A Review on Weight Optimization of Connecting Rod using Composite Materials

Mr. Rohit S. Phatale, Prof. B. S. Allurkar

***Abstract*— In an internal combustion engines and compressors, connecting rod is a high volume production, critical component which is periodically subjected to high tensile, compressive and bending loads caused by the thrust and pull on the piston and by the centrifugal force of the rotating crankshaft. The connecting rods can be manufactured using variety of methods and variety of materials but it depends on application case, which technology and material to use. Existing connecting rods are mostly manufactured by using carbon steel. Aluminium and titanium alloys are strong and light weight alloys known. Titanium finds its application in high performance automotives where light weight but strength of components is needed. ANSYS is the analysis tool to calculate Von mises stress, Von mises strain and deformation etc.**

***Index Terms*— ANSYS, composite materials, Connecting rods, weight optimization.**

I. Introduction

Connecting rod is integral component of internal combustion engine; it acts as a linkage between piston and crankshaft which is subjected to high tensile, compressive and bending loads during internal combustion engine operation. It converts reciprocating motion of piston into rotary motion of the crank. It has three main zones, the small end, the central shank and the big end. The small end is the piston pin end, the big end is the crankshaft end and the central shank is of I-cross section. Connecting rod is a pin jointed strut in which more weight is concentrated towards the big end. In that point of view the location of the CG point of connecting rod lies more towards the big end. Connecting rods are most made of steel for production engines, but can be made of Aluminium (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for combination of strength and lightness at the expense of affordability) for high performance engines, or of cast iron.

Connecting rods of automobiles should be lighter, should consume less fuel and at the same time they should be durable, which unfortunately leads to increase in weight. This tendency in automobile construction led the invention and implementation of quite new materials which are light in weight and meet design requirements [1]. They can be produced either by casting, powder metallurgy or forging. However, connecting rods could be produced by casting, the difference between others and it usually, they have blow holes which are adverse from durability and fatigue points of view. The fact that forgings produce blow hole free and better rods gives them an advantage over cast rods. Powder metal manufactured blanks have the advantage of being near net shape, reducing material waste. However, the cost of the blank is high due to the high material cost and sophisticated manufacturing techniques [2].

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II. LITERATURE REVIEW

Venu Gopal Vegi and Leela Krishna Vegi [3] in their paper describe designing and analysis of a connecting rod. Currently existing connecting rods are made of carbon steel. The model of connecting rod is modelled using CATIA software and analysis is carried out on ANSYS software. Finite element analysis is carried out on a connecting rod made of forged steel. The parameters like Von mises stress, strain, deformation, factor of safety etc were calculated and found that forged steel have more factor of safety, reduced weight, greater stiffness than carbon steel.

Vikas Gupta [4] in his research work altered the dimensions of already existing design of a connecting rod of a tractor engine. This analysis was done under static and fatigue loading. Optimization was done under same boundary and loading conditions for validation in few stress and fatigue parameters. The critical regions under both static and fatigue analysis are identified and improved. The connecting rod was modelled and optimized for the reduced weight, improved life and manufacturability. The material was kept same and a significant change was observed in Von mises stress. 9.4% less stress was observed at critical point under static load conditions. Only 5 gm of weight was reduced which is very low. From this we can conclude that not only materials but also design parameters can be considered for optimization.

The comparison of fatigue behaviour of forged steel and powder metal connecting rods was discussed by A. Afzal et al. [5]. The experiments included strain controlled specimen testing with specimen obtained from the connecting rods as well as strain controlled connecting rod bench testing. Monotonic and cyclic deformation behaviour and strain controlled fatigue properties of two materials are evaluated and compared. The stress concentration factors were obtained from FEA, and modified Goodman equation was used to account for the mean stress effect.

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The connecting rod is a most stressed part in internal combustion engine. During its operation various stresses are acting on it. The effect of compressive stress is more due to gas pressure and whipping stress. Fanil Desai and all [6] compared two samples of connecting rod made of forged steel. Static analysis was done using ANSYS software and experimental analysis with Universal Testing Machine (UTM). Experimental results were verified with the numerical results.

To reduce weight and cost of forged steel connecting rod, Ambrish Tiwari et al. [2] extremely used the numerical tools during the development phase. Therefore, to complete understand the mechanisms involved as well as the reliability of the numerical methodology are extremely important to take technological advantages, such as, to reduce project lead time and prototypes cost reduction. The work shows complete FEA methodology to explore weight and cost reduction opportunities for production of forged steel connecting rod. Considering the modified Goodman diagram, fatigue study based on stress life theory was also performed.

Kuldeep B. replaced the conventional materials of connecting rod by aluminium based composite materials reinforced with silicon carbide and fly ash. The comparative study between conventional materials and new materials found that new materials have less weight and better stiffness. It resulted in reduction of 43.48% of weight with 75%reduction in displacement [1].

Ramanpreet Singh in his study used isotropic and orthotropic composite materials. The modelling of connecting rod was done using CATIA v5 and stress analysed in MSC. PATRAN. Linear static analysis was carried out for both materials with tetrahedron with element size of 4mm to obtain stress results. Comparison of both materials was done keeping the boundary conditions same. Author concluded that there was a reduction of 33.99% of stresses when isotropic material (i.e. steel) is replaced with orthotropic material (i.e. E-glass/Epoxy). Also there was reduction in displacement of about 0.026% [7].

G.M. Sayeed Ahmed [8] et al. In their work, a broken connecting rod made of forged steel is replaced with aluminium alloys and carbon fiber. By doing so, the authors found that weight of connecting rods was reduced and all performed to the level of expectation. The carbon fibers have good strength and are light in weight. The rods were tested in ideal condition and also by applying variable loads. The rods tested to their extreme capacities and they performed well. The analysis also carried out on the crankshaft of aluminium which gave good results and pressure induced on connecting rod was less.

Existing connecting rod is manufactured using ferrous alloys. Authors S. Vijaya Kumar et al. Replaced material of connecting rod with chrome steel and titanium. Modelling is done using Creo Parametric 2.0 software and analyzed over ANSYS. Composites used for manufacturing helped optimizing weight and cost and improved its life span than the original design. The maximum stress was within the allowable stress limit for chrome steel and titanium [9].

III. CONCLUSION

Connecting rods are being manufactured by conventional method of forging. Steel can be replaced by aluminium and titanium alloys on a cost of affordability. Weight optimization is possible using composite materials without varying the allowable stresses and boundary conditions.

REFERENCES

[1] Kuldeep B, Arun L.R, Mohammed Faheem, “Analysis and optimization of connecting rod using ALFASiC composites”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 6, pp 2480-2487, June 2013.

[2] Ambrish Tiwari, Jeetendra Kumar Tiwari, Sharad Kumar Chandrakar, “Fatigue Analysis of Connecting Rod Using FEA to Explore Weight and Cost Reduction Opportunities for a Production of Forged Steel Connecting Rod”, International Journal of Advanced Mechanical Engineering, Volume 4, Issue 7, pp. 783-802, 2014.

[3] Venu Gopal Vegi, Leela Krishna Vegi “Design And Analysis of Connecting rod using forged steel”, International Journal of Scientific & Engineering Research, vol. 4, Issue 6, June 2013.

[4] Vikas Gupta ,Om Prakash, Vinod Mittal “Optimizing the Design of Connecting rod under Static and Fatigue Loading” International journal of Research in Management, Science & Technology(IJRMST) Vol. 1, issue. 1, June 2013.

[5] Afzal, A. and A. Fatemi, "A comparative study of fatigue behavior and life predictions of forged steel and PM connecting rods". SAE Technical Paper. 2004.

[6] Fanil Desai, Kirankumar Jagtap, Abhijeet Deshpande “Numerical and Experimental Analysis of Connecting Rod”, International Journal of Emerging Engineering Research and Technology (IJEERT), Volume 2, Issue 4, PP 242-249, July 2014.

[7] Ramanpreet Singh “Stress Analysis of Orthotropic and Isotropic connecting rod using Finite Element Method”, International Journal of Mechanical Engineering and Robotics Research vol. 2, No. 2, Aprl 2013.

[8] G.M Sayeed Ahmed, Sirajuddin Elyas Khany, Syed Hamza Shareef, “Design, Fabrication and Analysis of a Connecting Rod with Aluminum Alloys and Carbon Fiber”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 10, pp-16674-16687, October 2014.

[9] S.Vijaya Kumar, S.K. Thenadayaal, V.P. Vasanth, V. Vasantha Kumar “Design and Analysis of Two Wheeler Connecting Rod”, International Journal of Innovative Research in Science, Engineering and Technology, Volume 4, Special Issue 6, May 2015.

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