Comparative Performance Analysis of Connecting Rod using two Distinct Composite Materials by F.E.A.

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Abstract: *In internal combustion engine, connecting rod is a vital link by which rotary motion of crank shaft is obtained by converting the reciprocating motion of piston. Due to combustion and inertia, connecting rod undergoes high cyclic load and high tensile load. In this paper a two-wheeler connecting rod was designed by analytical method and a proper geometrical model was developed in Creo. Then the model is imported in ANSYS Workbench 17.0 that provides a highly interactive and visual environment to analyze structural system of connecting rod. For given loading condition, the Von-mises stress, shear stress and deflection were found in the connecting rod and then compared these output values for two distinct materials namely E-Glass/Epoxy and Al-MWCNTS (aluminum composite reinforced with carbon nanotubes). A modal analysis performed to analyze the global behavior of the connecting rod and to predict the dynamic response of the connecting rod.*

Keywords: *Connecting rod, Ansys, Von-Mises stress, Modal analysis*

I. INTRODUCTION

Connecting rod is one of the important and critical component in internal combustion engine. Connecting rod bears forces in between of wrist pin of the piston and crank shaft. It provides fluid movement between pistons and a crankshaft. Now the automobile industries are focused on light materials, especially for internal combustion engine to increase performance of the vehicle. Composite materials are light in weight and designed for stronger than aluminum and steel. The specialty of composite material is that they can be designed to be both light and strong. Sushant [1] et.al. investigated the performance analysis of two-wheeler connecting rod of two different material and observed von-mises stress, shear stress, and bending stress of Al-7068 connecting rod was improved than C-70 connecting rod in. Vivek C. Pathade [2] et. al. investigated the stress concentration effect on big end and small end, and maximum stress at fillet section of the small end of connecting rod by photo elastic technique. Cheng Gang [3] et. al. analyzed the failure mechanism of connecting rod by ADAMS software. The connecting rod fatigue strength and life prediction are researched with the Goodman fatigue law. Abhinav Gautam [4] et. al. conducted FEA analysis on SS304 material connecting rod on ANSYS workbench 14.0 and taken four different sections of connecting rod for analyzing. D.Gopinath [5] et. al. conducted topology optimization for weight reduction of connecting rod and optimized geometry was less than 10.38% than the current connecting rod. G.M Sayeed Ahmed [6] et. al. conducted FEA analysis on aluminum 6061, aluminum 7075, aluminum 2014, carbon fiber 280 and observed the aluminum 7075 and carbon fiber connecting rod were better than aluminum 6061 and aluminum 2014. By Improving the property of epoxy in carbon fiber the connecting rod can withstand high temperature in combustion-chamber. Slavko Rakic [7] investigated the failure analysis of connecting rod which is used in 12-cylinder diesel engine. He identified the Inadequate machining, absence of polishing and highest stress as the main elements of failure. Mohammed Mohsin Ali H [8] et. al. studied the behavior of connecting rod when concentric load and cosine type is applied at the bigger end at the connecting rod. G Gopal [9] et. al. studied and compared the of two different materials and identified the Al 2618 Piston, Titanium Connecting rod and High Alloy Steel Crankshaft having less values than Al 6061 Piston, Al 6061 Connecting rod and EN308

Crankshaft in terms of displacement, von-mises stress and strain. F. Folgar [10] et. al. performed computerized industrial tomography to identify casting quality for connecting rod. Mahipal Manda [11] et. al. conducted modal analysis of diesel engine connecting rod to calculate natural frequency of connecting rod.

II. DESIGN OF CONNECTING ROD: CONNECTING ROD IS DESIGN ON THE FOLLOWING PARAMETERS

Table 1. Basic design parameters of engine [1]

Petrol Engine	
No. of Cylinders	1
Engine Speed	1800 r.p.m.
Maximum Pressure	5 N/mm^2
Compression Ratio	9.25:1
Length of Connecting Rod	104mm
Piston Diameter	53mm
Stroke	45mm
Factor of Safety	4

Connecting rod is directly subjected to alternating compressive forces and tensile forces. The reason for designing a connecting rod as a strut is that the cross-section area of the connecting rod undergoes much higher compressive forces as compared to tensile forces [1].

Table 2. Dimensions of the connecting rod [1]

Inside diameter of big end	33.4 mm
Outside diameter of big end	44.12 mm
Inside diameter of small end	13.24 mm
Outside diameter of small end	19.24 mm
Thickness	3.04 mm
Depth near big end	16.72 mm
Depth near small end	12.16 mm
Length of connecting rod	95 mm
Stroke	45mm

III. MATERIAL SELECTION

Selection of material is another important factor for analyzing the behavior of connecting rod. In recent year automobile sector focus in cost reduction, improving the design, weight reduction etc. For reducing the weight of the component composite materials are used by most of the automobile companies. Composite material provides high impact strength, design flexibility, dimension stability etc. For simulation analysis two different materials namely, E-Glass/Epoxy and Aluminum composite reinforced with Carbon nanotubes were selected. Properties of these two materials as:

Table 3. Composition of E-Glass/Epoxy [10]

Components	E-Glass	Epoxy
Composition (Vol %)	40%	60%

Table 4. Composition of Al-MWCNTS [12]

Components	Al	MWCNTS
Composition (Vol %)	Al- 95%	MWCNTS- 5%

Table 5. Mechanical properties

Parameters	Al-MWCNTS [12]	E-Glass/ Epoxy [10]
Density (g/cc)	2.35	1.90
Modulus of Elasticity (GPa)	90	80
Poisson's Ratio	0.33	0.217
Ultimate Tensile Strength (MPa)	485	490
Behavior	Isentropic	Orthotropic

IV. F.E.A. OF CONNECTING ROD

3-d model is created in Creo software and then imported in ANSYS for analysis work.

Fig 1. Connecting rod 3-d model in Creo

V. MESHING OF THE MODEL

Making mesh of accurate quality for engineering solution is one of the most vital aspects. In Meshing, model is divided into very small division known as elements Finite element mesh is generated using Tetrahedron element.

Table 6. Nodes and Elements

Entity	Size
Nodes	377535
Elements	241216

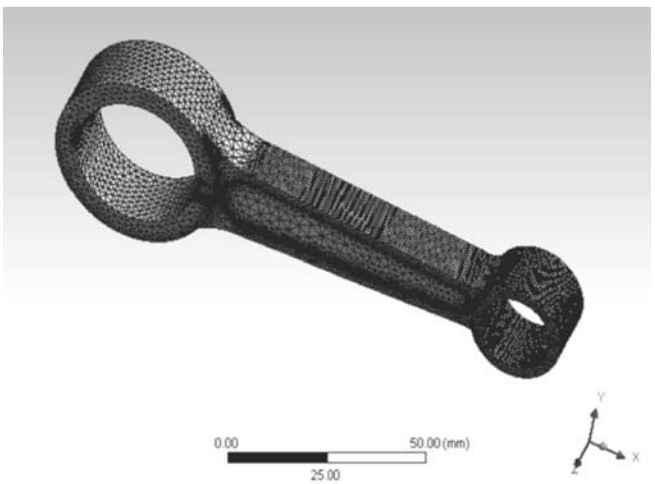

Fig 2. Meshing of the connecting rod

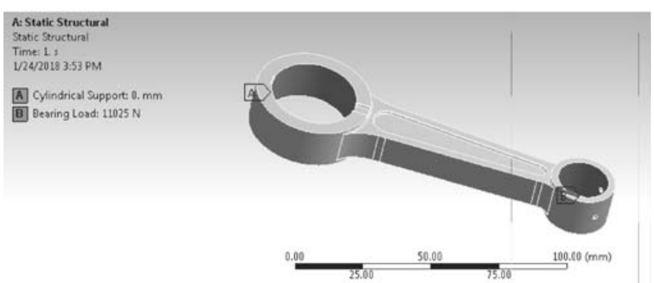

Fig 3. Boundary Condition

Boundary Conditions

Boundary conditions are given to the component so it can have performed as real conditions. Keeping big end fixed bearing load of 11025 N is applied at smaller end [1].

VI. ANALYSIS

a) Analysis of Connecting Rod (E-Glass/Epoxy) When Load is Applied at Small End

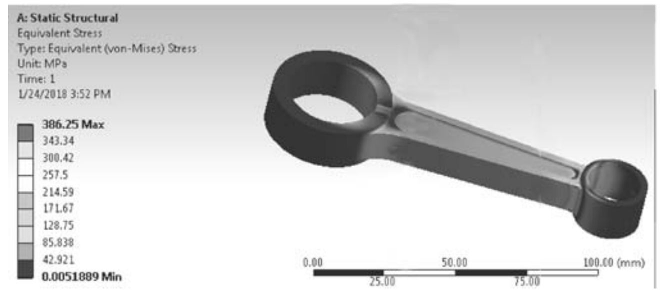

Fig 4. Von-Mises Stress

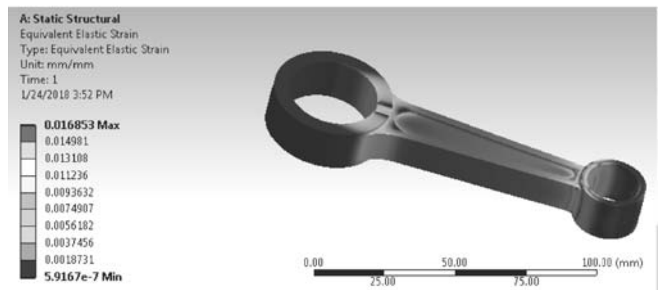

Fig 5. Equivalent Elastic Strain

Table 7. Natural frequencies of connecting rod (e-glass/epoxy)

Set	Frequency(Hz)
1	493.73
2	558.27
3	1072.4
4	2512.8
5	2584.7
6	4662.9

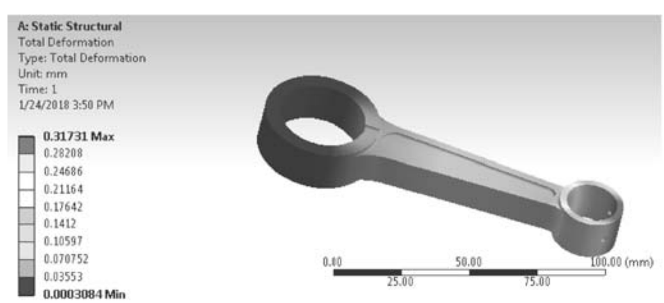

Fig 6. Total Deformation

b) Analysis of Connecting Rod (Al-MWCNTS) When Load is Applied at Small End

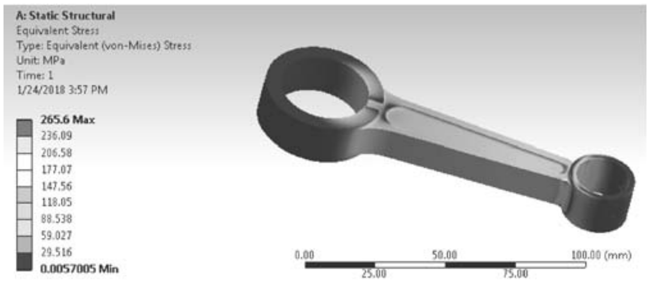

Fig 7. Von-Mises Stress

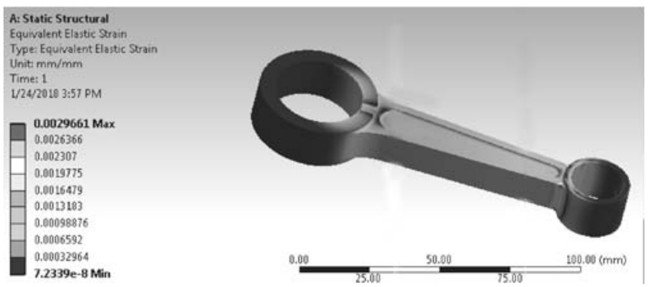

Fig 8. Equivalent Elastic Strain

Table 8. Natural frequencies of connecting rod (Al-MWCNTS)

Set	Frequency (HZ)
1	669.51
2	780.5
3	1240.3
4	2561.3
5	4351
6	4819.2

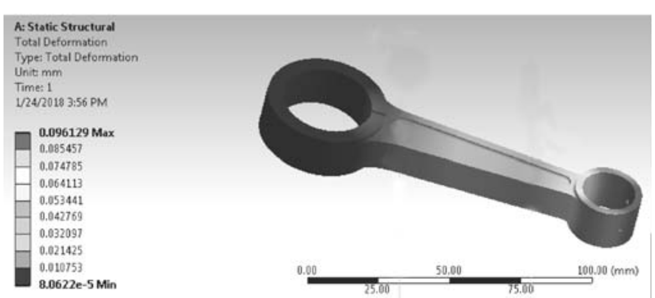

Fig 9. Total Deformation

Table 9. results of connecting (e-glass/epoxy and al-mwcnts) rod

Sr. No.	Type	E-Glass/ Epoxy	Al-MWCNTS
1	Von-Mises Stress (MPa)	498.42	284.44
2	Equivalent Elastic Strain (mm/mm)	0.036217	0.00331994
3	Total Deformation (mm)	0.40918	0.08968

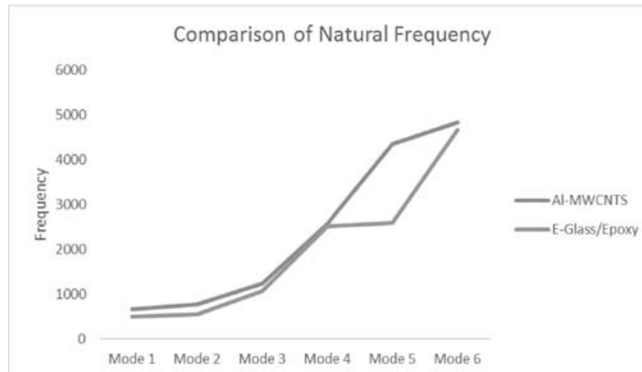

Fig 10. Comparison of Natural Frequency

VI. CONCLUSION

Two different material were simulated under same boundary conditions and it was observed that Al-MWCNTS material performance was better than E-Glass/Epoxy material in terms of Von-mises stress, Equivalent elastic strain and total deformation. There was reduction of 42.93% Von-mises stress, reduction of 90.8332% equivalent elastic strain, reduction of 78.083% total deformation using AL-MWCNTS material connecting rod as compared to E-Glass/Epoxy material. It is observed that frequency of Al-MWCNTS connecting rod is higher than E-Glass/Epoxy connecting rod.

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