

# Static Structural and Linear Buckling Analysis of Automotive Connecting Rod

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**Abstract**— Connecting Rod is one of the significant segments in a car IC motors which give responding movement from the rotating movement to the cylinder. In an IC motors the high ignition gas will create, because of which high loads will be created in the interfacing pole. It is essential to contemplate the conduct of interfacing pole in an IC motor because of high weights on associating bar. Consequently it is a lot of basic to examine the static and dynamic conduct of the interfacing pole. It is additionally essential to examine the clasping heap of the associating bar which may decrease the disappointment of interfacing pole. Subsequently in the venture the static basic and direct clasping investigations has been led for gauge the most extreme burdens, greatest twisting, clasping load factor and basic clasping load with various materials like Aluminum Alloy 6061, Titanium Alloy, Magnesium Alloy and Aluminum Boron Carbide and New Modified Design. Computer aided design model of associating bar has been created by utilizing modern CAD apparatus Solidworks and Analysis has been finished by utilizing mechanical CAE device Ansys Workbench. In this venture the aftereffects of Static and Buckling Analysis has been looked at and introduced the appropriate plan of associating bar for better executing.

**Keywords:** Connecting Rod, CAD, CAE

## I. INTRODUCTION

A Connecting rod is a motor part that moves movement from the cylinder to the driving rod and capacities as a switch arm. Interfacing bars are ordinarily produced using projected aluminum combination and are intended to withstand dynamic loads from ignition and cylinder development. The little finish of the interfacing pole associates with the cylinder with a cylinder pin. The cylinder pin, or wrist pin, gives a turn point between the cylinder and associating rod. Spring clasps, or cylinder pin locks, are utilized to hold the cylinder pin set up.

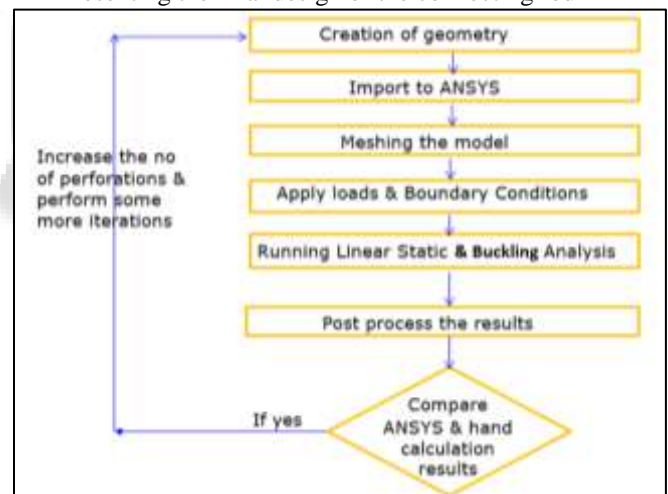
The enormous finish of the interfacing bar associates with the crankpin diary to give a rotate point on the driving rod. Associating poles are produces as one piece or two-piece parts. A bar top is the removable part of a two-piece interfacing bar that gives a heading surface to the crankpin diary. The bar top is joined to the associating pole with two top screws for establishment and expulsion from the driving rod.

The most well-known utilization of interfacing street is in interior ignition motors and steam motors. Ranch supplies, vehicles and truck, development gear and some other kind of vehicle with an inside burning motors utilizes some sort of associating bar.

## II. OBJECTIVES AND METHODOLOGY

### A. Major Objectives:

- The primary objective of the current work is to optimize the weight, strength and
- buckling factor or buckling load of the connecting rod with the different MMC's and different design for better performance
- Conduction of linear static and buckling analysis of the connecting rod to optimize the design of connecting rod
- Determination of Maximum Stresses, Deformations and Buckling Factor of the connecting rod with existing material and different composite materials to find out the better design of the connecting rod
- Determination of the buckling factor of the connecting with different materials and design to estimate the critical buckling load
- Optimization of the connecting rod with reduced weight
- Presenting the final design of the connecting rod



### B. Methodology of the project:

- 1) Review the design of Connecting Rod with international journals.
- 2) Generating the model of Connecting Rod in Solidworks
- 3) Import the geometry into ANSYS Workbench.
- 4) Mesh the model and preparation of boundary conditions.
- 5) Estimate the Stresses, Deformations and Buckling Load Factor of the Base line Design using FE Approach.
- 6) Compare the results with literature.
- 7) Validate ANSYS results with Theoretical Results.
- 8) Design modifications to increasing the efficiency

## III. RESULTS AND DISCUSSIONS

### A. Engine configuration of automotive connecting rod:

Following table shows the engine configuration of the diesel engine for the crankshaft:

Capacity	125cc
No. Cylinders	1
Compression Ratio	18:1
Max Power	8.1 HP@3600RPM
Max. Torque	16.7 N.m@2200RPM
Max. Pressure	6 MPa
Bore Dia	65.5 mm

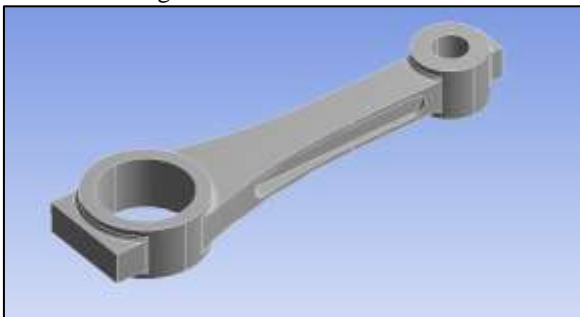
Engine Specifications

**B. FEA Results of modified design of automotive connecting rod:**

In this project Static Structural and Linear Buckling Analysis of Automotive Connecting Rod has been conducted for different materials as follows:

- 1) Aluminium Alloy 6061
- 2) Titanium Alloy
- 3) Magnesium Alloy
- 4) Aluminium Boron Carbide

Below fig shows 3D model of Automotive



Connecting Rod generated by using CAD tool Software

**C. Loading and Boundary conditions for Structural and Buckling analysis:**

In this project, Automotive Connecting Rod is acting under maximum combustion pressure of 6 MPa by the Piston and hence the Load 10,000 N is applied at the piston end of the connecting rod and fixed at the crank end as shown in the figure.



Static Structural Boundary Conditions and loading conditions

**1) Linear Static and Buckling analysis of automotive connecting rod with Aluminium Alloy 6061:**

YOUNGS MODULUS	71 GPa
POISSONS RATIO	0.33
DENSITY	2810Kg/m <sup>3</sup>
THERMAL EXPANSION	2.32 e <sup>-5</sup> /K
TENSILE YIELD STRESS	827 MPa

Material properties of aluminium alloy 6061:

**D. Material Properties of Aluminium Alloy**

Results of Von-Mises stress and deformation of piston with aluminium alloy 6061:

- Maximum stress of 95.25 MPa has got at the time of Combustion Pressure
- The maximum stress is within the allowable stress, hence the design is safe
- Maximum deformation of 0.0771 mm has achieved at the time of combustion Pressure

Results of buckling load factor and critical load of connecting rod with aluminum alloy 6061:

- Buckling Load Factor of 7.558 has got at the time of maximum load
- The Connecting Rod with Aluminium Alloy 6061 can withstand 13 times the load applied
- Critical Buckling Load ( $F_c$ ) = Applied Load ( $F_a$ ) × Load Factor/Multiplier ( $\lambda$ )

$$F_c = 10000 \times 7.558$$

$$F_c = 131.3 \text{ KN}$$

- The Critical Load for the connecting rod with Aluminium Alloy 6061 is of 131.3 KN

**1) Linear Static and Buckling analysis of automotive connecting rod with titanium alloy:**

YOUNGS MODULUS	96 GPa
POISSONS RATIO	0.36
DENSITY	4620Kg/m <sup>3</sup>
TENSILE YIELD STRESS	900 MPa

Material Properties of Titanium Alloy

**E. Results of Von-Mises Stress and deformation of connecting rod with aluminium alloy:**

- Maximum stress of 95.09 MPa has got at the time of Combustion Pressure
- The maximum stress is within the allowable stress, hence the design is safe
- Maximum deformation of 0.0569 mm has achieved at the time of combustion Pressure

**F. Results of buckling load factor and critical load of connecting rod with titanium alloy:**

- Buckling Load Factor of 10.21 has got at the time of maximum load
- The Connecting Rod with Titanium Alloy can withstand 17 times the load applied
- Critical Buckling Load ( $F_c$ ) = Applied Load ( $F_a$ ) × Load Factor/Multiplier ( $\lambda$ )

$$F_c = 10000 \times 10.21$$

$$F_c = 102.1 \text{ KN}$$

- The Critical Load for the connecting rod with Titanium Alloy is of 102.1 KN

1) *Linear Static and Buckling analysis of modified automotive connecting rod with magnesium alloy:*

Linear Static and buckling analysis of connecting rod with Magnesium Alloy has been conducted. Below table shows the material properties of Magnesium Alloy.

YOUNGS MODULUS	44.12 GPa
POISSONS RATIO	0.35
DENSITY	1740Kg/m <sup>3</sup>
TENSILE YIELD STRESS	250 MPa

Material properties of magnesium alloy

G. *Results of Von-Mises Stress and deformation of piston with magnesium alloy:*

- Maximum stress of 95.14MPa has got at the time of Combustion Pressure
- The maximum stress is within the allowable stress, hence the design is safe
- Maximum deformation of 0.1215 mm has achieved at the time of combustion Pressure

H. *Results of buckling load factor and critical load of connecting rod with magnesium alloy:*

- Buckling Load Factor of 8.31has got at the time of maximum load
- The Connecting Rod with Magnesium Alloy can withstand 8 times the load applied
- Critical Buckling Load ( $F_c$ ) = Applied Load ( $F_a$ ) × Load Factor/Multiplier ( $\lambda$ )

$$F_c = 10000 \times 4.79$$

$$F_c = 47.9 \text{ KN}$$

- The Critical Load for the connecting rod with Magnesium Alloy is of 47.9 KN

1) *Linear Static and Buckling analysis of modified automotive connecting rod with aluminium boron carbide:*

Linear Static and buckling analysis of connecting rod with Aluminium Boron Carbide has been conducted. Below table shows the material properties of Aluminium Boron Carbide.

YOUNGS MODULUS	200 GPa
POISSONS RATIO	0.3
DENSITY	2950Kg/m <sup>3</sup>
TENSILE YIELD STRESS	300 MPa

Material Properties of Aluminium Boron Carbide

I. *Results of Von-Mises Stress and deformation of piston with aluminium boron carbide:*

- Von-Mises Stress plot of Aluminium Boron Carbide Maximum stress of 95.43 MPa has got at the time of Combustion Pressure
- The maximum stress is within the allowable stress, hence the design is safe
- Maximum deformation of 0.0274 mm has achieved at the time of combustion Pressure

J. *Results of buckling load factor and critical load of connecting rod with aluminium boron carbide:*

- Buckling Load Factor of 36.96 has got at the time of maximum load
- The Connecting Rod with Aluminium Boron Carbidecan withstand 36 times the load applied

- Critical Buckling Load ( $F_c$ ) = Applied Load ( $F_a$ ) × Load Factor/Multiplier ( $\lambda$ )

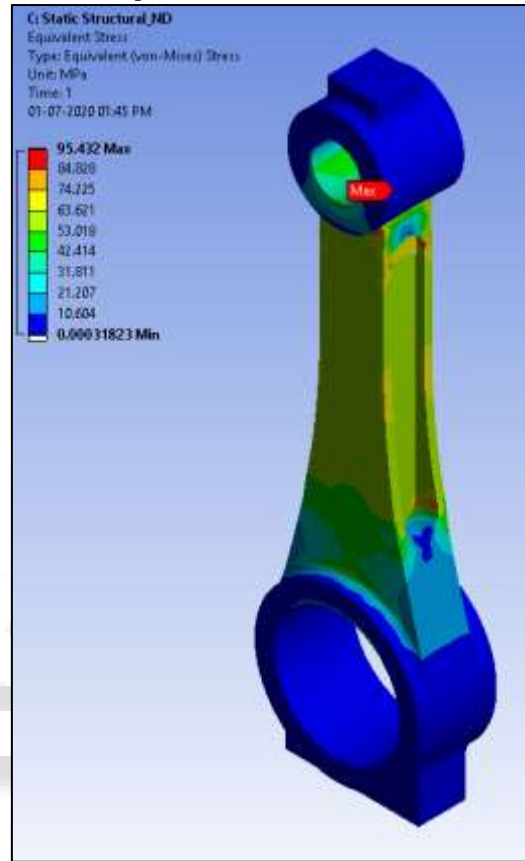
$$F_c = 10000 \times 21.296$$

$$F_c = 212.9 \text{ KN}$$

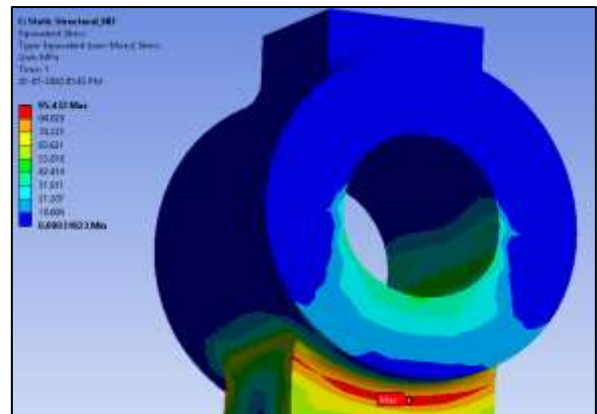
- The Critical Load for the connecting rod with Aluminium Boron Carbide is of 212.9 KN

K. *Analysis results images of Aluminium boron carbide:*

Von-Mises stress plot of aluminium boron carbide:

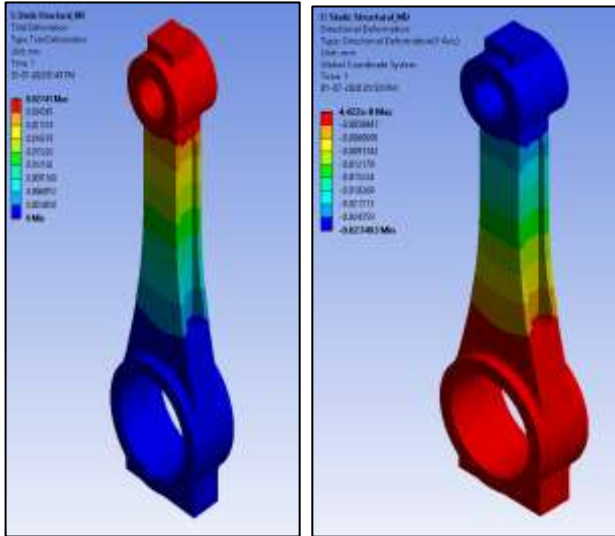


Von-Mises Stress Plot



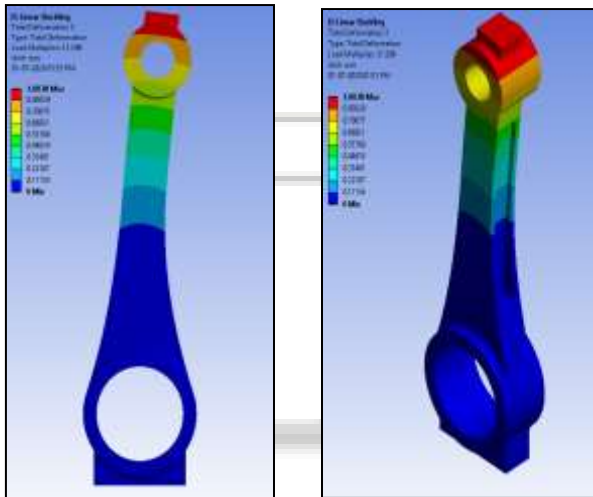
Zoom In View of Maximum Stress Plot

L. Deformation plot aluminium boron carbide:



Directional Deformation plot      Deformation plot

M. Buckling load factor plot of aluminium boron carbide:



Front View of Buckling Load Factor Plot      Buckling Load Factor Plot

N. Results of linear static analysis for different material of modified design of automotive connecting rod:

Following table shows the results of Von-Mises Stress and Maximum Deformations for the different materials with base design:

Material	Von-Mises Stress (MPa)	Maximum Deformation (mm)	Weight (gms)
Aluminum Alloy 6061	95.25	0.0771	110.9
Titanium Alloy	95.09	0.0569	184.9
Magnesium Alloy	95.14	0.1215	73
Aluminium Boron Carbide	95.43	0.0274	118.12

Results of Von-Mises Stress & Max. Deformations for Different Material of Base Design

O. Results of linear buckling analysis for different material of modified design of automotive connecting rod:

Following table shows the results of buckling analysis for the different materials:

Material	Buckling Load Factor	Buckling Load (Critical Load)
Aluminum Alloy 6061	7.5	75.75 KN
Titanium Alloy	10.21	102.1 KN
Magnesium Alloy	4.79	47.9 KN
Aluminium Boron Carbide	21.29	212.9 KN

Results of Buckling Analysis for different material of Base Design

IV. CONCLUSION

From the above results of Linear Static Structural and Linear Buckling Analysis following conclusions can be made to optimize the design of Connecting Rod:

- Maximum Stresses and Maximum Displacements generated by the Linear Static Structural Analysis
- The Maximum Stresses and Maximum Deformations generated are less in the connecting rod with the Aluminium Boron Carbide Compared to other materials Like Aluminium Alloy 6061, Titanium Alloy & Magnesium Alloy
- Above table shows the results of Buckling Factor and Critical Buckling Load generated by the Linear Buckling Analysis
- From the buckling analysis it is cleared that the modified design of connecting rod with Aluminium Boron Carbide can withstand more loads that is of 21 time the applied load compared to other materials
- From the bucking analysis it is also cleared that the critical buckling load is more in the modified design of connecting rod with Aluminium Boron Carbide compared to other materials
- The main objective of the project is to optimize the material and design of connecting rod and hence it can be cleared that the design of the connecting rod with Aluminium Boron Carbide is suitable.
- As per the design if the safety factor is greater than 1 then the design is safe and hence in this project it can be clear that the piston with Magnesium Silicon Carbide is safe to use.

Finally it can be concluded that the connecting rod with material Aluminium Boron Carbide can be replaced with existing material like Aluminium Alloy 6061, Titanium Alloy & Magnesium Alloy for better efficiency.

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