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Design Optimization and Comparative Stress Analysis of Connecting Rod using Finite Element Analysis

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Design Optimization and Comparative Stress Analysis of Connecting Rod using Finite Element Analysis

Himanshu Arora [α], Ashwani Mishra [σ], Swatantra Kulkarni [ρ], Prabhjot Singh [Ѡ] & Ramanpreet Singh [¥]

Abstract- A connecting rod is an important member of the engine assembly accompanied by mass production all over the world. Moreover it possesses great opportunity for research and development in terms of its material and its design parameters. In the present research work initially modelling of connecting rod was done in ANSYS 14.5 software and then analysed in again ANSYS 14.5 software itself. Analysis was mainly focussed on design parameters and its material .Then best design parameters and best material was chosen.

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I. Introduction

A connecting rod acts as a bridge between piston assembly and crankshaft .By acting as a bridge it changes the motion of piston assembly which is nothing but a reciprocating motion to the rotating motion of the crankshaft. Therefore it is an important member of the engine assembly. Moreover it also witnesses high cycle of tensile and compressive loading during its operation and researchers have found out that piston end witnesses maximum stress and that can be decreased by either increasing the material near the piston end or by changing the design parameters of the connecting rod. Also being an important member of the engine assembly its proper functioning and safety from failure is important because its failure can lead to the replacement cost of the engine assembly. Additionally we are witnessing huge production of connecting rod as its demand is increasing day by day. Therefore there is a need for research and development in the field of its design parameters, material and a lot more to widen our horizon for the betterment of connecting rod and engine performance.

a) Literature Review

Anusha B et al. (2013) did a case study on a Hero Honda splendor connecting rod .In this study piston end was made to bear a pressure of 3.15 Mpa whereas big end was kept fixed. Modeling and analysis were performed in Pro/E and ANSYS respectively. The whole study was focused on the comparison of connecting rod made up of structural steel and cast iron which resulted in the fact that lesser stresses were induced in the structural steel connecting rod than cast iron connecting rod. Therefore connecting rod made up of structural steel was advised to use.

Vazhappilly C V et al. (2013) presented a literature survey of various research and developments that took place in the field of optimization technique, fatigue modelling, manufacturing cost analysis etc. Furthermore importance of CAD and Finite Element Analysis for optimization process was also presented.

Pathade V.C. et al. (2013) made three loads, 69kg, 85kg, and 99 kg, to be applied over the small end. Three approaches namely experimental, theoretical and numerical (Finite Element Analysis) were taken to do stress analysis of connecting rod. Comparison of the results of these methods was done and then it was noticed that small end was prone to more stresses than the other end.

Sarkate T. S. et al. (2013) performed static analysis and comparison of alloy aluminum 7068 and AISI 4340 alloy steel by using Pro/E Wildfire 4.0 and ANSYS V12. Aluminum 7068 alloy showed a reduction of 63.95% weight and 3.59% stresses.

Rao G N M et al. (2013) examined genetic steel, Aluminum, Titanium and Cast Iron to widen the horizon of the weight reduction possibilities for the connecting rod. Initially load to be applied was calculated, FEA was performed and then optimization was achieved. It was noticed that genetic steel connecting rod came out with better results than Aluminum, Titanium and Cast Iron in terms of deflection and stresses.

Prakash O. et al. (2013) investigated connecting rod of Universal Tractor (U650).They re-optimised, performed static and fatigue analysis and improved critical areas of connecting rod. Their work decreased the weight by 5gm and hence increased the performance of the engine.

b) Modeling

The connecting rod on which the present investigation is done is taken from the research paper of Pal S, Kumar S(2012), "Design Evaluation and optimization of connecting rod parameters using FEM" *IJEMR, Vol. 2, issue 6*[7].Modeling of the connecting rod is performed in ANSYS 14.5.

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c) Validation

The rod with the dimensions same as that of reference paper [7] was modeled and even the same compressive loads and fixed support were applied on the same portion of the connecting rod as in the reference paper [7].

Table 1 : The results of the maximum equivalent von-mises stresses in Mpa are

S. no.	Compressive Loads	Existing Model	Our Model	Variation (%)
1.	4319N	71.20	74.816	4.83

Hence our model is validated as we have got approximately same results as in the reference paper.

After validation Changes in design parameters of model taken from reference paper[7] was made and 3 more models of connecting rod were prepared and static FEA was performed on all of them including existing model from reference paper by applying 2 different orthotropic materials on all of them one by one and they were compared. The drawing of existing and best model is shown below.

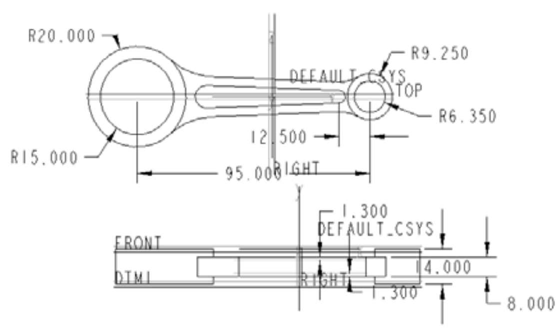


Figure 1 : Model from reference paper[7]

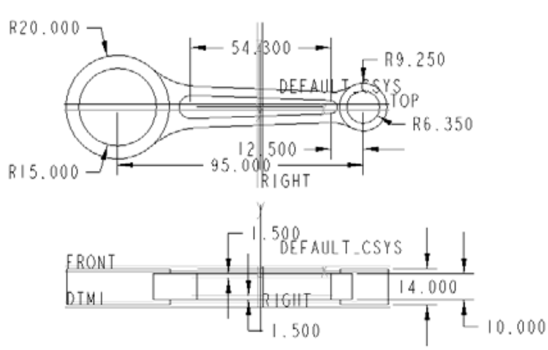


Figure 2 : Modified model I

II. Material Properties

Two orthotropic materials were used and compared.

Table 2 : Properties of E-glass/Epoxy [8]

Properties	E-Glass/ Epoxy
Longitudinal modulus *E*1 (GPa)	41Gpa
Transverse in-plane modulus *E*2	12Gpa
Transverse out of plane modulus *E*3	12Gpa
In-plane shear modulus *G*12	5.5Gpa
Out of plane shear modulus *G*13	5.5Gpa
Out of plane shear modulus *G*23	3.5Gpa
Major in plane Poisson's ratio υ12	0.28
Major out of plane Poisson's ratio υ13	0.28
Major out of plane Poisson's ratio υ23	0.5
Density(kg/m^3)	1850

Table 3 : Properties of Kevlar 49/Epoxy[8]

Properties	Kevlar 49/Epoxy
Longitudinal Modulus *E*1	80gpa
Transverse In-Plane Modulus *E*2	5.5 Gpa
Transverse Out of plane Modulus *E*3	5.5Gpa
In-Plane Shear Modulus *G*12	2.2Gpa
Out Of Plane Shear Modulus *G*13	2.2Gpa
Out Of Plane Shear Modulus *G*23	1.8Gpa
Major In-Plane Poisson's Ratio *Y*12	0.34
Major Out Of Plane Poisson's Ratio *Y*13	0.34
Major Out Of Plane Poisson's Ratio Y_{23}	0.4
Density(Kg/M^3)	1252

a) Loads

The crank end was kept fixed in every analysis and a compressive bearing load of 4319N [7] was applied.

III. Results

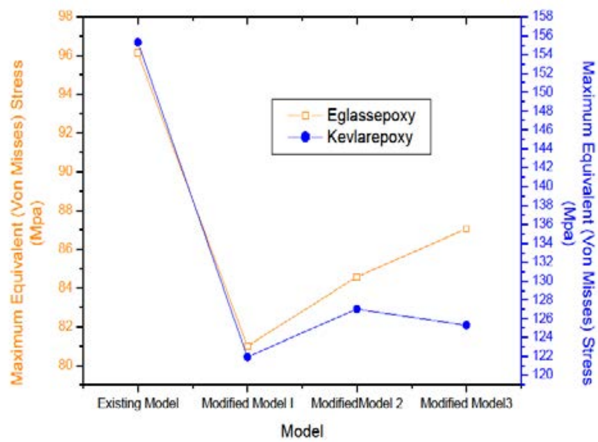
All the models and materials were compared on the basis of maximum equivalent von-mises stress which was noted after every analysis.

Table 4 : For Compressive bearing load 4319 N and Maximum equivalent von-mises stress

Parameters	Eglass/ Epoxy (Mpa)	Kevlar49/ Epoxy (Mpa)
Existing Model	96.135	155.31
Modified Model I	80.995	121.95
Variation*(%)	15.75	21.479
Modified Model 2	84.567	127.03
Variation*(%)	12.033	18.20
Modified Model3	87.05	125.31
Variation*(%)	9.45	19.31

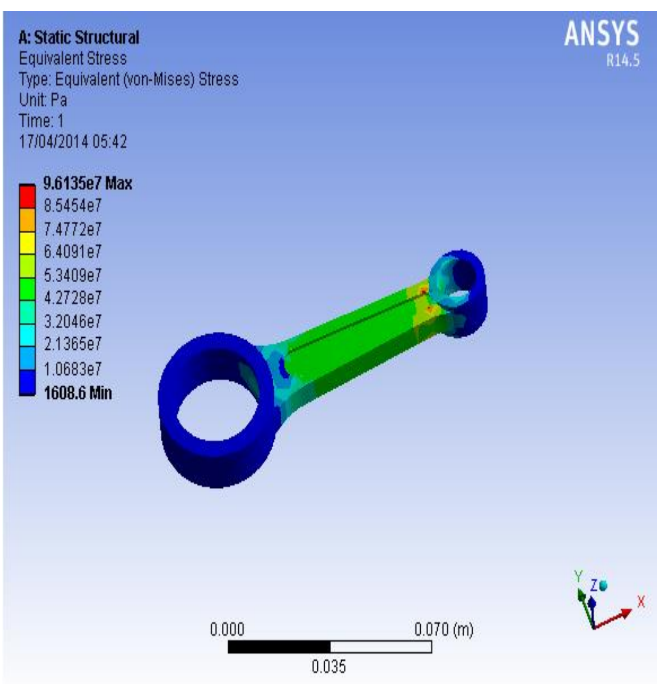
**Variation (%) with existing model.*

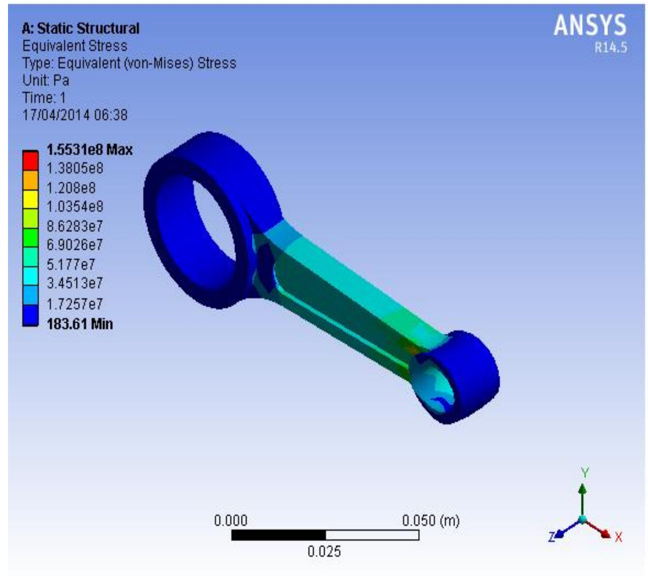
The comparison presented in above table have also been presented by graph.

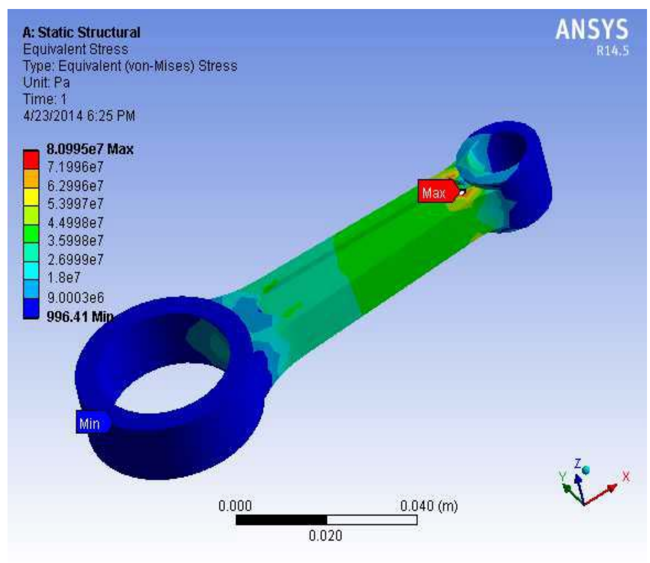


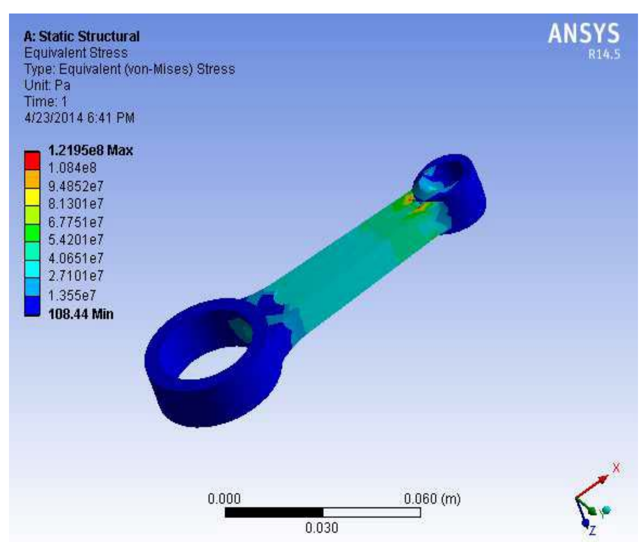
Graph for Table I

Following figures presents a comparison of static FEA between existing model from reference paper [7] and best modified design i.e. Modified Model I of connecting rod when compressive bearing load applied was 4319N and material used were E-glass/Epoxy and Kevlar49/Epoxy.









IV. Conclusion

Static FEA was performed on a connecting rod by applying a compressive bearing load on its piston end making the crank end fixed. The design of existing connecting rod taken from reference paper[7] was modified and all the designs were tested with 2 different orthotropic materials.

From analysis it was inferred that

a) Modifying the design parameters can yield better results. Since modified model I gave best results. Therefore this design proved to be the best among others tested.

b) Among 2 orthotropic materials investigated and compared the E-glass/epoxy proved to be best.

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