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CONNECTING ROD TESTING FOR IMPROVEMENT OF ENGINE PERFORMANCE WITH NANO COMPOSITE MATERIAL APPROCH

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ABSTRACT

The connecting rod of automobile engine is a high-volume production critical component. Every vehicle that uses an internal combustion engine requires at least one connecting rod. Connecting rod is the intermediate link between the piston and the crank. And is responsible to transmit the push and pull from the piston pin to crank pin, thus converting the reciprocating motion of the piston to rotary motion of the crank. Generally connecting rods are manufactured using carbon steel and in recent days' aluminium alloys are finding its application in connecting rod. Connecting rod use of composite material to weight and cost as well as to improve to mechanical property. Finite element analysis of connecting rod is done by considering the materials vice. In order to determine desirable strength and durable alternate material for connecting rod various research papers has been reviewed, based upon those papers suitable alternate material such as Aluminium alloy 360, Alfesic etc. will be selected and modelling will be done using solidworks2016 3.0. Strength analysis will be carried out using ANSYS2016.

Connecting rod is a mechanical element used to transfer energy from piston to crank. Generally it consists of two ends namely bigger end and small end. Small end is used to connect piston by using gudgeon pin and bigger end is used to connect camshaft. During each rotation of the crankshaft, a connecting rod is often subject to large and repetitive forces: shear forces due to the angle between the piston and the crankpin, compression forces as the piston moves downwards, and tensile forces as the piston moves upwards. These forces are proportional to the engine speed (RPM) squared. In a few two-stroke engines, the connecting rod is only required to push. In which it undergoes structural deformations. Thus in this project we are designing the connecting rod by using design analysis procedure. Then we are modeling a connecting rod in solid works 2016 design software and doing static structural analysis in ansys work bench 14.5 software.

SCOPE OF WORK

Connecting rod is a critical element in an automotive power transmission system, being the kinematic link between the piston and the crankshaft. It is used to convert the reciprocating motion of the piston to the rotary motion of the crankshaft. In the present study, the stress and deformation analysis of the connecting rod has been carried out, and viable changes in three domains, namely the manufacturing processes, material and design of the connecting rod, have been proposed.

Lastly, the design of the connecting rod has been modified to get the best combination of overall stress, stress concentration and deformation. In this process, areas of high stress concentrations are identified and attempts have been made to relieve stresses in these sections. Modifications in each of the above mentioned stages have led to stress and weight reduction and increase in the stiffness,thus enhancing the overall performance of the connecting rod. Static and fatigue analysis has been carried out in ANSYS 15.0 Workbench. The main objective is to reduce the weight of connecting rod by replacing steel with aluminium fly ash composite material without losing any of its strength and hardness.

Experimental results are obtained from the compressive and tensile tests of connecting rods. Spectrometer test is also performed and the results are found out. It is found that by using aluminium fly ash composite material weight is greatly reduced up to 50% without losing any of its strength and hardness. Finally aluminium and steel connecting rods are analyzed with the help of Ansys and the FEA results are compared with the experimental results both the results are give equal value.

OBJECTIVES OF THE STUDY

- To design, modeling and strength analysis of connecting rod for 4 stroke single cylinder 10 hp (7.35 kw) diesel engine-a review
- To design and analysis of composite connecting rod
- To design and analysis of connecting rod with modified materials and fea analysis
- To design fabrication, material and design modification based analysis of connecting rod using fea
- To design and comparative analysis of connecting rod using finite element method

LITERATURE REVIEW

Mr. Ajinkya et al (2015) proposed weight optimization process through ANSYS software, modelling is done by parametric modelling and FEA is done under compressive load and static tensile load by giving standard boundary conditions. Conclusion made in face of results is that change in design and material results in significant effort on weight, as it achieves the objective of reducing the weight the engine component, thus reducing inertia load, engine weight and improving engine performance and fuel economy. Fatigue strength was the most significant factor in the design and optimization of connecting rod.

Christy V Vazhappilly (2013) stated to explore cost optimisation opportunity by performing detail load analysis. Steel connecting rod is chosen change in material results into less machining and manufacturing costs. Two cyclic loads are under consideration according to the paper that are dynamic tensile and static compressive load. Study deals with determination of loads acting as a function of time. Existing connecting rod material can be replaced with new material. Composite material the fracture crack ability feature etc. Same performance can be expected in terms of component durability. After experimenting the data, it was conclude that the connecting rod can be design, analysed under a load ranging from tensile load, corresponding to various degree crank angle at maximum engine speed at one extreme load, and compressive load corresponding to the peak gas pressure at other extreme load. Fatigue strength is most significant factor and the portion, which develops less stress, is removed.

D.Gopinatha,Ch.V.Sushmab (2000) Connecting rod is a critical element in an automotive power transmission system, being the kinematic link between the piston and the crankshaft. It is used to convert the reciprocating motion of the piston to the rotary motion of the crankshaft. In the present study,the stress and deformation analysis of the connecting rod has been carried out,and viable changes in three domains, namely the manufacturing processes, material and design of the connecting rod,have been proposed. Under the head of manufacturing processes, different processes including forging and sintering have been discussed. Effect of shot peening on fatigue strength and heat treatment on the overall performance of the connecting rod have been taken into account. Newer and more efficient materials, namely C-70 steel, Micro-alloyed steels and aluminium based composites with particle and fiber reinforcements have been tested. Lastly, the design of the connecting rod has been modified to get the best combination of overall stress, stress concentration and deformation. In this process, areas of high stress concentrations are identified and attempts have been made to relieve stresses in these sections. Modifications in each of the above mentioned stages have led to stress and weight reduction and increase in the stiffness,thus enhancing the overall performance of the connecting rod.

K. Bari,⁎, A. Rolfea, A. Christofia, C. Mazzucaa, K.V. Sudhakarb (2017) Connecting rod is a major link which connects the piston to the crankshaft and is responsible for transferring the power from the piston to the crankshaft. In this paper Finite element analysis of connecting rod used in single cylinder four stroke petrol engines is taken for the study. Static stress analysis is conducted on connecting rod made up of two different materials viz. E-glass/Epoxy and Aluminium composite reinforced with Carbon nanotubes. Modelling and comparative analysis of connecting rod is carried out in commercially used FEM software ANSYS 14.0. Static structural analysis was done by fixing the piston end and applying load at the crank end of the connecting rod. Output parameters in static stress analysis are von-Mises stress, Shear stress, total deformation and equivalent elastic strain for the given loading conditions.

METHODOLOGY

Reducing the Weight, increasing the hardness are the objectives of our project. The existing connecting rod material is steel C55Mn75 which is used in the vehicle like Trump 40 Travelers etc., The dimensions of the connecting rod are measured which is shown in table 1. The mechanical properties of the C55Mn75 material connecting rod are shown in table 2. For reducing the weight and maintaining the strength of the connecting rod, Aluminium is mixed with fly ash. The detailed fabrication methods for aluminium with fly ash content are discussed below.

Introduction to aluminium Lm6 (Al-Sil2) LM6

Aluminium is an alloy of silicon and aluminium often used in marine applications due to its corrosion resistance. LM6 can be used as a pressure die casting alloy but is also suitable for both gravity and low pressure casting techniques. LM6 is an Aluminium casting alloy (Al-Sil2). It possesses exceptional casting characteristics, which enable them to be used to produce intricate castings of thick and thin sections. Fluidity and freedom from hot tearing increase with silicon content and are excellent throughout the range. Their resistance to corrosion is very good, but special care is required in machining. In general, the binary alloys are not heat treated; at elevated temperatures their strength falls rapidly. Although of medium strength their hardness and elastic limit are low but they possess excellent ductility. The chemical composition of aluminium LM6 is shown table.

Table Chemical composition of LM6

Chemical Composition	%
Copper(Cu)	0.1max
Magnesium(Mo)	0.10max
Silicon(Si)	10.0-13.0
Iron(Fe)	0.6max
Manganese(Mg)	0.5max
Nickel(Ni)	0.1max

Fly ash

Fly ash is the finely divided residue that results from the combustion of pulverized coal that is carried from the combustion chamber of a furnace by exhaust gases. Fly ash produced during the burning of powdered coal in thermal power plants is a hazardous waste. However, its physical and chemical properties make it an ideal raw material for producing high quality and cost-effective bricks, interlocking pavers, herb stones and mosaic tiles. The chemical composition and engineering properties of fly ash is shown in table.

Fabrication of connecting rod

Figure Aluminium LM6 materials

Figure Fly ash

The aluminium and Fly Ash is chosen for fabricating the connecting rod. Aluminium LM6 is the chosen grade which is shown in the Figure 1, due to its low cost. The fabrication of connecting rod is started by fabricating the composite material. At initial step, the fly Ash is shown in the Figure, which is pre heated from 150°C to 400°C. The aluminium LM6 is then heated up to 800°C then the fly Ash is mixed with aluminium. The aluminium and Fly Ash is mixed in the ratio of 5:1. Then heated composite is made into rectangular blocks is shown in the Figure. Sand casting method is used in making these blocks.

RESULTS

In this work, the aluminium (LM6) with fly ash material is used to fabricate the connecting rod. The fabricated connecting rod is compared with the steel connecting rod. The tensile strength and compressive strength of the two different materials connecting rods are compared. And it is noted that both the connecting rods are of equal strength. The hardness number of both connecting rods is also compared and it is noted that they are of nearly equal hardness. Both the connecting rod weight is also compared and it is found that the aluminium with fly ash composite material connecting rod is less weight when compared to the steel connecting rod. The final result is shown in table.

Finite Element Analysis Using Ansys analysis software

the steel type connecting rod and aluminium fly ash material connecting rods were subjected to compressive load and tensile load. Then the rods under different loads were analyzed and the results were found and it is tabulated then which is compared with experimental results. The experimental results and FEA results are shown in table 6. In FEA analysis for analyzing the both connecting rods 8 node quad (plane 82) chooses as a element type. Poisson’s ratio taken as 0.3. Mesh range selected as 0.5. table 6. Shows the FEA results for both steel and aluminium connecting rods.

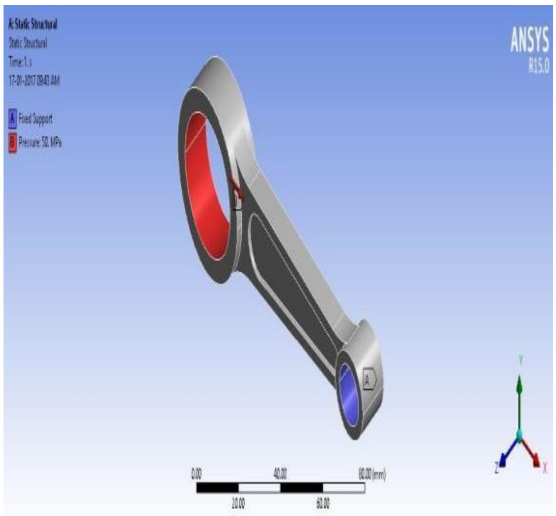

Figure shows the connecting rod model constrain

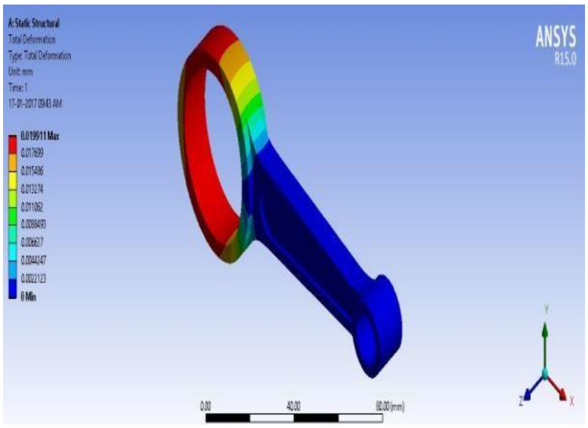

Figure shows the connecting rod deformation

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.9911e-002 mm

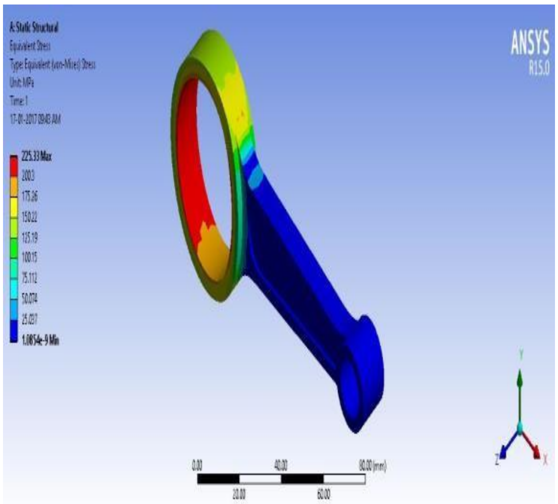

Figure shows the connecting equivalent stresses

Details of "Equivalent Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	1.0854e-009 MPa
Maximum	225.33 MPa

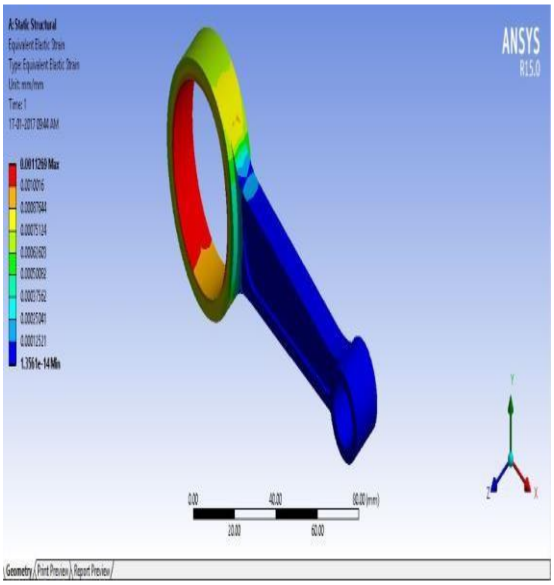

Figure shows the connecting rod strain

Details of "Equivalent Elastic Strain"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent Elastic Strain
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	1.3561e-014 mm/mm
Maximum	1.1269e-003 mm/mm

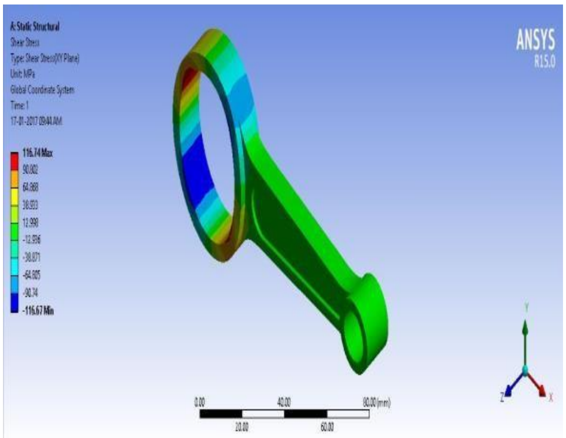

Figure shows the connecting rod shear stresses

Details of "Shear Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Shear Stress
Orientation	XY Plane
By	Time
Display Time	Last
Coordinate System	Global Coordinate System
Calculate Time History	Yes
Identifier	
Suppressed	No

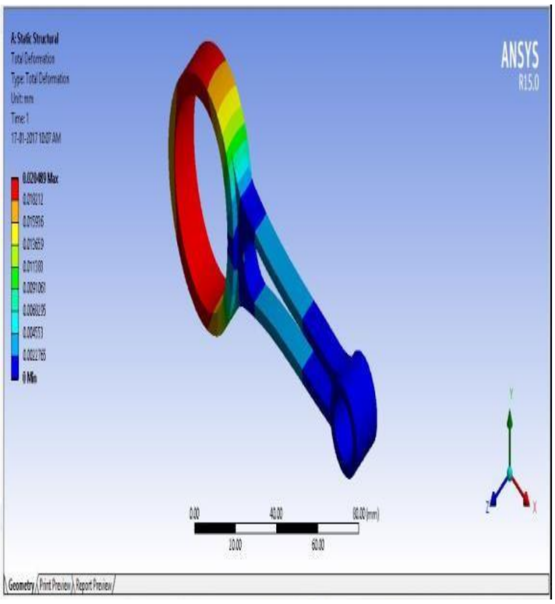

Figure shows the connecting rod total deformation

Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	2.0489e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

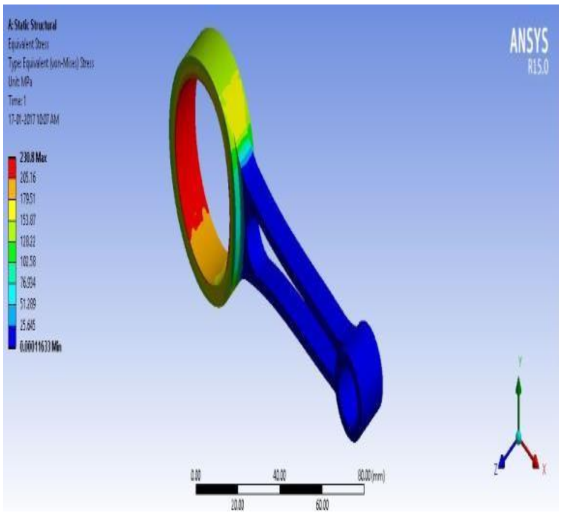

Figure shows the connecting rod equivalent stresses

Details of "Equivalent Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent (von-Mises) Stress
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	1.1633e-004 MPa
Maximum	230.8 MPa

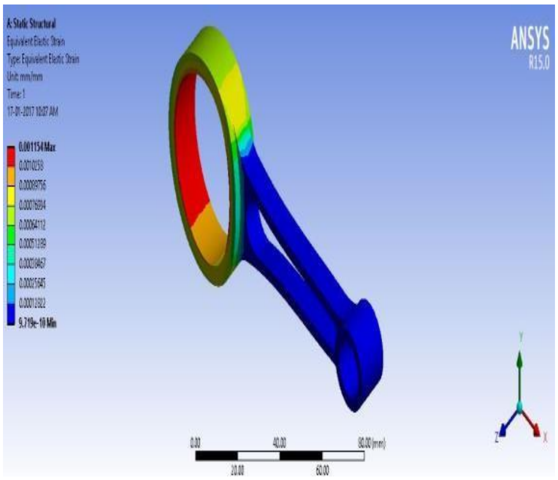

Figure shows the connecting rod elastic strain

Details of "Equivalent Elastic Strain"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Equivalent Elastic Strain
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	
Minimum	9.719e-010 mm/mm
Maximum	1.154e-003 mm/mm

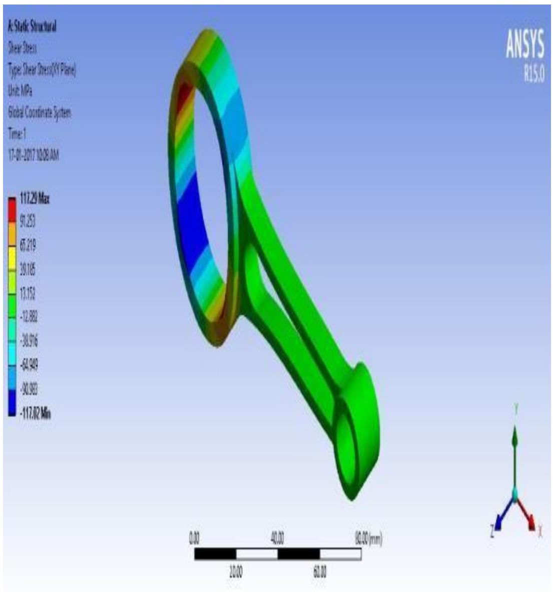

Figure shows the connecting rod stresses

Details of "Shear Stress"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Shear Stress
Orientation	XY Plane
By	Time
Display Time	Last
Coordinate System	Global Coordinate System
Calculate Time History	Yes
Identifier	
Suppressed	No
Integration Point Results	
Display Option	Averaged
Average Across Bodies	No
Results	

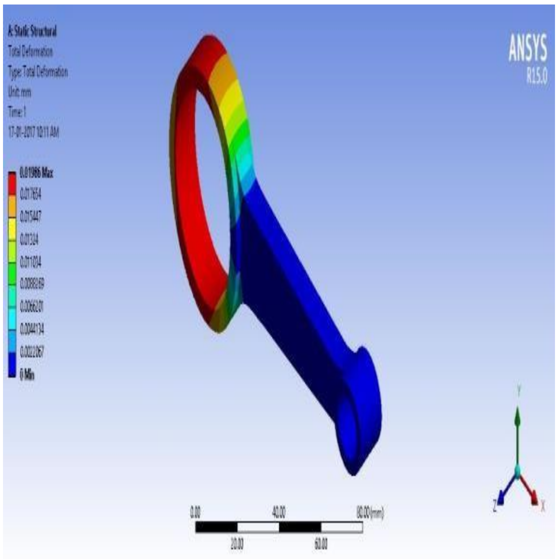

Figure shows the connecting rod total deformation

Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
By	Time
Display Time	Last
Calculate Time History	Yes
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.986e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

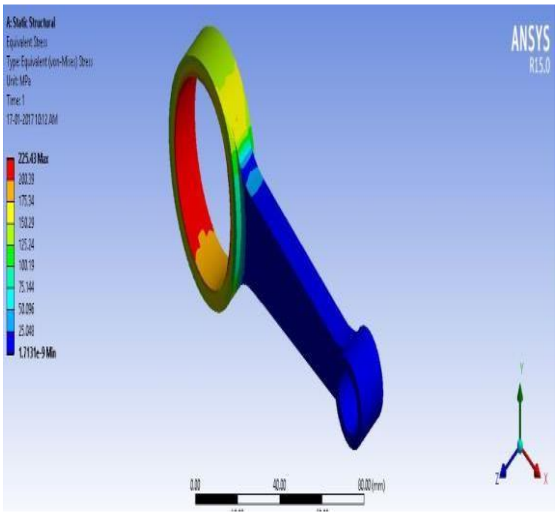

Figure shows the connecting rod stresses

Details of "Static Structural (A5)"	
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

CONCLUSION

In this paper, modifications in the connecting rod in three areas namely, manufacturing process, material and design have been proposed. The results and validity of the discussed changes may be summarised as follows:

(1) Besides addressing the problem of crackability of connecting rod, advanced materials namely, C70 (Crackable) steel and Micro-alloyed steel exhibit better combination of strength and stiffness than steel manufactured by forging and sintering. Weight reduction in the latter two cases compared to forged and sintered steel is also quite evident.

(2) Shot peening serves to increase the fatigue life and improves the fatigue strength of the model. The residual stresses produced on the surface as a result of shot peening may be relieved by subsequent heat treatment.

(3) The connecting rods made of metal matrix composites (namely, Al-15%Al2O3 and Al10%SiC) have lower weight and higher stiffness than that manufactured by the conventional material (i.e. Al-6061).

(4) The stresses in the shank section may be reduced by machining small holes at appropriate locations in the connecting rod. There is 3.395% reduction in Maximum Von-Mises stress in the modified model.

(5) The stress distribution is more uniform in case of the modified model.

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