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Analysis and Comparison of Metal Matrix Composite and Steel Connecting Rods

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Abstract: Connecting rod is an important intermediate between piston and Crankshaft.Connecting rod transmits piston load to the crank causing the latter to turn, thus converting the reciprocating motion of piston into rotary motion of the crank. Connecting rods are subjected to static and dynamic loading forces generated by mass and fuel combustion. It undergoes high cyclic loads of the order of 10^8 to10^9cycles, which ranges from high compressive loads due to combustion, to high tensile loads due to inertia. The connecting rod has been the topic of research for the aspects such as production, performance simulation, materials etc.

This paper describes Design, modeling and analysis of connecting rod. The main aim of paper is to analyze static stresses developed in connecting rod i.e. compressive stress and tensile stress, to explore weight reduction possibilities for the production of connecting rods. The material used for the purpose is Aluminum Metal Matrix. The comparative study is done between steel and AMC connecting rods.

Therefore, study has been divided in two subjects, first, static stress analysis of the connecting rod and second, optimization of weight of connecting rod.

Keywords: Aluminium metal matrix, static stress analysis.

I. INTRODUCTION

There are distinct types of materials and production methods used in the manufacturing of connecting rods. Connecting rod undergoes high amount of compressive loading due to combustion as well as tensile loading due to inertia.If the connecting rod fails, damage will occur to the engine and it require costly repairs.

Therefore, it is important to properly determine the stresses present within the rod. Due to which we can ensure that even under worst conditions it will have to perform without failing .The importance of the connecting rod as well as the crank shaft for the operation of an engine reliably. Time and effort are necessary to create the best design for a connecting rod to overcome high stresses while minimizing weight. The reduction of weight of connecting rods is important to ensure that the engine can operate safely in higher speed due to the decreased inertia held within the lighter rods. The goal is to remove as much material from the rod while to maintain their strength and integrity, by being able to model the connecting rod and determining the forces present on it under all conditions. The literature review was undertaken for the work. Pushpendra Sharma [1] et al, describes the static finite element analysis of the connecting rod. The optimization was performed to reduce weight. Weight of connecting rod can be reduced by changing the material. Mohammed et al [2] analyze the cause of failure of connecting rod by finite element analysis with help of MSC Patron software. In this paper, the metallographic study of buckled connecting rod is also performed. Asadi, et al (2010) [3] describes detailed load analysis for connecting rod under service loading conditions. The maximum pressure stress is obtained between pin end and rod linkage. The maximum tensile stress is obtained in lower half end. Abhinav Gautam et al. [4] performed static stress analysis of connecting rod made up of stainless steel. The analysis concludes that the area close to root of the smaller end of connecting rod is very prone to failure. Suraj Pal et al. [5] carried out FEA of the connecting rod of a Hero Honda Splendor. Fatigue and Static stress analysis is done to determine the von Misses stress, elastic strain, total deformation and shear stress. They found that stress is highest at the piston end so the material is increased in the stressed potion to reduce stress. Ram Bansal et al. [6] performed the dynamic analysis of the connecting rod. In his work, model of connecting rod of single cylinder- four stroke diesel engines is modelled in CATIA V5R18 software and analysis is done.Static load analysis is done.

II. MATERIAL SELECTION AND PROPERTIES

Generally there are a few materials that are commonly used in the manufacturing of connecting rods. Like- steel alloy, aluminum and titanium.Aluminum and titanium are both materials that are also used in the manufacturing of connectingrods. The connecting rods are usually made of steel alloys like 42CrMo4, 43CrMo4, 44ccr4, C-70, EN-8D, SAE1141, etc. Connecting rods are usually drop forged out of a steel alloy. Connecting rods for automotive applications are typically manufactured by forging from either wrought steel or powder metal.

In this work, for manufacturing of connecting rod aluminum metal matrix is selected as a material. This is compared with the connecting rod having conventional steel material.Aluminum metal matrix shows low density and high strength.Compositions of these materials are listed in table1.

Table.1 Chemical Composition of Aluminum Metal Matrix

Component	AL	Cr	Cu	Fe	Mg
Weight (%)	87.1-91.4	0.18-0.28	1.2-2	Max 0.52	2.1-2
Min	Other, each	Other, total	Si	Ti	Zn
Max 0.3	Max 0.05	Max 0.15	Max 0.4	Max 0.2	5.0-6.1

Table.2 Properties of Aluminum Metal Matrix

Parameters	Properties
Physical Properties	
Density	3.0 g/cc
Mechanical Properties	
Young's Modulus E	89 GPa
Poisson's Ratio	0.33
Ultimate Tensile Strength	435 MPa
Behavior	Isotropic

A. *Design of Connecting Rod*

The different dimensions of the engine and connecting rod aregiven below,

Connecting rod length = 104.5mm, Speed of the engine = 1400r.p.m.

Maximum gas pressure = 3.7MPa, Bearing pressure at big end = 8.5MPa

Bearing pressure at small end = 15MPa, Allowable stresses in the bolts = 60MPa

Allowable stresses in the cap = 80MPa

The maximum force acting on the piston due to gas pressure,

$$F = \frac{\pi * D^2 * p}{4}$$

$$= 2769.32N$$

Since factor of safety is considered, F= 14236.4 N

Radius of crank = 96/2= 48 mm

Maximum Tensile Force:

Mass of the connecting rod, m = vol.× length×density= 0.425kg

Maximum Bending moment = m× ω^2×r× (l/9√3)= 646.32 N-mm

Section modulus = Ixx/ (5t/2) = 1856.8mm^3

Maximum bending stress due to inertia bending forces = M_{max}/Z_{xx}= 2.85N/mm2

Table.3Specifications of connecting rod.

Sr. No.	Parameter	Dimensions
1.	Length of Connecting Rod	104.5 mm
2.	Inner diameter at big end	38 mm
3.	Outer diameter at big end	55 mm
4.	Inner diameter at small end	17 mm
5.	Outer diameter at small end	29 mm
6.	Thickness	18

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III. MODELING AND ANALYSIS

Design tool CATIA V5 is used for modeling of connecting rod. First model of connecting rod is created in CATIA V5R18 software. Analysis is done by using ANSYS 16.0. The focus of analysis is to find out the total stress generated in connecting rod and deformation produced in it. Fig (1)shows the meshing generated on the connecting rod. The rectangularelement type meshing is done on the model. Total number of elements 43367 and Total number of nodes 67038were generated.

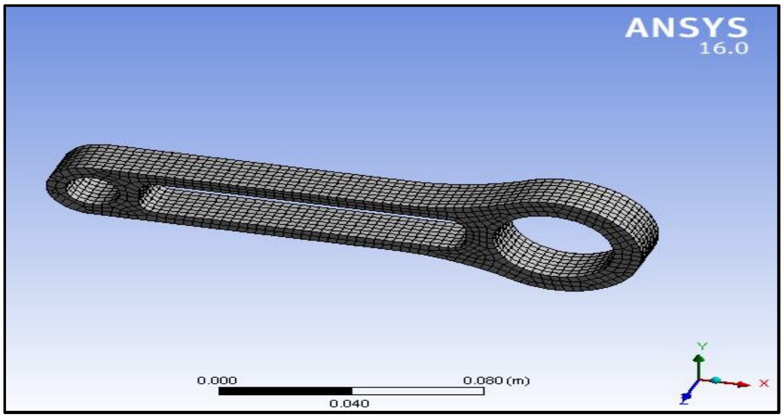


Fig: (1) Meshing on Connecting Rod.

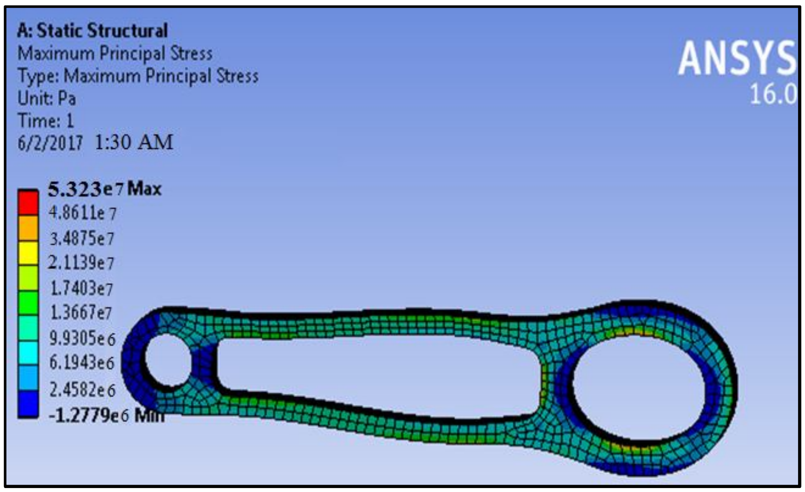


Fig: (2) Maximum principal stress of Steel Connecting Rod.

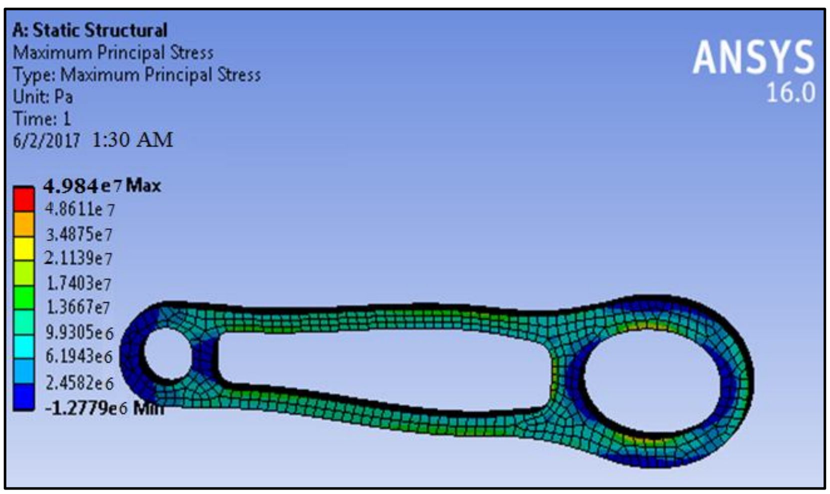


Fig: (3) Maximum principal stress of AMM Connecting Rod.

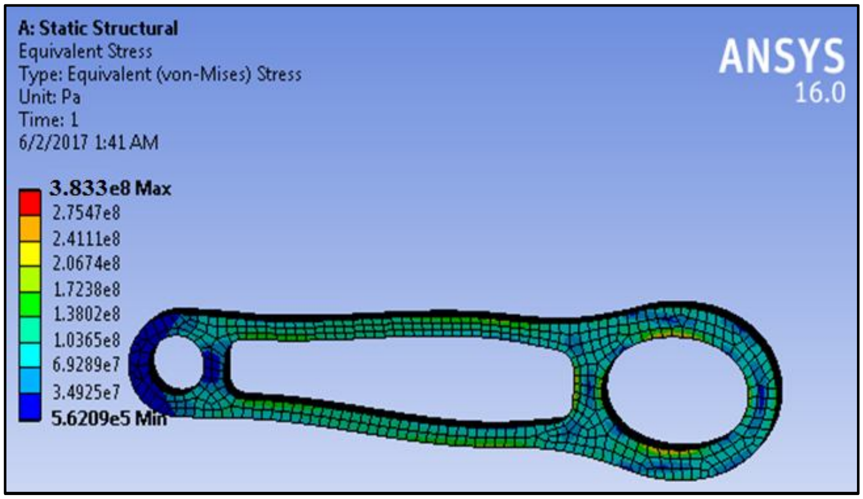


Fig: (4) Equivalent Von-misses stress of Steel Connecting Rod.

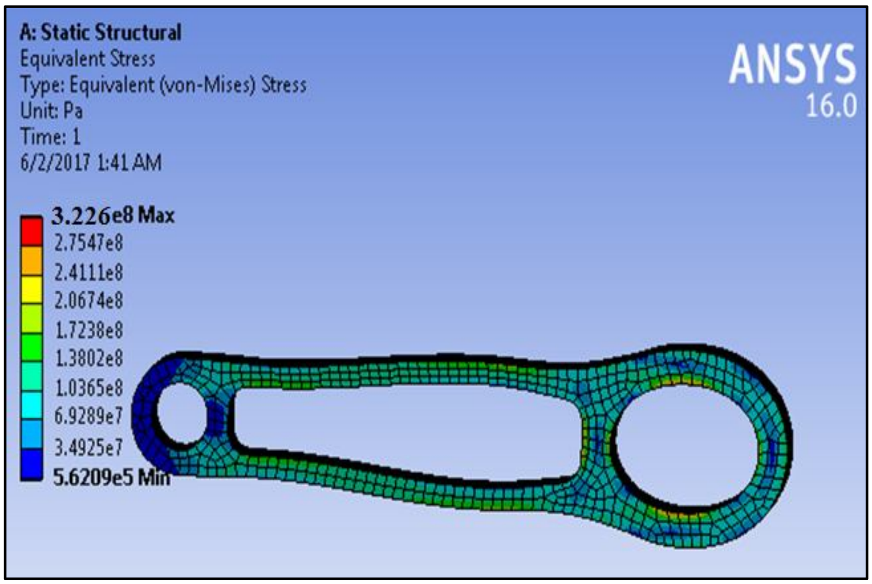


Fig: (5) Equivalent Von-misses stress of Connecting Rod.

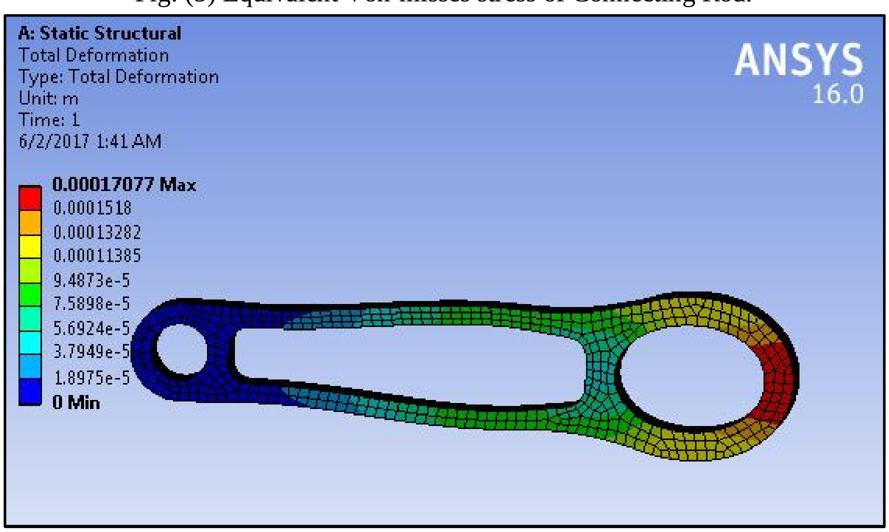


Fig: (6) Total deformation of Connecting Rod.

IV. MANUFACTURING

The manufacturing technique used for manufacturing of connecting rod is as follows,

A. Fabrication Techniques

The fabrication of the metal matrix composites are mainly based on two technological methods such as solid state processing and liquid state processing. In solid state processing, reinforcement are embedded in the matrix through diffusion phenomenon and are produced at high pressure and temperature. In this process, some special care should be taken to avoid the growth of undesirable phases or compounds species on interface. Some commonly used techniques under this method are diffusion bonding, powder metallurgy etc. In liquid state processing, the matrix is in liquid form and the reinforcement either in form of fibers or particles are embedded into it. The uniformity in distribution of reinforcement can be made by means of applying some mechanical actions. This is one of the most used and inexpensive method for fabrication of metal matrix composites. Hot forming, liquid infiltration, squeeze casting and stir casting are some common techniques under this method.

Among the variety of techniques available for fabrication of MMCs, stir casting is generally most simple, cost effective and accepted technique.

In this method,

1) After the matrix material is melted.
2) It is stirred vigorously to form a vortex at the surface of the melt.
3) The reinforcement material is then introduced at the side of the vortex.
4) The particles transfer into the matrix melt due to the pressure difference between the inner and the outer surface of the melt.

B. Procedure

In this process, melting of the matrix alloy is carried out separately about 800^0C, above its melting temperature using muffle furnace. After melting, the required quantity of filler particulates (0, 3, 6 and 9 wt.%), preheated to around 350^0C, are added to the molten metal and stirred continuously by using a mechanical stirrer .

The stirrer is rotated at a high speed for 3-4 min in order to get uniform mixing of filler particulate in the matrix material.

During stirring, to enhance the wettability, small quantities of magnesium are added to the melt. The molten metal is then poured into permanent mold of size 106×58×20mm (i.e. length × width × thickness) for casting and the temperature is then lowered gradually.

After solidification, the castings are taken from the mold and are cut to the required shape and sizes **(104.50×55×18 mm)** for test.

Fig: (7) Manufacturing process of Connecting Rod.

C. Testing

For stress analysis two most critical areas is considered bigger end and smaller end of connecting rod. Load is applied at bigger end and smaller end kept fixed. Three different loads which are obtained with the help of engine specifications are used for analysis purpose. By using universal testing machine tensile testing is carried out. As shown in figures, initially Connecting rod is attached in lower jaw of Universal Testing Machine. After travelling lower jaw specimen is attached in to the upper jaw. Then the tenssile load is applied on the specimen.

Fig:(8) Connecting rod is attached in lower jaw of Universal Testing Machine.

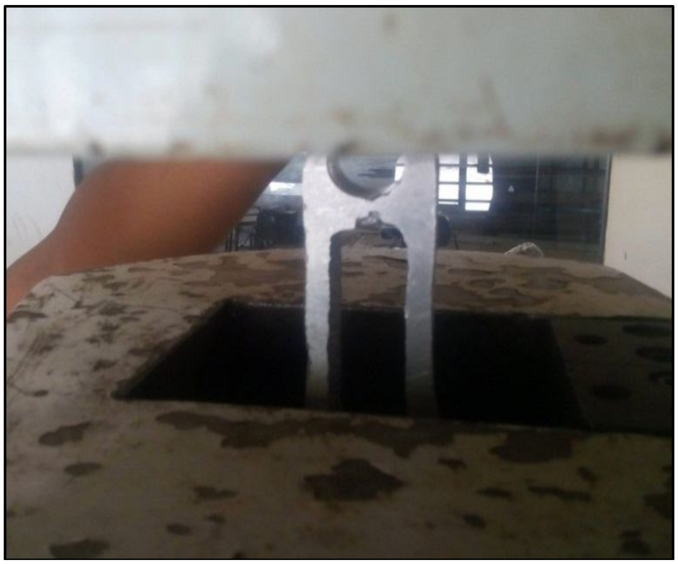
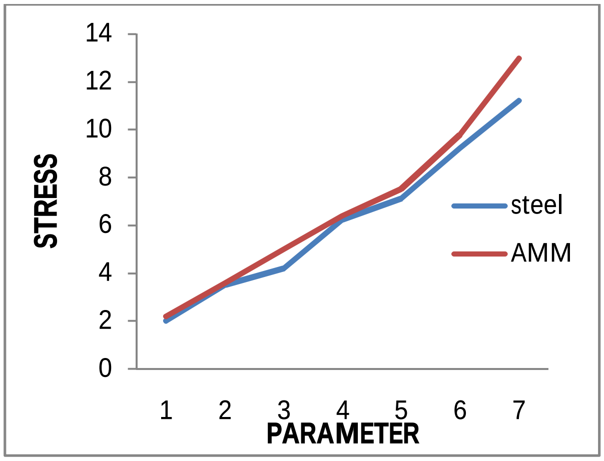


Fig: (9) After travelling lower jaw specimen is attached in to the upper jaw

Fig: (10) connecting rod is fixed in upper and lower jaw of UTM machine.

The testing report is as follows, For Aluminium metal matrix and conventional steel the stresses and deformation values is as follows,



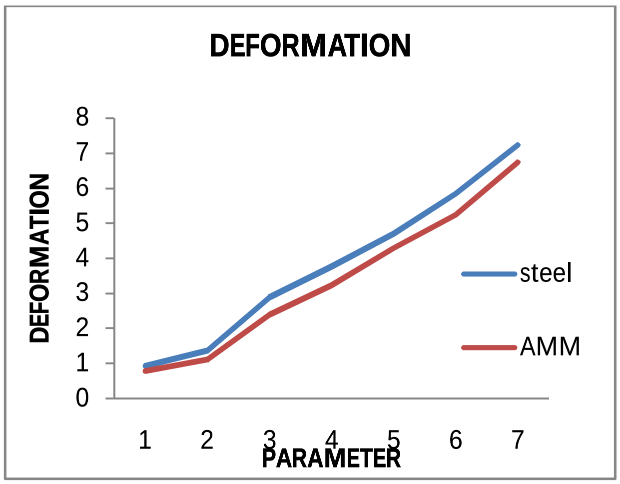


Fig: (11) Stress and deformation in connecting rod.

V. RESULTS AND DISCUSSION

Results for steel and aluminium metal matrix connecting rod is as below,

Table.4 Result of connecting rod.

Sr.No.	Parameter	Steel	Aluminium Metal Matrix
1	Von-Mises Stress (MPa)	38.34	32.26
2	Maximum Principal Stress (MPa)	53.23	49.84
3	Maximum Shear Stress (MPa)	32.8	31.62
4	Deformation(mm)	7.86	6.2
5	Weight (kg)	0.68	0.425

VI. CONCLUSION

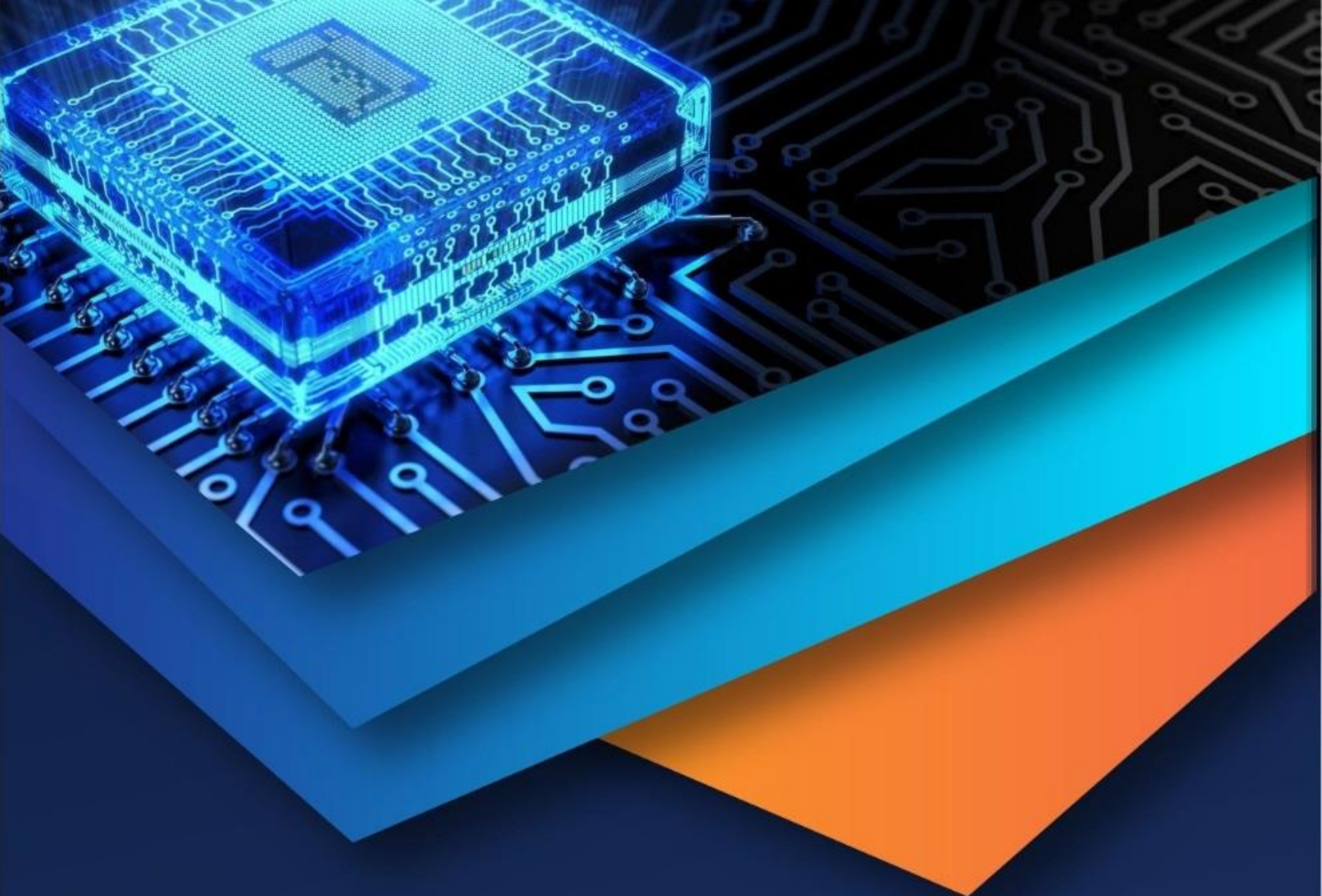
From the static structural analysis,the result obtained as Von-Mises stresses for steel and aluminium are nearly same for a given loading conditions and shear stresses for steel and aluminium are 32.8 MPa and 31.62 Mpa.Optimization in weight is obtained if we see the weight of both the specimens. Mass of aluminimum metal matrix connecting rod is 425 grams. Therefore weight in reduction is obtained by changing the aluminium metal matrix material.

Hence we can conclude this study as the stresses developed in the rods (steel and amc)are nearly equal.

The objective of the study as to reduce weight in amc connecting rod is satisfied.

REFERENCES

[1] "Fatigue analysis and optimization of connecting rod using finite element analysis",Pushpendra Sharma, Borse Rajendra R etal. International Journal of advance research in Science and Engineering, Vol. No.1, Issue No. I (September 2012.),pp- 3367-3371.
[2] "Analysis of Fatigue Stresses on Connecting Rod Subjected toConcentrated Loads at the Big End", Mohammed etal. Elsevier Materials Today: Proceedings 2 (2015), pp-2094 – 2103.
[3] "Paper of Optimization of connecting rod of MF-285 tractor", Asadi, et al. (2010).
[4] "Static Stress Analysis of Connecting Rod Using Finite Element Approach", Abhinav Gautam, K Priya Ajit, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 10, Issue 1 (Nov.-Dec. 2013), PP 47-51.
[5] "Design Evaluation and Optimization of Connecting Rod Parameters Using FEM", Suraj Pal et al., International Journal of Engineering andManagement Research, Vol.-2, Issue-6, (December 2012), ISSN No.: 2250-0758, pp: 21-25.
[6] "Dynamic simulation of connecting rod made of aluminium alloy using finite element analysis approach", Ram Bansal, IOSR Journal of Mechanical and Civil Engineering, Volume 5, Issue 2 (Jan.-Feb. 2013) pp- 01-05.
[7] "Modeling and Analysis of Two Wheeler Connecting Rod", K. Sudershn Kumar et al., International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.5, (Sep-Oct. 2012), pp-3367-3371.



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