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Design and Analysis of Connecting Rod for High-Speed Application in I.C Engine

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***Abstract*— Connecting rod is most important part of IC Engine and its intermediate link between the piston and crank which converting the reciprocating motion of the piston to rotary motion of crank. The main objective of this paper is to Design of connecting rod for high speed application in IC engine using two different materials likes Aluminum and Aluminum Alloy (ALFASIC) and also mentions the its mechanical properties which are required for Design of Connecting rod. And find the optimal solution after the theoretical calculation and also suggest suitable material for connecting rod in IC Engine.**

Keywords*— Connecting rod, Aluminum, Aluminum alloy (ALFASIC)

I. INTRODUCTION

The automobile Engine connecting rod is a High volume production critical component. It connects reciprocating piston to rotating crank shaft, transmitting the thrust of the piston to the crank shaft. For manufacturing of connecting rods the various material are available, mostly cast Iron was used in automobile sector. But its have more density, that leads to increasing weight of connecting rod. Hence we need to find the alternative solution. Now a day's aluminum material is used by replacing carbon steel. And recently aluminum also replaced by aluminum alloy (ALFASIC) connecting rod which more suitable for high speed application.

In this paper describe the design and modeling analysis IC engine connecting rod using two different materials. 1st one cast aluminum and 2nd one aluminum fly ash silicon carbide based composite material. Compare to the cast aluminum to the ALFASIC composite found to have less weight and better stiffness. By carrying out these modification to engine element will result ineffective reduction of weight increase of durability of particular part will lead to decrease of overall weight improvement in its traction parameter and increasing performance of Engine

II. MECHANICAL PROPERTIES OF MATERIAL

a) Aluminum (AL 360)

Sr. no	Mechanical properties	Values
1	Yield strength (MPA)	170
2	Ultimate strength (MPA)	303
3	Modulus of elasticity (GPA)	60
4	Density (g/cm3)	2.8
5	Poisons ratio	0.33

Table no.1

b) Aluminum alloy (ALFASIC) (Aluminum 6061) – (9%.sic) & (15% fly ash)

Sr. no	Mechanical properties	Values
1	Yield strength (MPA)	363
2	Ultimate strength (MPA)	422
3	Modulus of elasticity (GPA)	70
4	Density (g/cm3)	2.61
5	Poisons ratio	0.33

Table no. 2

III. DESIGN OF CONNECTING ROD

Taking 180cc engine configuration to calculating connecting rod thickness of I section
Displacement – 178.60 cc
Maximum power -16.8 BHP @ 8500 rpm
Maximum Torque – 14.2 N-m @ 6500 rpm
Engine Description – 4-stroke, Petrol Engine, Air cooled, single cylinder
Bore Diameter – 63.5 mm
Stroke length – 56.4 mm

From standard for high speed application I section of connecting Rod are used and According to design Data book the following empirical relation with related to Thickness (t) in mm

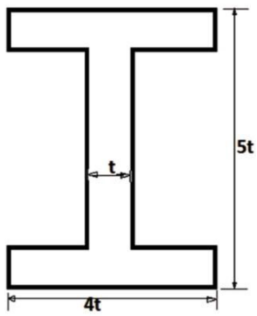

Fig.1: I Section for connecting rod

Thickness of flange and web of the section = (t) mm
Width of the section B = 4t
Total height of I section H = 5t
Area of I section $A = 11\ t^2$
Moment of inertia about X axis and Y axis Ratio is
$I_{xx}/I_{yy} = 3.2$

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Length of the connecting Rod (L)
=2 times of stroke of the
= 56.4 x 2
= 112.8 mm

Kxx & Kyy Radius of gyration of the section about x-x and y-y axis respectively
$(Kxx)^2$ =Ixx/A
Kxx= 1.78 t

Pressure calculation for connecting rod following are the consideration used

Compression ratio = 9.35/1
Density of petrol at 274 k is 737.22 x 10^{-9} g/cc
Molecular weight m(petrol)= 114.228 g/mole
Ideal gas constant R = 8.3143 j/mol –k

Mass of the air fuel mixture in the cylinder
= Density of petrol x volume of the cylinder
=737.22 x 10^{-9} x 178.60
=0.13 Kg

R specific = R/Mass
=8.314/0.13
=63.95

Pressure on connecting Rod

P=m x $R_{specific}$ x T/V
=0.13 x 63.95 x 274/178.60
=12.75 N/mm^2

Fp = Force acting on piston
=Area of cylinder x Gas pressure

Fp=(3.14/4) x$(63.5)^2$ x 12.75
= 40378.24 N/mm^2

Maximum inertia load on the piston

Fi= m x w^2 x r x (1+1/n)

Where,
M= mass of air fuel mixture =0.13 Kg
W=angular velocity (2 N/60) = 890.11 rad. /sec
R= crank radius = (stroke length /2)=56.4/2= 28.2 mm
N=ratio of length of connecting rod to crank radius = (112.8/28.2)=4
Putting all value in given formulae
We get Maximum inertia load on the piston

Fi = 3604 N

Net load on piston
F=Force acting on piston -Maximum inertia load on the piston-
F = Fp –Fi
=36774.24 N

Using Racking –Gordon formula for find the thickness of I section

W =(Fc x A)/(1+ a(l/Kxx)^2)

Where,
W =Buckling load in N
A= Area of I section = 11 t^2
Fc= Material compressive Yield stress in N/mm^2
For Aluminum is 170 N/mm^2, and Aluminum Alloy (ALFASIC) is 363 N/mm^2
Buckling formula constant = a
For Aluminum and ALFASIC Composite is 1/500
Length of connecting rod =l in mm =112.8 mm
Kxx= radius of the Gyration of the section about x-x Axis = 1.78 t

VI. RESULT

Description / Material	Aluminum	ALFASIC
Thickness of I section T=t mm	5.07	3.78
Width of I section W=4t mm	20.20	15.12
Height of I section H=5t mm	25.35	18.90
Area Of I section A=11t^2 mm^2	282.75	157.17
Height at the piston end H1=0.64 x H mm	16.224	12.09
Height at the Crank end H2=1.25 x H mm	31.68	23.62

Connecting rod Small End Calculation
Force on piston (Fp) = 40378.25 N
Fp= Projected area x Bearing pressure
The all allowable bearing pressure for the piston pin push is usually taken from 12.5 to 16 MPA

And (l/d) ratio for the piston pin Bush is taken from 1.5 to 2 it made of phosphor bronze bush of 3 mm thickness
Fp= dp x lp x pb
Where,
Fp – force on piston N
dp – diameter of piston pin, mm
pb – permissible bearing pressure piston pin, N/mm2
40378.25= dp x 1.5dp x 16
dp= 41.01 mm
lp= 1.5 dp=61.52 mm
dpo= dp+2tb+2tm
=41.01=(2x2)+(2x5)
=53.01 mm

Connecting rod Big End calculation
Fp=dc x lc x pc
Where,
dc- Diameter of Big End bearing, mm
lc – Length of crank pin, mm
pc- Permissible Bearing pressure crank pin, N/mm2
The all allowable bearing pressure for the piston pin push is usually taken from 5 to 10 MPA
And (l/d) ratio for the piston pin Bush is taken from 1.25 to 1.5 it made of bronze or steel material with thin lining (1 mm or less)
40378.25= dc x 1.5dc x 10
dc = 51.88 mm

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lc = 1.5 x 51.88 = 77.82 mm
dco = dc + 2tb + 2tm + 2tmb
=51.88+(2*2)+(2*5)+(2*3)
=71.88 mm
Where
Thickness of bush (tb) = 3 to 5 mm
Marginal thickness (tm) = 5 to 10 mm
Marginal thickness for bolt (dp) = 3 to 6 mm

Bolt design bearing pressure for big end pb2 = 10.8 to 12.6 N/mm2 and length of the crank pin lc = (1.0 to 1.25) d2
Root diameter of the bolt
= ((2 Fi)/(π x stroke)) ^0.5
= (2 x 3604.0/ π x 56.4)
=6.37 mm
(db)= 1.2 root diameter of the bolt
=1.2 x 6.37
=7.65 mm

Modeling and analysis of cast aluminum (old material)

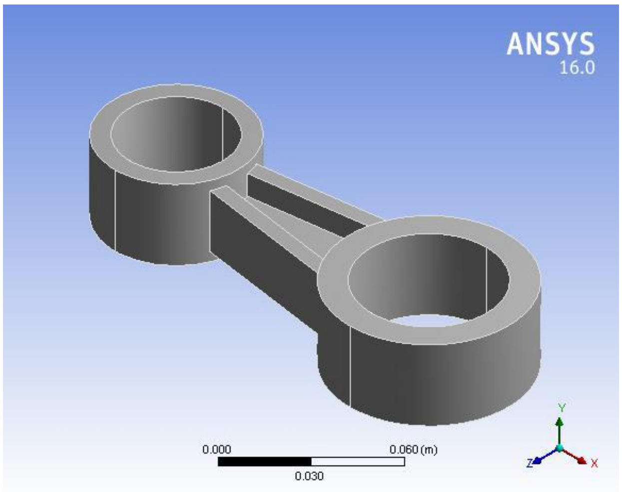

Fig.1 Model

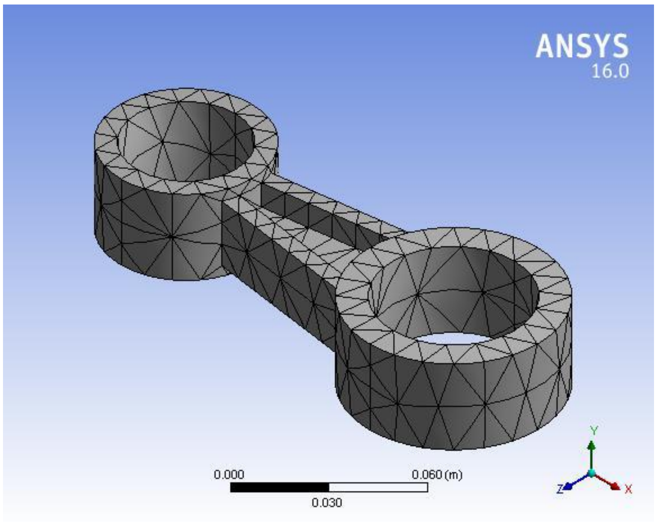

Fig.2 Mesh

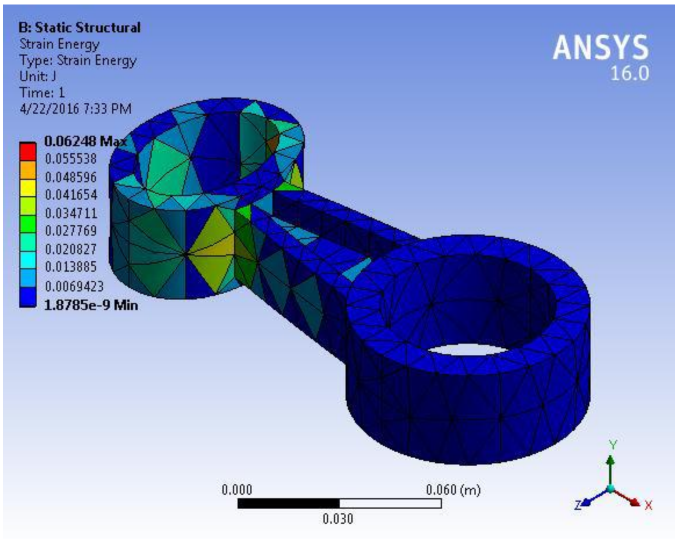

Fig.3 Strain Energy

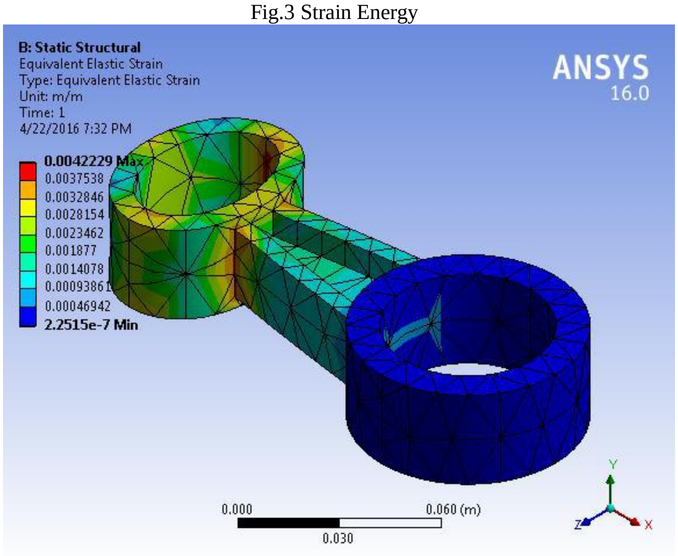

Fig.4 Equivalent Elastic Strain

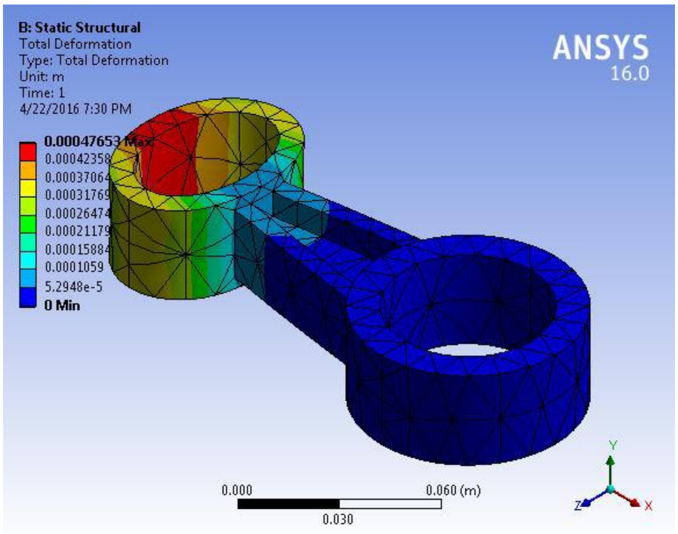

Fig. 5 Total Deformation

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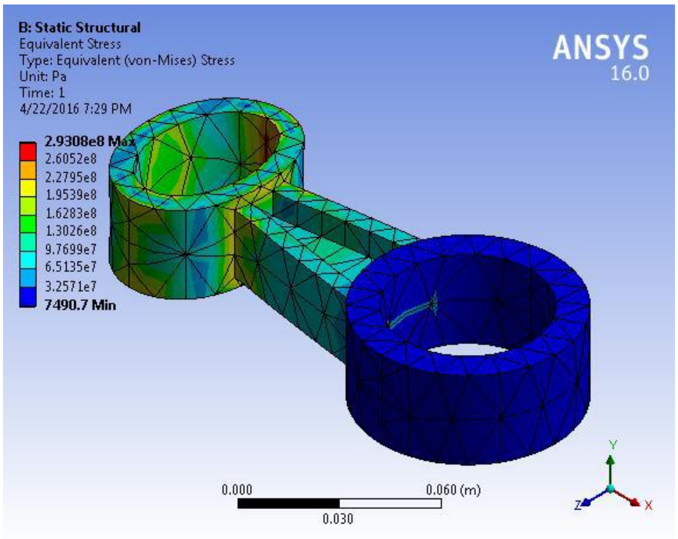

Fig.6 Equivalent Stress

Modeling and analysis of ALFASIC composite

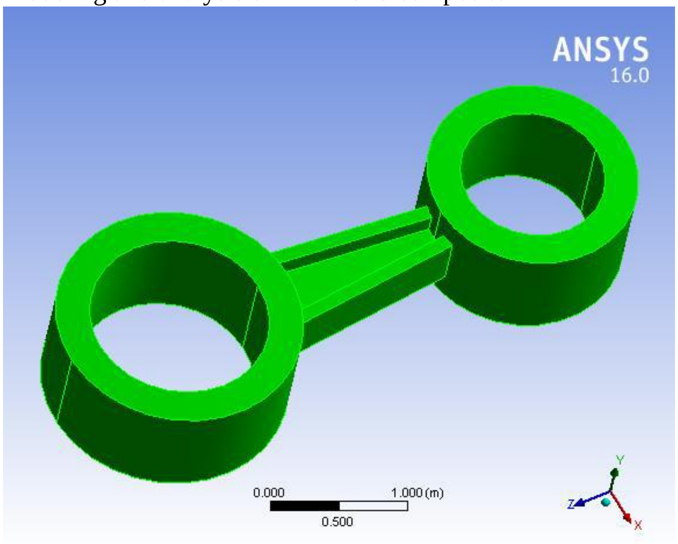

Fig.7 Model

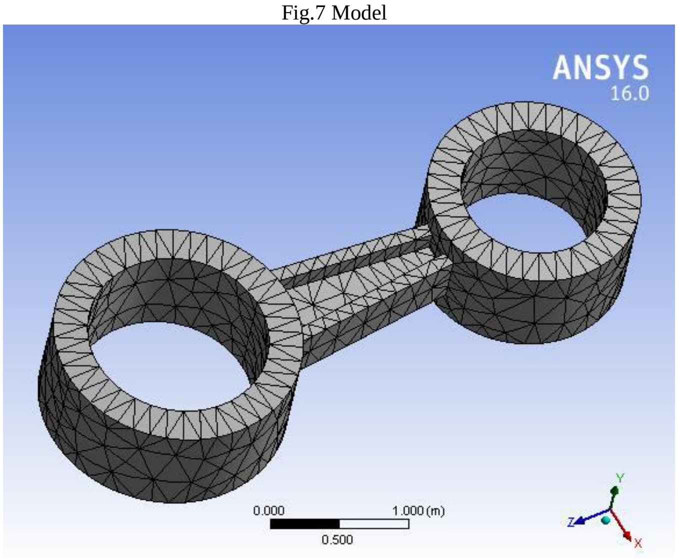

Fig. 8 Mesh

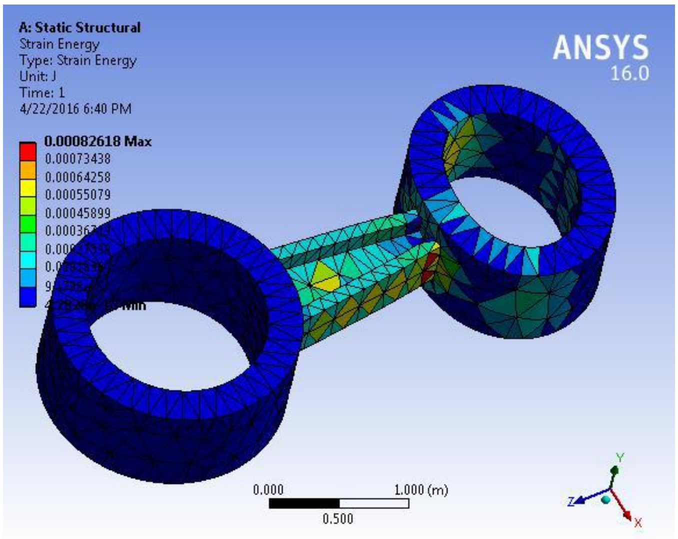

Fig. 9 Strain Energy

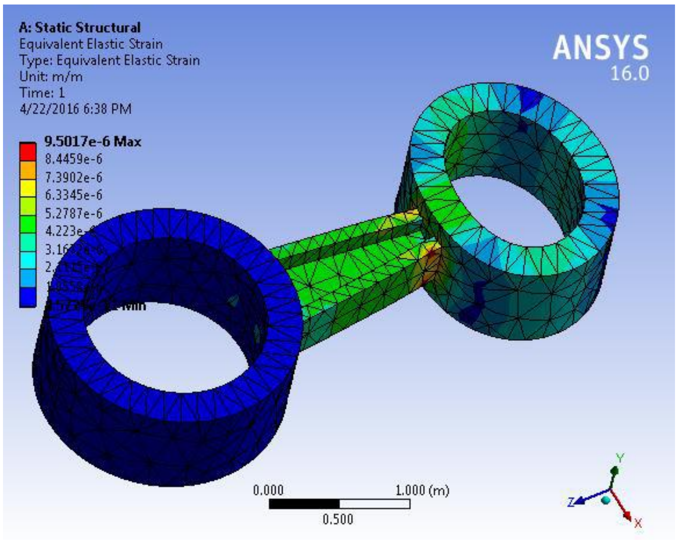

Fig . 10 Equivalent Elastic Strains

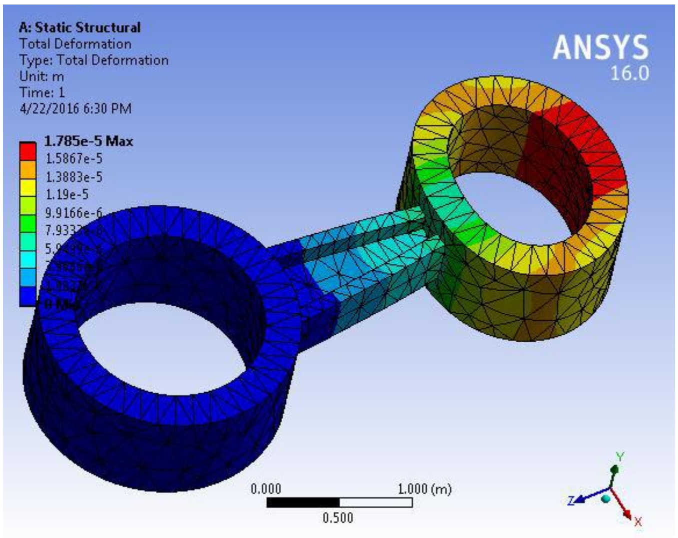

Fig. 11 Total Deformation

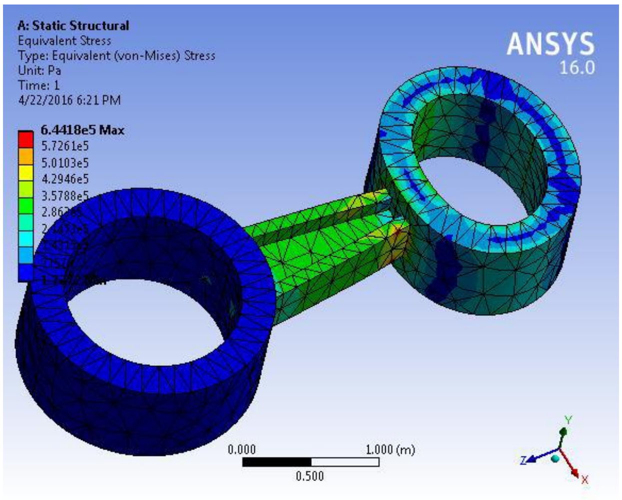

Fig. 12 Equivalent Stress

ANALYSIS RESULT

Parameter	AL (Old material)	ALFASIC Composite
Equivalent stress Max. Min.	2.9308 e08 pa 7490.70 pa	6.4418 e05 pa 1.7372 pa
Total Deformation Max. Min.	0.0004765 m 5.294 e-05 m	1.785 e-05 m 0 m
Equivalent Elastic strain Max. Min.	0.00422 m/m 2.251 e-07	9.5017 e-06 m/m 4.5725 e-11 m/m
Strain Energy Max. Min.	0.06248 J 1.878 e-09 J	802618 e-04 J 4.2828 e-13 J

Result comparison between AL (Old material) and ALFASIC Composite

Sr. no.	AL (Old material)	ALFASIC Composite
1	This material has high deformation	This material has low deformation. So have low deformation the result is increasing the life time of the connecting rod .
2	This material has low von misses stress so the result is low strength.	This material has high von misses stress so it has high strength.
3	This material has high von misses strain so the result is low hardness	This material has low von misses strain so the result is high hardness.

CONCLUSION

The Aluminum connecting rod having a more weight & low stiffness as compare to ALFASIC composite connecting rod. If connecting rod having more weight it's consume more fuel. And its leads to increase in weight of engine as well as gross weight of vehicle.

According to recent research we found new material ALFASIC composite which having similar mechanical properties and having less weight as well as high stiffness as compare to Aluminum IC connecting rod. By carrying out these modification to engine element will result ineffective reduction of weight increase of durability of particular part will lead to decrease of overall engine weight improvement in its traction parameter & increasing performance of engine.

This type of connecting rod Design (ALFASIC composite) connecting rod can be used for KTM DUKE 200 cc and BAJAJ PULSER 200 cc Bikes. This is applicable for high-speed application in I.C Engine.

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