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Analysis of Connecting Rod for Weight Reduction in Case of a CI Engine

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***Abstract*— internal combustion engine is one of the best and reliable sources of power generation. It is widely used in domestic and industrial transportation. Every vehicle has internal combustion engine and every IC engine has connecting rod. The main objective of this study was to suggest weight reduction opportunity for connecting rod by analyzing it with different materials. This study deals with static stress analysis of existing connecting rod and second optimization of rod for weight reduction by experimenting it with two new materials. For this study we selected the medium duty compression ignition engine connecting rod. After obtaining dimensions we developed the 3D model of connecting rod by using CATIA software. By importing 3D model in ANSYS static stress analysis was carried out for both ends of connecting rod. Analysis was done for compressive as well as tensile loading, in results determined von mises stress distribution and deformation of connecting rod also we checked weight of connecting rod. Using same procedure we experimented with three different materials and compared the results.**

***Keywords*— CATIA, ANSYS, Connecting rod, IC Engine**

I. INTRODUCTION

Every vehicle which uses IC engine require at list one connecting rod. Connecting rod is the intermediate linkage between piston and crank or crankshaft. Together with the crank, it forms a simple mechanism which converts reciprocating motion into rotating motion and its primary function is to transmit the thrust of piston to crank shaft. Combustion in IC Engine produces very high load which transmits to crankshaft via connecting rod therefore connecting rod is subjected to many stresses. The tensile and compressive stresses are produced due to gas pressure, during compression and power strokes the connecting rod is subjected to compressive loads and during the last part of the exhaust and the beginning of the suction strokes, to tensile loads, therefore durability of this component has critical importance. Connecting rod is the assembly of shank region, cap, nuts, bolts etc. as shown below

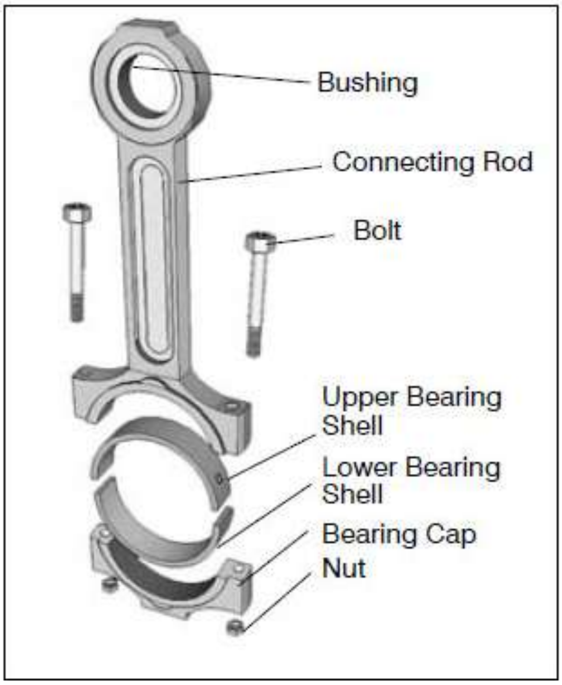

Fig1. Parts of connecting rod

II. LITERATURE REVIEW

- A.Prem kumar has performed work on “Design and analysis of connecting rod by using composite materials” he selected Al6061 and Al6061+B4C composites for analysis. Found low von mises stresses in Al6061+B4C compared with Al6061 composite. Also they found Al6061+B4C connecting rod has low von mises strain.
- Gurunath V Shinde, Vinayak D Yadav: performed stress analysis of connecting rod by using ANSYS software. And found stresses developed in connecting rod by static analysis. For optimisation they suggested buckling load and dynamic analysis of connecting rod.
- Magesh Kumar, Ankush K Biradar: proposed work on design analysis of connecting rod by concluding Weight optimization is possible using composite materials without varying the allowable stresses and boundary conditions.
- Dattatray S.Galhe, Satish Wable: performed work on “Analysis of Stresses Induced in Connecting Rod of Two Wheeler Engine”. They found that minimum stresses were developed in aluminium MMC connecting rod compared with carbon steel connecting rod.

For this study we selected medium duty Compression ignition engine connecting rod to explore weight reduction opportunity.

III. MODELING AND ANALYSIS

During modelling firstly all parts of connecting rod as connecting rod, Cap, Nut, Bolt etc. are prepared by using CATIA V5 software. All these parts of connecting rod are assembled in CATIA itself. For all three materials 3D models were prepared and analysed for static structural analysis. During analysis once load was applied on small end while big end fixed and then load applied on big end while small end fixed.

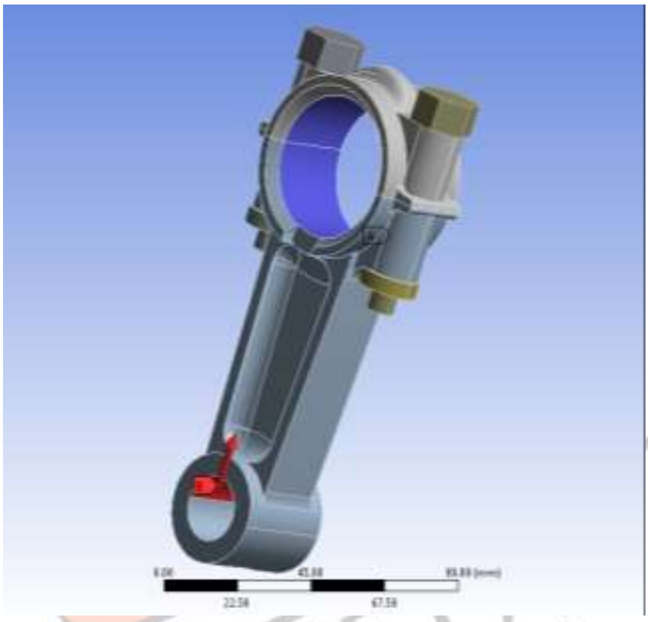

Fig 02.Model with big end fixed, load applied on small end

By applying different boundary conditions connecting rod was analysed for three materials .Existing Gray Cast Iron and two new materials as Carbon Fiber and Glass Fiber. Static structural analysis was carried out by applying 16804N force at 15^0 angle of inclination of connecting rod; on both ends same load was applied in results we obtained von mises stresses. Following are the analysis results for three materials.

A. *For Gray cast iron*

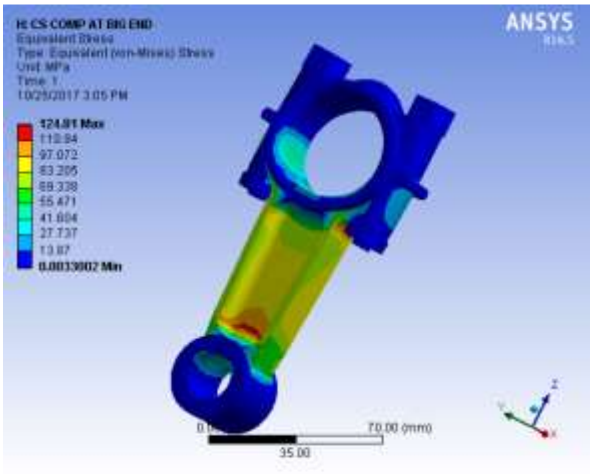

Fig 03.compressive force at big end

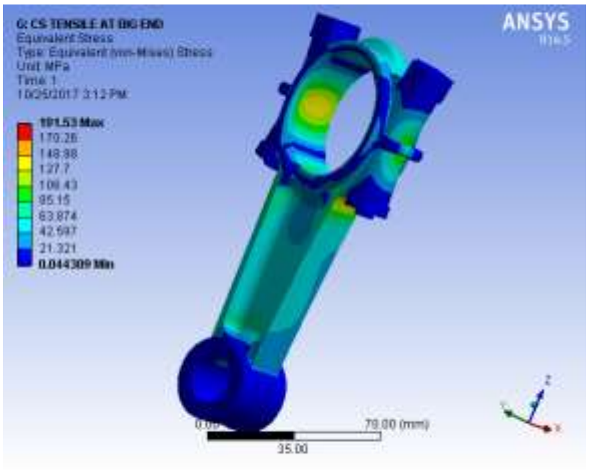

Fig.04.Tensile force at big end

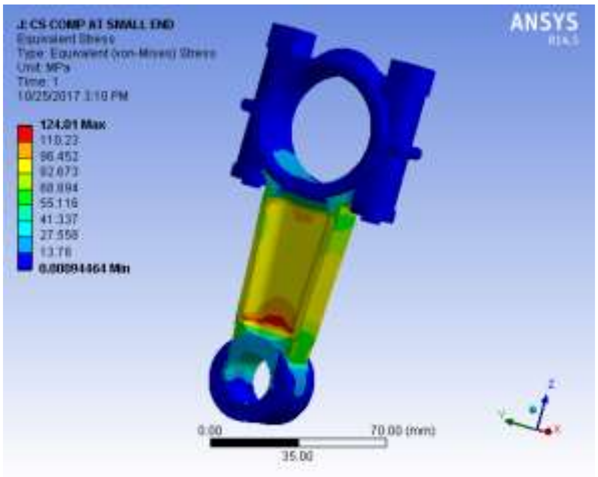

Fig05. Compressive force at small end

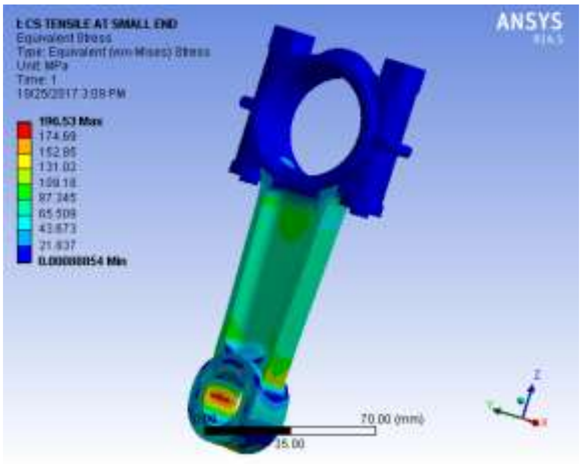

Fig.06.Tensile force at small end

B. *For Glass fiber*

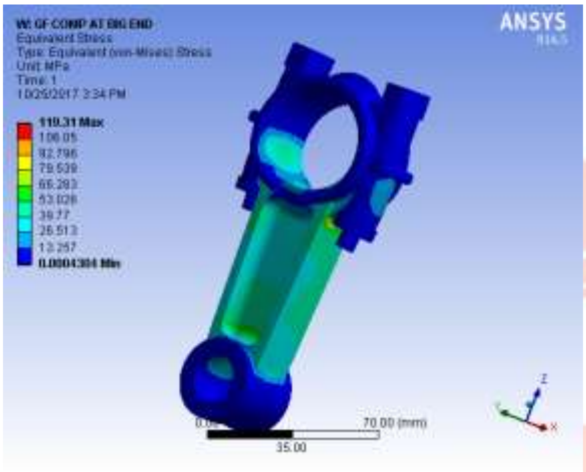

Fig07. Compressive force at big end

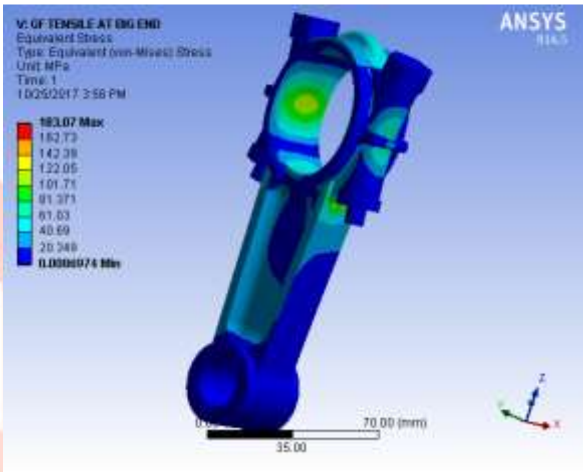

Fig.08.Tensile force at big end

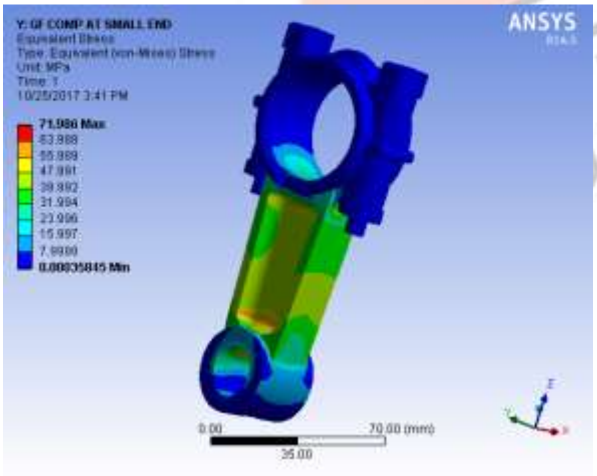

Fig09. Compressive force at small end

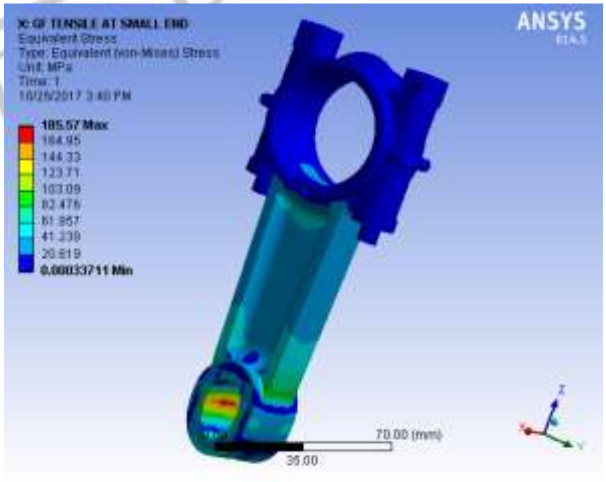

Fig10. Tensile force at small end

C. *For Carbon fiber*

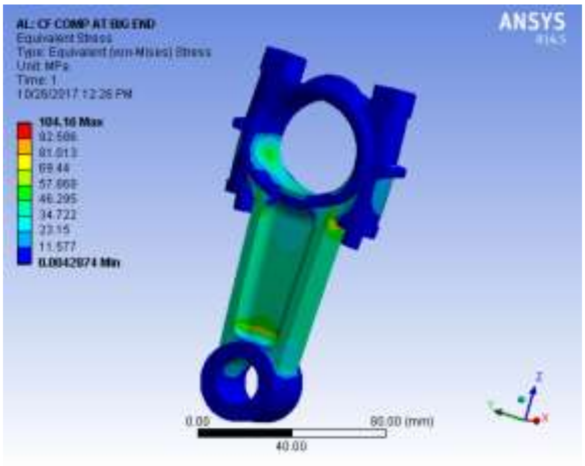

Fig11.Compressive force at big end

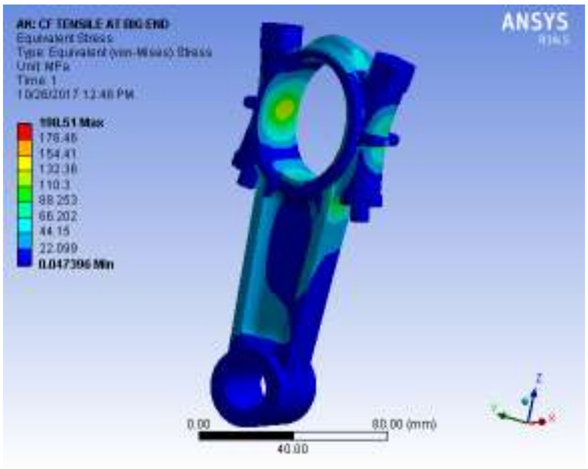

Fig.12.Tensile force at big end

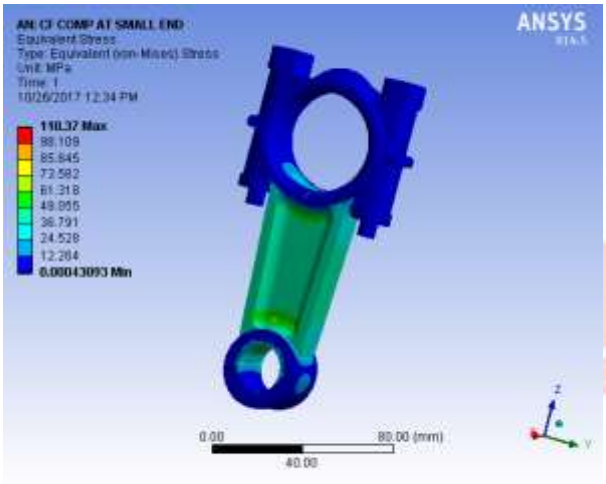

Fig13. Compressive force at small end

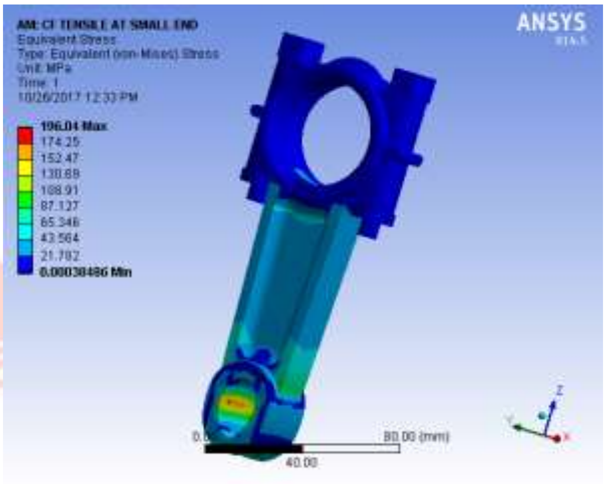

Fig.14.Tensile force at small end

Result table 01 *Analysis results of connecting rod*

Pressure applied	Result for	Type of loading	Cast iron	Carbon Fiber	Glass Fiber
Big end	Stress	Compressive	124.81	104.16	119.31
		Tensile	191.53	198.51	183.07
Small end	Stress	Compressive	124.01	110.37	71.986
		Tensile	196.53	196.04	185.57

Graphical representation of results:

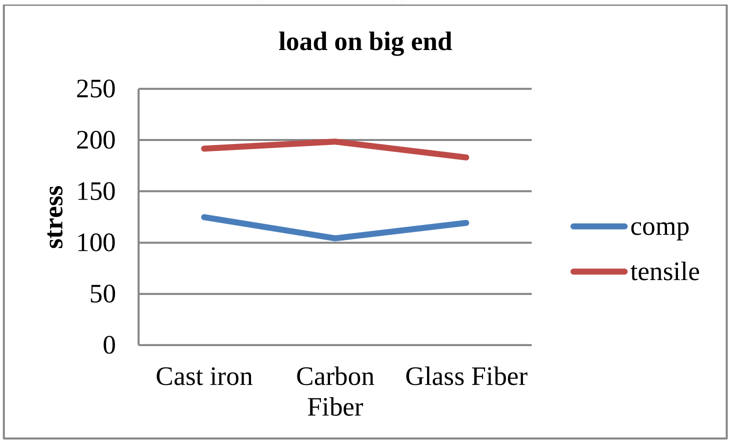

Fig.15. Load applied on big end of connecting rod

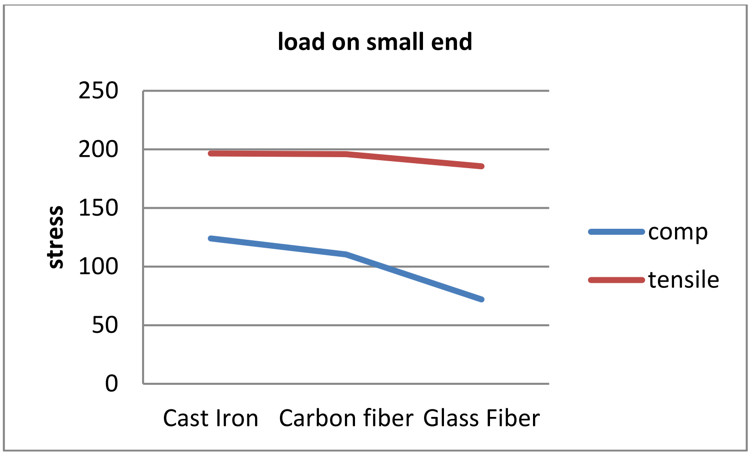

Fig.16. Load applied on small end of connecting rod

From above graph we can observe that on big end of connecting rod more tensile stresses were developed compared with compressive. Tensile stresses developed in carbon fiber are more as compared with other materials.

Weight of connecting rod:

According to software
Cast iron connecting rod weight= 0.5832216 kg = 583 grams.
Carbon fiber connecting rod weight= 0.163232 kg = 163 grams.
Glass fiber connecting rod weight= 0.20404 kg = 204 grams.
According to software results there was up to 70% reduction in weight

Experimentation was carried out on specimen material rods of three different materials. Software analysis on connecting rod material demonstrated that maximum stresses developed were tensile hence for experimentation; tensile tests were conducted on specimen material rods of three different materials. Post experimental tests, weight comparison also conducted to find out difference of actual weights of three different specimen materials.

Table 02. Analysis results of testing sample rod

Load (N)	**Cast Iron**		**Carbon Fiber**		**Glass Fiber**	
	Stress	**strain**	**stress**	**Strain**	**Stress**	**Strain**
1000	8.7688	0.000079726	5.6764	0.0005419	6.317	0.00099611
2000	17.538	0.00015945	11.725	0.0011241	12.636	0.0019922
3000	26.306	0.00023918	16.98	0.0016861	18.954	0.0029883
4000	35.075	0.0003189	23.451	0.0022482	25.272	0.0039845
5000	43.844	0.00039863	29.314	0.0028102	31.589	0.0049806

Table 03 Weight of testing sample rods:

Sr. no	**Material**	**Theoretical Weight (gram)**	**Software Weight (gram)**	**Actual Weight (gram)**	**Error%**
1	Cast iron	190.75	190.85	195	2.5
2	Carbon Fiber	42.39	42.412	45	5.7
3	Glass Fiber	52.98	53.014	49	7

From above chart we can observe that there is negligible difference between values. Considering negligible difference in weight calculated by different methods of theoretical, numerical and physical specimen we can say that the weight calculated for connecting rod through analysis software should also match with physical model of new materials.

IV. RESULTS AND DISCUSSION

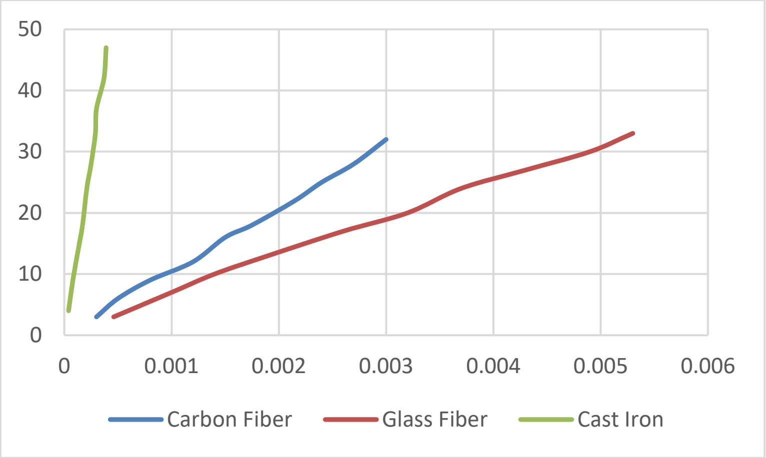

Fig.17. Experimental results for Cast iron, Carbon fiber and Glass fiber

From above experimental results graph minimum stresses were observed in glass fiber material compared with other two materials. Maximum strain was observed in carbon fiber and glass fiber materials compared with cast iron material.

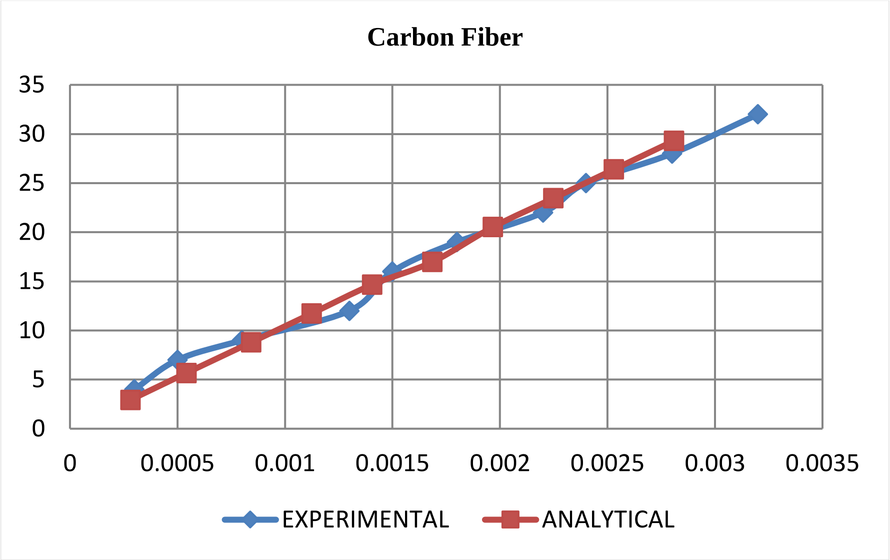

Fig.18 comparison of Carbon fiber results

Above graph shows experimental and analytical results comparison for carbon fiber rod. In above graph along X-axis strain is plotted and along Y-axis stress is plotted. We can observe that there is minimum difference between both results. Comparatively with increase in load strain varies more.

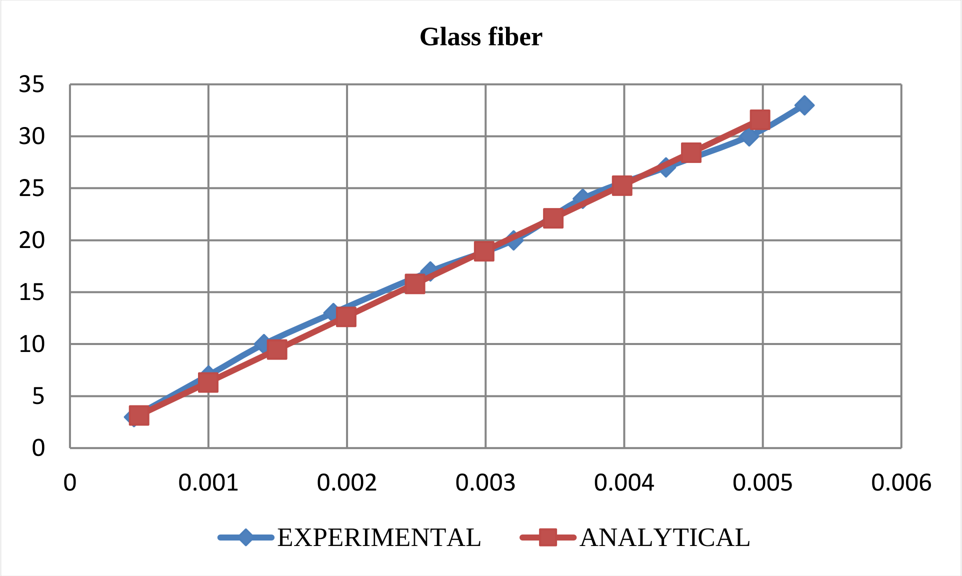

Fig19. Comparison of Glass fiber results

Above graph shows experimental and analytical results comparison for Glass fiber rod. In above graph along X-axis strain is plotted and along Y-axis stress is plotted. In above graph we can observe that there is very minimum difference between both readings.

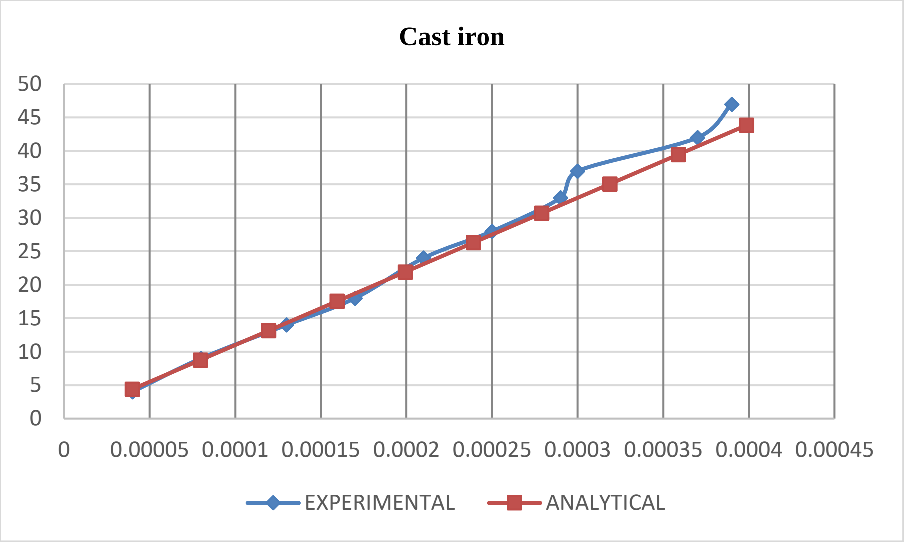

Fig20. Comparison of Cast iron results

Above graph shows experimental and analytical results comparison for Glass fiber rod. In above graph along X-axis strain is plotted and along Y-axis stress is plotted. From graph we can observe that in case of cast iron, graph varies in very small region for strain and also with increase in load there is a more variation in results for both stress and strain.

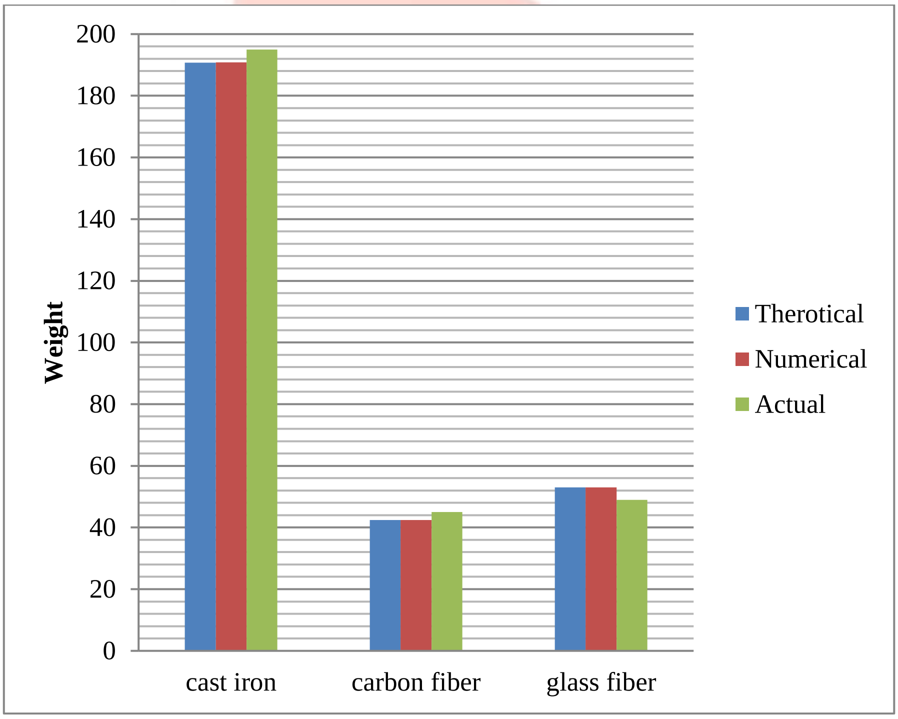

Fig: 21. Weight comparison Graph

From above graph we can observe that with new materials weight is significantly reduced compared with existing cast iron material.

V. CONCLUSION

- After carrying static structural analysis on IC engine connecting rod it was observed that stresses induced in glass fiber and carbon fiber were less as compared with existing cast iron material.
- During analysis maximum stresses were observed under tensile loading compared with compressive stresses and Composite materials show more deformation compared with Cast iron material. Though deformation is more it can be reduced by improving composition and properties of material of material.
- The main objective of this study was to reduce weight of connecting rod by using composite materials. Weight of Cast Iron, Carbon Fiber and Glass Fiber was 583 g, 163g, and 204g respectively.
- Actual weight of sample rods of Cast Iron, Carbon Fiber and Glass Fiber was 195 g, 45g, 49g respectively

Therefore, at last we can conclude that with the use of composite materials like carbon fiber maximum weight reduction can be obtain.

VI. ACKNOWLEDGMENT

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