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Modeling and Analysis of Two Wheeler 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 Carbon steel. This paper describes modeling and analysis of connecting rod. In this project connecting rod is replaced by Aluminum reinforced with Boron carbide for Suzuki GS150R motorbike. A 2D drawing is drafted from the calculations. A parametric model of connecting rod is modelled using PRO-E 4.0 software. Analysis is carried out by using ANSYS software.

Finite element analysis of connecting rod is done by considering two materials ,viz.. Aluminum Reinforced with Boron Carbide and Aluminum 360. 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. Compared to carbon steel, aluminum boron carbide and aluminum 360, Aluminum boron carbide is found to have working factor of safety is nearer to theoretical factor of safety, 33.17% to reduce the weight, to increase the stiffness by 48.55% and to reduce the stress by10.35% and most stiffer.

Keywords: *Connecting rod, Static analysis, Carbon steel, Aluminum, Aluminum reinforced with Boron carbide, Aluminum 360.*

I. INTRODUCTION

Connecting rods are widely used variety of engine. The function of connecting rod is to transmit the thrust of the piston to the crank shaft, and as the result the reciprocating motion of the piston is translated into rotational motion of the crank shaft. It consist of a pin –end. A shank section, and crank an end .Pin end and crank end pin holes are machined to permit accurate fitting of bearings. One end of the connecting rod is connected to the piston by the piston pin. Connecting rods are subjected to forces generated by mass and fuel combustion .Theses two forces results in axial load and bending stresses. A connecting rod must be capable of transmitting axial tension, axial compression, and bending stress caused by the thrust and full of the piston and by centrifugal force. Finite element (FEM) Modal is a modern way for fatigue analysis and estimation of the component .The influential component factors are able to change such as material .cross section conditions etc.

In modern automotive internal combustion engine, the connecting rods are most usually made of steel for production engine. But can be made of aluminum or titanium for high performance of engines of cast iron for application such as motor scooters. They are not rigidly fixed at either end , so that the angle between the connecting rod and piston can change as the rod moves up and down and rotates around the crank shaft .T he big end connects to the bearings journal on the throw connecting rod is under tremendous stress from the reciprocating load represented by the piston ,actually stretching and being compressed with every rotation, and the load increases to the third power with increasing engine speed .Connecting rod for automotive applications are typically manufactured by forging from either wrought steel or powder metal. Schematic diagram for connecting rod as shown in figure 1

Fig:1 Schematic diagram of connecting rod.

II. SPECIFICATION OF THE PROBLEM

The objective of the present work is to design and analyses of connecting rod made of Aluminum Reinforced with Boron carbide. Steel and aluminum materials are used to design the connecting rod. In this project the material (carbon steel) of connecting rod replaced with Aluminum Reinforced with Boron carbide. Connecting rod was created in Pro-E. Model is imported in ANSYS 12.0 for analysis. After analyis a comparison is made between exisisting steel and aluminum connecting rod viz., Aluminum Reinforced with Boron carbide in terms of weight, factor of safety, stiffnes, deformation and stresse.

III. THEORETICAL CALCULATIONS OF CONNECTING ROD

1. A connecting rod is a machine member which is subjected to alternating direct compressive and tensile forces. Since the compressive forces are much higher than the tensile force, therefore the cross-section of the connecting rod is designed as a strut and the Rankin formula is used.

2. A connecting rod subjected to an axial load W may buckle with x-axis as neutral axis in the plane of motion of the connecting rod, {or} y-axis is a neutral axis. The connecting rod is considered like both ends hinged for buckling about x-axis and both ends fixed for buckling about y-axis. A connecting rod should be equally strong in buckling about either axis.

Let

A = cross sectional area of the connecting rod.

L = length of the connecting rod.

σc =compressive yield stress.

Wcr =crippling or buckling load.

Ixx and Iyy =moment of inertia of the section about x-axis and y-axis respectively.
Kxx and Kyy =radius of gyration of the section about x-axis and y- axis respectively.
Rankin formula = (Ixx=4Iyy).

3.1 PRESSURE CALCULATION FOR 150CC ENGINE

Suzuki GS 150 R Specifications

Engine type air cooled 4-stroke
Bore × Stroke (mm) = 57×58.6
Displacement = 149.5CC
Maximum Power = 13.8bhp@8500rpm
Maximum Torque = 13.4Nm@6000rpm
Compression Ratio = 9.35/1
Density of Petrol C_8H_{18} = 737.22kg/m^3
= 737.22E^{-9}kg/mm^3
Temperature = 60F = 288.855K
Mass = Density × Volume
= 737.22E^{-9}×149.5E^3
= 0.11Kg
Molecular Weight of Petrol 114.228 g/mole
From Gas Equation,
PV=Mrt
R = R*/Mw = 8.3143/.114228
= 72.76
P = (0.11x72.786x288.85) / 149.5E^3
P = 15.469 Mpa.

3.2 DESIGN CALCULATION FOR CARBON STEEL

Thickness of flange & web of the section = **t**
Width of section **B= 4t**
The standard dimension of I SECTION.

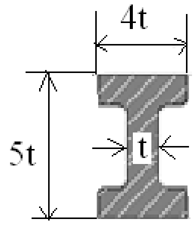

Figure2: Standard dimension of I - Section.

Height of section **H=5t**
Area of section A= 2(4t×t) +3t×t
A=11t²
MI of section about x axis:
Ixx$=1\backslash 12\,(4t\,(5t)^3-3t\,(3t)^3)$ = $\mathbf{419\backslash 12t^4}$
MI of section about y axis:
$\mathbf{I_{YY}} = (2+1\backslash 12t(4t)^3+1\backslash 12(3t)\,t^3)$ = $\mathbf{131\backslash 12\ t^4}$
$\mathbf{I_{XX}\backslash I_{YY}=3.2}$
Length of connecting rod (L) = 2 times the stroke
L = 117.2 mm
Buckling load w_B = maximum gas force × F.O.S
$$\mathbf{W_B} = \frac{\sigma_C \times A}{1+a(L\backslash K_{XX})^2} = \mathbf{37663\ N}$$
$\boldsymbol{\sigma_C}$ = compressive yield stress = **415MPa**
Kxx = $I_{XX}\backslash A$
Kxx = 1.78t
a= $\sigma_c\backslash\pi^2E$
a = 0.0002
By substituting σ_C, A, a, L, K_{XX} on W_B then
$4565t^4-37663t^2-81639.46=0$
t^2 =10.03
t=3.167mm
t=3.2mm
Width of section B = 4t =12.8mm
Height of section H = 5t = 16mm
Area A = 11t^2 = 112.64mm^2
Height at the big end (crank end) = H_2 = 1.1H to 1.25H
H_2 =17.6mm
Height at the small end (piston end) = 0.9H -0,75H
H_1 =12mm

3.3 DESIGN CALCULATION FOR ALUMINUM 360.

Buckling load w_B = maximum gas force × F.O.S
$$\mathbf{W_B} = \frac{\sigma_C \times A}{1+a(L\backslash K_{XX})^2} = \mathbf{31386\ N}$$
$\boldsymbol{\sigma_C}$ = compressive yield stress = **172 MPa**
Kxx = $I_{XX}\backslash A$
Kxx = 1.78t
a= $\sigma_c\backslash\pi^2E$
a = 0.002
By substituting σ_C, A, a, L, K_{XX} on W_B then
$4565t^4-37663t^2-81639.46=0$
t^2 =16.64
t =4.08mm
t =4.1mm
Width of section B = 4t =16.4mm
Height of section H = 5t = 20.5mm
Area A = 11t^2 = 184.91mm^2
Height at the big end (crank end) = H_2 = 1.1H to 1.25H
H_2 =25.625mm
Height at the small end (piston end) = 0.9H -0,75H
H_1 =18.45mm

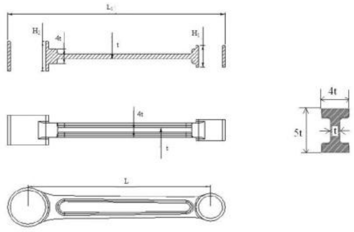

Figure3: 2D drawing for connecting rod.

IV. SPECIFICATION OF EXISTING CONNECTING ROD

Table 1 shows the specifications of the connecting rod for carbon steel (Suzuki GS). The typical chemical composition of the material is 0.61%C, 0.095% Al, 0.82%Mn, 0.00097%Br, 0.145% C, 7.8Co, 75.56Fe and 3.25 Mo.

Table: 1 Specifications of connecting rod:

S.No	Parameters	Value
1	Bore × Stroke (mm)	57×58.6
2	Length of connecting rod	112 mm
3	Thickness of connecting rod	For C.S = 3.2mm For AL 360 = 4.1 mm
4	Width of connecting rod	For C.S = 12.8mm For AL 360 = 16.4 mm

5	Height of connecting rod	For C.S H_1 =12mm H_2 =17.6mm
		For AL 360 H_1 =18.45mm H_2 =25.625mm

V. STRUCTURAL ANALYSIS OF CONNECTING ROD

Dimensions of Width and height of the conecting rod is For C.S = 12.8mm and For AL 360 = 16.4 mm. A 3-D model of connecting is used for analysis in ANSYS 12.0. The loading conditions are assumed to be static. Analysis done with pressure load applied at the piston end and restrained at the crank end or other load applied at the crank end and restrained at the piston end. The element choosen is SOLID 187, it was used with the tetrahedral option, making it a 10-node element with 3 degrees of freedom at each node. The finite element analysis is carried out on carbon steel connecting rod as well as on three different materials of carbon steel, aluminum boron carbide and aluminum 360. From the analysis the equivalent stress (Von-mises stress), strain, displacements were determined and are shown in figure 4-15. Table 2 shows the comparative of factor of safety for three different materials.

VI. STRUCTURAL ANALYSIS OF CONNECTING ROD

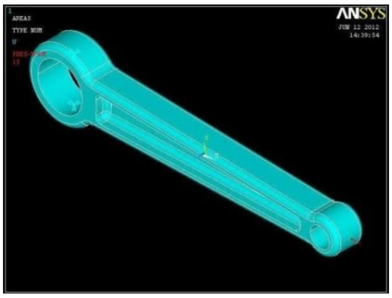

Figure4: loads and boundary conditions.

6.1 CARBON STEEL:

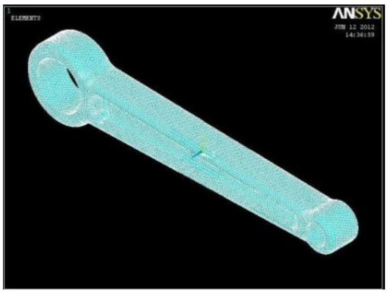

Figure5: Mesh of carbon steel.

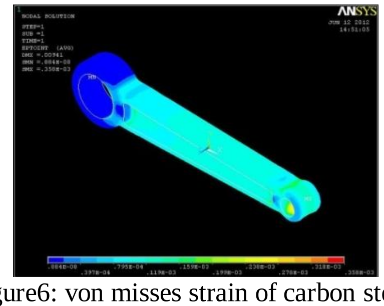

Figure6: von misses strain of carbon steel.

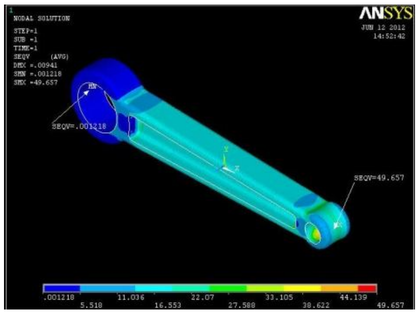

Figure7: von misses Stress for carbon steel.

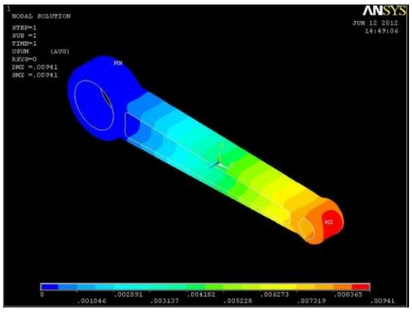

Figure8: Displacement of carbon steel.

6.2 ALUMINUM 360:

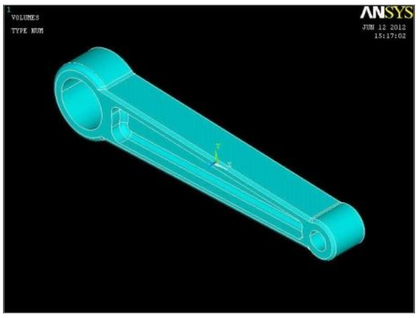

Figure9: modeling of aluminum 360.

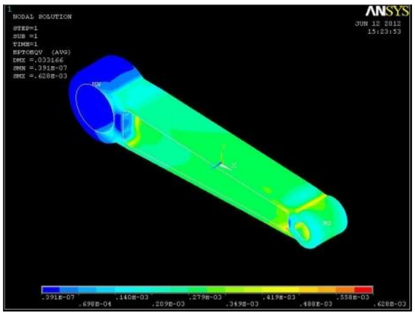

Figure10: von misses strain of aluminum 360.

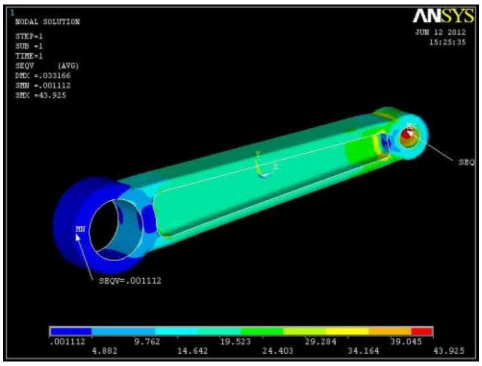

Figure11: von misses stress of aluminum 360.

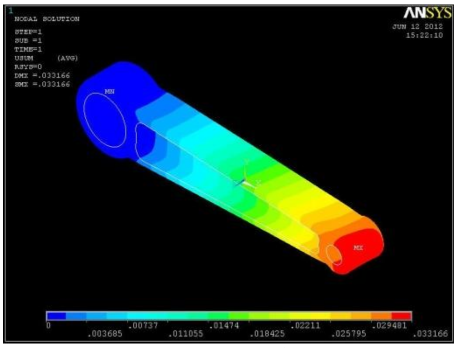

Figure12: Displacement of aluminum 360.

6.3 ALUMINUM BORAN CARBIDE:

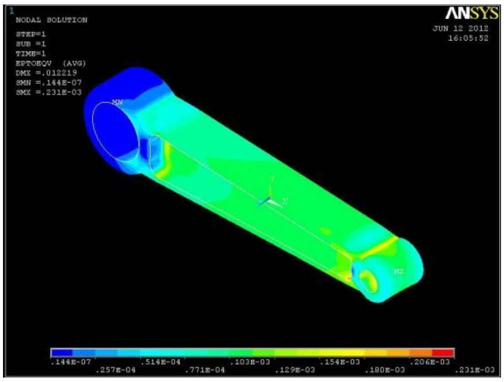

Figure13: von misses train of aluminum boron carbide.

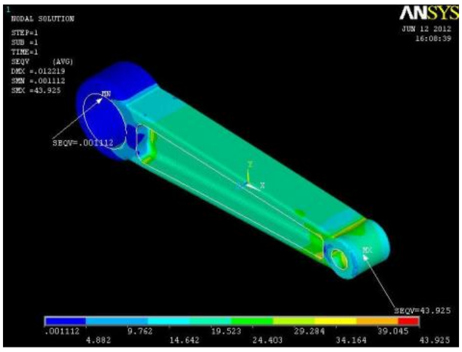

Figure14: von misses stress aluminum boron carbide.

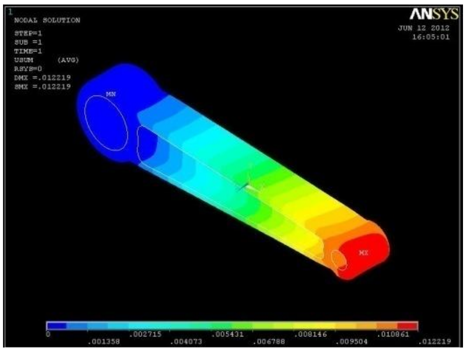

Figure15: Displacement aluminum boron carbide.

VII. RESULTS

Table 2. Comparison of factor of safety.

Material properties	Carbon steel	Aluminum 360	Aluminum boron carbide
Yield strength (Mpa)	415	172	300
Tensile strength (Mpa)	540	317	485
Theoretical Factor of safety (N)	6	6	6
Allow stress (Mpa)	69.16	28.47	50
Ansys result (Mpa)	49	43.925	43.925
Working Factor of safety (N)	8.47	4	6.95

7.1. RESULT FOR WEIGHT OF CONNECTING ROD

Density of Carbon steel = $7.87e^{-6}$ Kg/mm^3
Volume of connecting rod = 92419.78mm^3
Weight of connecting rod = Density × Volume
=7.87e-6×92419.78
= 0.727 kg
= 7.131 N

1. Density of Al 360 =2.685e-6 kg/mm^3
Volume of connecting rod =180935.21mm^3
Weight of connecting rod =Density × Volume
= 0.48581 kg
= 4.765 N

Percentage of reduction in weight = W of Carbon steel-W of Al 360 / W of Carbon steel
=0.727-0.48581/0.727
=0.3317

Aluminum boron carbide = W of Carbon steel-W of Aluminum boron carbide/W of Carbon steel
=0.727-0.48581/0.727
=0.3317

7.2. RESULT FOR STIFFNESS OF CONNECTING ROD:

Carbon steel

Weight of connecting rod =0.727Kg
Deformation =0.00941mm
Stiffness =Weight/Deformation
=0.727/0.0094
=77.34 kg/mm

Aluminum360

Weight of connecting rod =0.48581Kg
Deformation =0.0033166mm
Stiffness =Weight/Deformation
=0.48581/0.00331
=146.77 kg/mm

Aluminum boron carbide

Weight of connecting rod =0.48581Kg
Deformation =0.012219mm
Stiffness = Weight/Deformation
= 0.48581/0.012219
= 39.7585 kg/m

7.3. RESULT FOR PERCENTAGE OF INCREASE IN STIFFNESS:

Aluminum 360 =77.34-146.77/77.34
= -0.8977
Aluminum boron carbide = 77.34-39.7585/77.34
= 0.4855

7.4. RESULT FOR PERCENTAGE OF STRESS REDUCTION:

Aluminum 360 =49.625-43.925/49.625
=0.1035
Aluminum boron carbide =49-43.925/49
=0.1035

VIII. GRAPHS

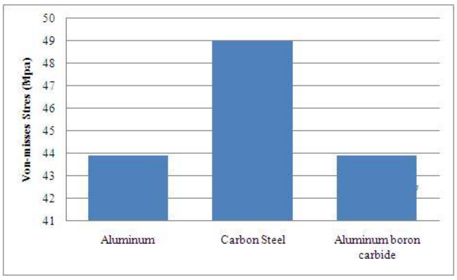

Fig 16: Von-Misses Stress for three materials.

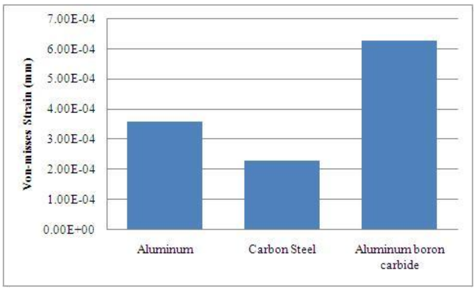

Fig 17: Von-Misses Strain for three materials.

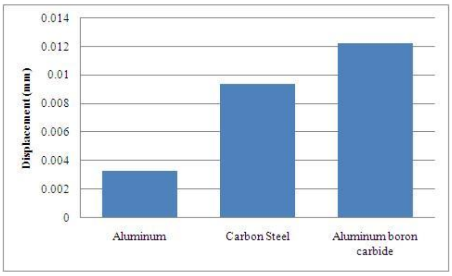

Fig 18: Displacement for three materials.

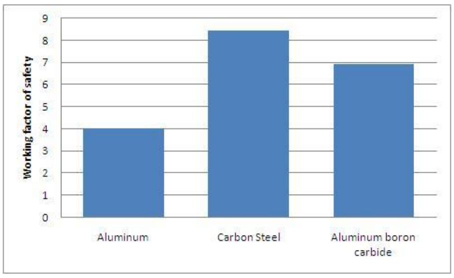

Fig 19: working factor of safety for three materials.

IX. CONCLUSIONS

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

For considering the parameters,
The working factor of safety is nearer to theoretical factor of safety in aluminum boron carbide.
Percentage of reduction in weight is same in Aluminum 360 and aluminum boron carbide.
Percentage of increase in stiffness in aluminum boron carbide is more.
Percentage of reducing in stress ALUMINIUM BORON CARBIDE and ALUMNUM is same than CARBON STEEL.

REFERENCES

1. Afzal, A. and A. Fatemi, 2004. "A comparative study of fatigue behaviour and life predictions of forged steel and PM connecting rods". SAE Technical Paper, 1: 1529.
2. Anonymous, 2008. "Nissan Z24engine Maintenance and Repayments catalogue". Megamotor Co.
3. Chen, N., L. Han, W. Zhang and X. Hao, 2006. "Enhancing Mechanical Properties and Avoiding Cracks by Simulation of Quenching Connecting Rod". Material Letters, 61: 3021-3024.
4. El-Sayed, M.E.M. and E.H. Lund, 1990. “Structural optimization with fatigue life constraints,” Engineering Fracture Mechanics, 37(6): 1149-1156.
5. Jahed Motlagh, H., M. Nouban and M.H. Ashraghi, 2003. "Finite Element ANSYS". University of Tehran Publication, PP: 990.
6. Khanali, M., 2006. "Stress analysis of frontal axle of JD 955 combines". M.Sc. thesis. Thran University, 124.
7. Kolchin, A. and V. Demidov, 1984. "Design of Automotive Engines". MIR Publication.
8. Meriam, J.L. and L.G. Kraige., 1998. Engineering Mechanics, 5th Edition, New York, john willey, 712.
9. Repgen, B., 1998. “Optimized Connecting Rods to Enable Higher Engine Performance and Cost Reduction,” SAE Technical Paper Series, Paper No. 980882.
10. Shigley, J.E. and C.R. Mischke, 2001. "Mechanical Engineering Design", McGraw-Hill, New York, 776. Webster, W.D., R. Coffell and D. Alfaro, 1983.
11. “A Three Dimensional Finite Element Analysis of a High Speed Diesel Engine Connecting Rod,” SAE Technical Paper Series, Paper No. 831322.

BOOKS:

1. Machine design by R.S. KHURMI, J.K GUPTA.
2. Design data by PSG.
3. A text book of Machine Design by S.Md. JALALUDEEN.