# Modelling And Analysis Of Metal Matrix Composite Of Connecting Rod By Finite Element Analysis

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*Abstract*— **Composite materials are now a days widely used in the engineering field. The general characteristics possessed by the composite materials are greatly found to be the reason for using it in the automotive applications. The objective of the project is to design and analysis the stress and strain of metal matrix composite (MMC) connecting rod. The connecting rods are commonly used in the IC engines and are forced to millions of varying stress cycles leading to fatigue failure. But the MMC connecting rods are lighter and may offer better compressive strength, stiffness when compared to conventional connecting rod and it's design still represents a major technical challenge. In this project both the standard steel alloy and composite connecting rods are modelled and analysed using SolidWorks 2016. A comparative study was undertaken to predict the structural behaviour of connecting rods using three dimensional finite element stress, and is determined for the most cost effective modelling and analysis approach. The finite element results proves that the performance is similar as that of standard steel connecting rod. The stress and fatigue analysis of the MMC connecting rods is observed to be better than that of the standard connecting rod.**

*Keywords*— **Connecting rod, Composite materials, Cost effective, Modelling, Analysis, Comparison of result.**

## I. INTRODUCTION

Connecting rod connects the piston and the crankshaft. Its primary function is to transmit the push and pull force from the piston pin to the crank pin and converts the reciprocating motion of the piston into the rotary motion of the crank. It consists of a shank a small end and a big end. The cross-section of the shank may be circular, rectangular, tubular "I section and H section". Generally H section is used only for low speed engines, where I section is preferred for high-speed engines.

The main advantages are the reduction of mass that is a crucial topic for a components subjected to a high inertial loads. Furthermore, the very good fatigue strength of such materials, meets the requirement to withstand cyclic loads. Connecting rod design is a quite complex task because engine operates at wide variable load conditions, and load on crank and slider mechanism are produced both by pressure and inertia.

Assuming that the connecting rod is to be replaced by the original component of an existing engine, the main objective is material replacement for principle design constrains to be considered are fatigue strength and buckling strength. Other data's required for design are the cylinder pressure at service RPM, load, reciprocating mass, slider and the crank mechanism geometric parameters. The design problem consists in the evaluation of objective and the constraint functions once design parameters is been chosen. The way to obtain desired functions in quite complex.

## II. PROBLEM DEFINITION

To drive out the major failures in an engine and the cause and effects of it, results predict the wear and tear of the moving parts in the connecting rod does the major role. In spite of that, the forged intermediate member that often fails due to its transformation from reciprocating to rotation deforms and buckles it. This mechanism is studied under investigation, deal with an engineering approach for its reason for failure and repeated replacements, frequently. Precision care has been taken in evolving out the typical reason for the failure and towards its solution. After an establishing survey, we made a conclusion in focusing towards replacement of forged carbon steel into metal matrix composite (MMC) connecting rod.

## III. OBJECTIVE

The main focus is on design and analysis of metal matrix composite connecting rod in the suitable method without affecting its properties and performance, for which an innovative technique is approached and MMC connecting rod is generated and analysed.

## IV. PROBLEM ANALYSIS

Though the task word is found to be so small and easy, the material replacement, but not at the work. Because connecting rod is a member which deserves certain constrains we should never even altered. For example its big end should greater than eye end, its shank length converging from big end to small end, "I section or H section". While in this case we have a solution, focusing towards material replacement, material properties a real factor will play a vital role without affecting other regular functioning of the connecting rod. Material replacement is a long step process which comprises of modelling of the conventional design and its analysis and modelling of modified material or optimized design and its analysis.

 

The objective that we are focusing on material replacement of the connecting rod in the right method is quite difficult in sense, without causing the connecting rod to fail at the same time positively making it a possible solution for the facing problem. As mentioned earlier material replacements has to be done from the connecting rod by which it should not suffer further more instability or damage. Considering the shank whose length should not suffer further more instability or damage. Considering the shank whose length should never be changed since it is proportional to l/r ratio governing the selection of connection rod to its corresponding power.

## V. EXPERIMENTATION

### *A. AL6061*

In this work, Al6061 material is used as the matrix element, and silicon carbide and fly ash as reinforcement.

### *B. Silicon Carbide*

Silicon carbide is the mixture of carbon and silicon. It is an excellent abrasive. It is having low density, high strength, high elastic modulus, high thermal conductivity, very good thermal shock resistance. Elevated temperature performance and it is observed that they reported only a 35% loss of strength at 1350ºC are their best qualities. And it has melting point of 2700 ºC.

### *C. Fly Ash*

Fly ash is one of the most in expensive and low density reinforcement available in large quantities as solid waste by-product while combustion of coal in thermal power plants. They constitute mostly of silicon dioxide (sio2), aluminium oxide/alumina (al2o3) and iron oxide (fe2o3). Fly ash particles are mostly spherical in shape and range from less than 1µm to 100 µm. It is having high electrical resistivity, low thermal conductivity.

## VI. CALCULATION BASED ON ENGINE SPECIFICATION

Consider a 150cc engine,

| | | |
|---|---|---|
| Engine type | = | Air cooled 4-stroke |
| Bore | = | 49mm |
| Stroke | = | 56mm |
| Crank radius | = | 56/2 = 28mm |
| Piston diameter | = | 48.5mm |
| Piston weight | = | 65g |
| RPM | = | 7500 |
| Torque | = | 0.8 kg-m |
| Compression Ratio | = | 9.35/1 |
| Displacement | = | 149.5CC |
| Load WB | = | 13020 N |

## VII. PERFORMANCE OF COMPOSITE DEPENDS ON

1. Properties of matrix and reinforcement,

2. Size and distribution of constituents,

3. Shape of constituents,

4. Nature of interface between constituents.

## VIII. ANALYSIS OF CONVENTIONAL CONNECTING ROD

The connecting rod is modelled by using Solidworks 2016 and the part option is used to model this connecting rod. Then the model is analysed in the Solidworks 2016 itself.

*Material properties of conventional connecting rod:*

| | | |
|---|---|---|
| Material type | : | C70 |
| % Carbon | : | 0.65-0.75 |
| % Manganese | : | 0.60-0.90 |
| Young’s Modulus | : | 210000 $N/mm^2$ |
| Poisson’s Ratio | : | 0.33 |
| Density | : | 7800 $kg/m^3$ |
| Ultimate tensile strength | : | 750 $N/mm^2$ |
| Yield tensile strength | : | 540 $N/mm^2$ |

**Fig. 1 Solid model of the connecting rod**

**Fig. 2 Meshed connecting rod**

*Boundary condition Compressive Analysis:*

| | | |
|---|---|---|
| Bottom end (Big end) | - | Fixed |
| Top end (Small end) | - | Application of load |
| FY | - | -13020 N |
| UX, UY, UZ, ROTX, ROTY | - | Fixed |

 

| | | |
|---|---|---|
| ROTZ | - | Free |

*Boundary condition Tensile Analysis:*

| | | |
|---|---|---|
| Bottom end (Big end) | - | Fixed |
| Top end (Small end) | - | Application of load |
| FY | - | +13020 N |
| UX, UY, UZ, ROTX, ROTY | - | Fixed |
| ROTZ | - | Free |

### A. Compressive test on conventional connecting rod

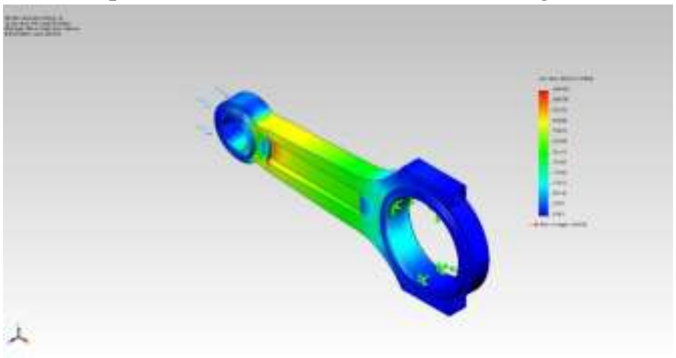

**Fig. 3 Stress analysis**

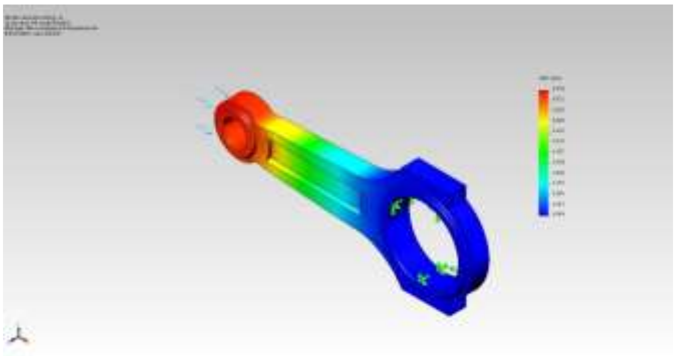

**Fig. 4 Displacement analysis**

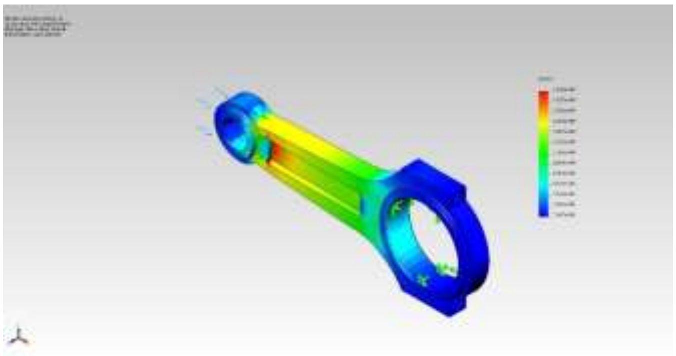

Fig. 5 Strain analysis

### B. Tensile test on conventional connecting rod

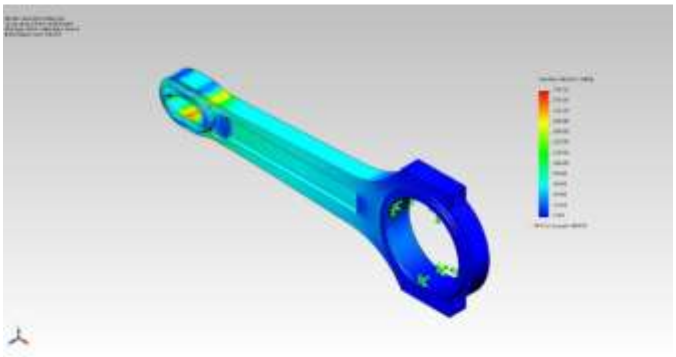

**Fig. 6 Stress analysis**

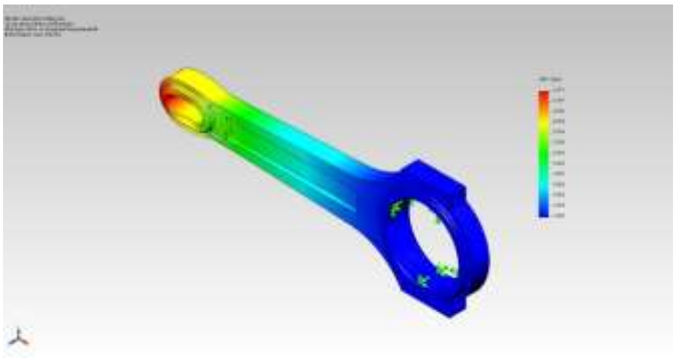

**Fig. 7 Displacement analysis**

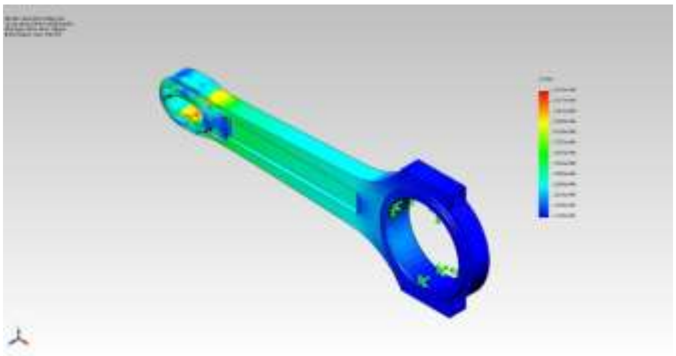

**Fig. 8 Strain analysis**

## IX. ANALYSIS OF MMC CONNECTING ROD

The same connecting rod that was modelled for analysis in the previous section is taken here and the only changes are the values in the material properties.

***Material properties of MMC:*** Aluminium and Magnesium casting reinforced with fibre are being developed for high performance automotive application. While they are lighter and may offer better compressive strength, stiffness, and fatigue resistance than conventional engine materials.

 

| | | |
|---|---|---|
| Material type | : | Al6061 |
| % SiC | : | 9 |
| % Fly ash | : | 15 |
| Young's Modulus | : | 70000 N/mm2 |
| Poisson's Ratio | : | 0.33 |
| Density | : | 2611.61 kg/m3 |
| Ultimate tensile strength | : | 422 N/mm2 |
| Yield tensile strength | : | 363 N/mm2 |

### *A. Compressive test on composite connecting rod*

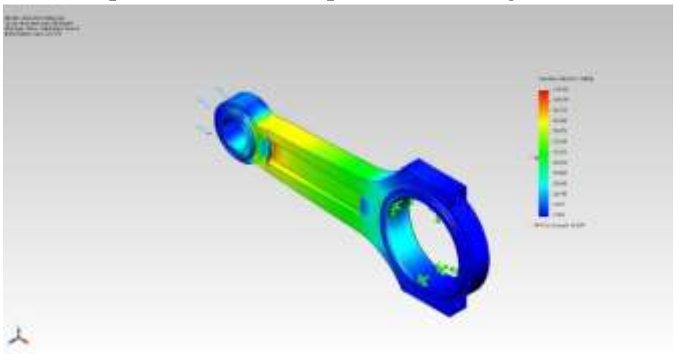

**Fig. 9 Stress analysis**

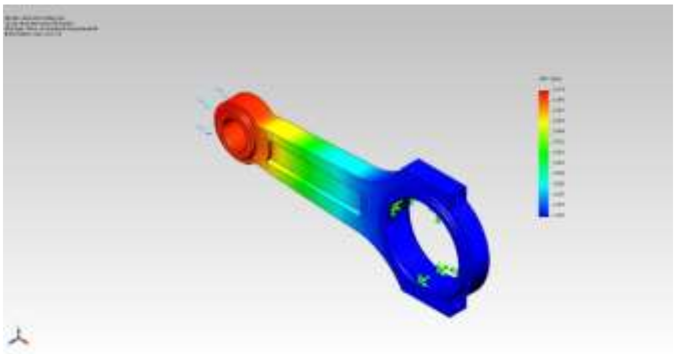

**Fig. 10 Displacement analysis**

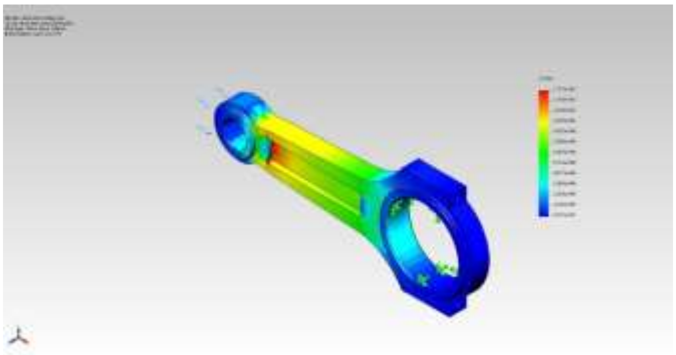

**Fig. 11 Strain analysis**

### *B. Tensile test on composite connecting rod*

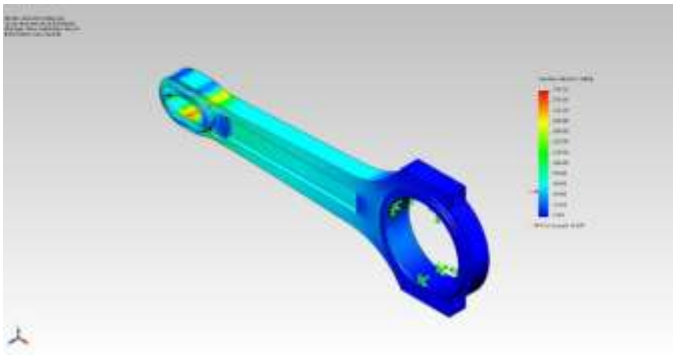

**Fig. 12 Stress analysis**

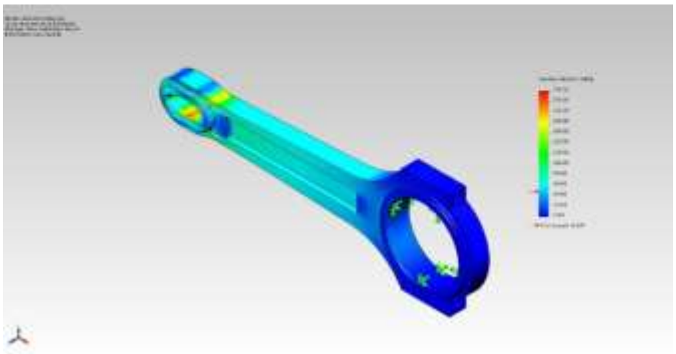

**Fig. 13 Displacement analysis**

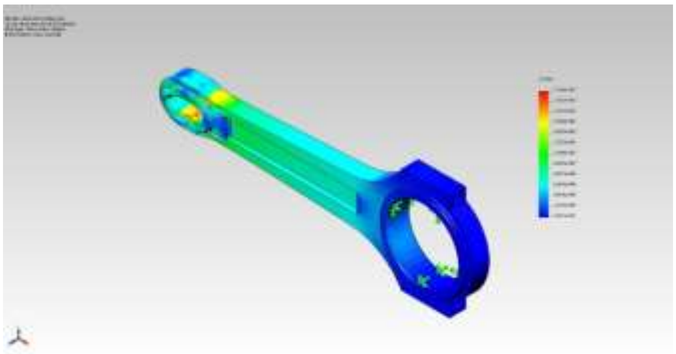

**Fig. 14 Strain analysis**

## X. RESULT

The FEA value of conventional and MMC connecting rod is obtained and is shown in the table.

**TABLE I**

| Stroke | Conventional CR | Composite CR |
|---|---|---|
| Mass (kg) | 0.34773 | 0.120368 |
| Compressive test results | | |
| Stress (Mpa) | 118.464 | 118.464 |

 

| | | |
|---|---|---|
| **Displacement (mm)** | 0.0342289 | 0.104175 |
| **Strain** | 0.000451065 | 0.00137281 |
| **Tensile test results** | | |
| **Stress (Mpa)** | 278.731 | 278.731 |
| **Displacement (mm)** | 0.051421 | 0.156499 |
| **Strain** | 0.000919339 | 0.00279799 |

## XI. CONCLUSION

- The conventional connecting rod used in the engines was replaced with composite connecting rod.
- The fabricated aluminium composite connecting rod has light good wear resistance.
- Equivalent elastic Stress in Al alloy composite connecting rod is same as structural steel connecting rod.
- It resulted in reduction of 33.26% of weight and it reduced the cost of connecting rod.

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