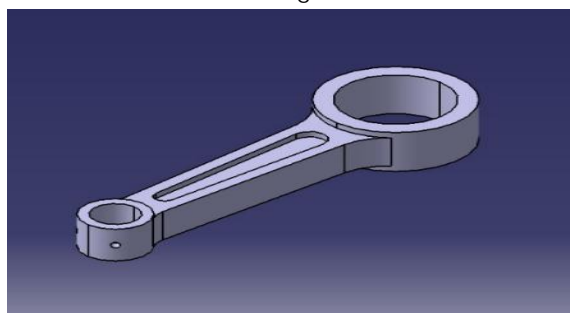


Fig-1: Connecting Rod Model

4. Analysis of Connecting rod Model

For the finite element analysis 15.48MPa pressure is applied. The meshing and the analysis are carried out using ANSYS software.

4.1 Von Mises Stresses

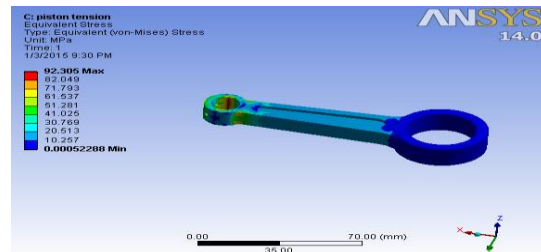


Fig2: Von Mises stresses in connecting rod for Al fly ash composite

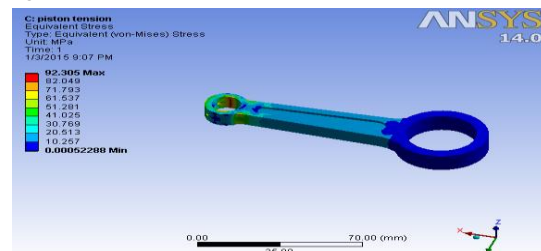


Fig.3: Von Mises stresses in connecting rod for Al360

The maximum stress developed in connecting rod is 92.305MPa which is same as that of Al360.

4.2 Deformation in Connecting Rod

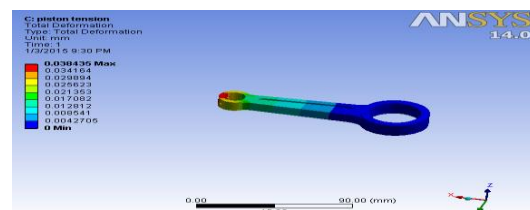


Fig3: Deformation for Al fly ash composite

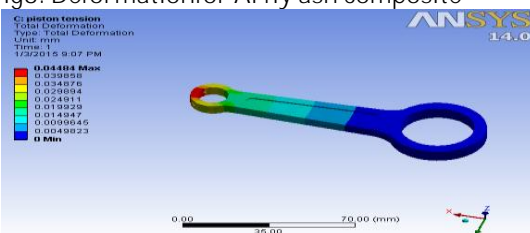
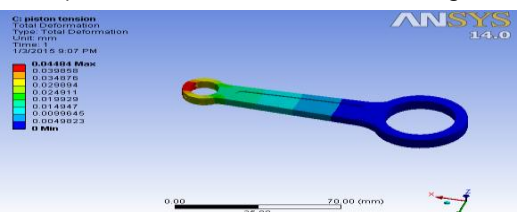


Fig4: Deformation in connecting rod for Al360

The maximum deformation obtained in the connecting rod is 0.038435 mm which is less than 0.4484 mm for Al360.

4.3 Equivalent Strain in Connecting rod



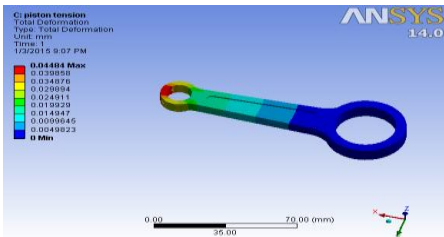


Fig5: Equivalent strain in Al fly ash composite

Fig 6: Equivalent strain in Al360

The maximum strain developed in the connecting rod is 0.0013414 which is less than 0.001565 for Al360

5. Result

The table given below compares the analysis results for the new model with existing connecting rod model

	Al Fly ash composite	Al360
Von Mises Stress	92.305MPa	92.305MPa
Deformation	0.038435	0.04484
Equivalent strain	0.0013414	0.001565

Table 2: Comparison of the results

6. Conclusion

Weight of the connecting rod can be reduced by replacing the old material Al360 by aluminium fly ash silicon composite which has higher strength than Al360 and is manufactured using industrial waste such as fly ash.

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BIOGRAPHIES



Mr. Farhan Pathan is currently pursuing his M.E. in Machine Design from SPP university.

