STATIC STRUCTURAL ANALYSIS AND OPTIMIZATION PNEUMATIC COMPRESSOR OF CANROD-FEA

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Abstract : Pneumatic compressor connecting rod is a dynamic link between piston and crankshaft, which all together forms a driving mechanism. They follow push and pull mechanism for transmission of power. Connecting rods are casted component which are designed to sustain higher bending stress due to initial loadings. Analytical calculation will be done to evaluate maximum structural bending load acting on pneumatic compressor connecting rod. Design/CAD of existing connecting rod will be done using CAD package CATIA V5. Element analysis will be done using Ansys package. FEA will help in identifying high strain and maximum stress occurs in connecting rod. Topology optimization will be done using material removal by reducing volume from location having no load. Existing connecting rod will be modified as per result from FEA by machining /FDM wire cutting method. Surface preparation will be done using before installing strain gage on component. Fixture will be designed for mounting component on UTM for application of bending load. Strain will be measured using strain gage indicator. Comparative analysis will be done with FEA & experimental result for validation of work. Conclusion and future work will be suggested.

I. INTRODUCTION

The reciprocating compressor uses a piston, which moves inside a cylinder, to compress the air. When the piston moves down, air is drawn in. When the piston moves up, the air is compressed. Two sets of valves take care of the air intake and exhaust. One-way valves (usually inside the cylinder head) make sure that the sucked-in air cannot escape and that the compressed air cannot flow back when the piston moves down again.

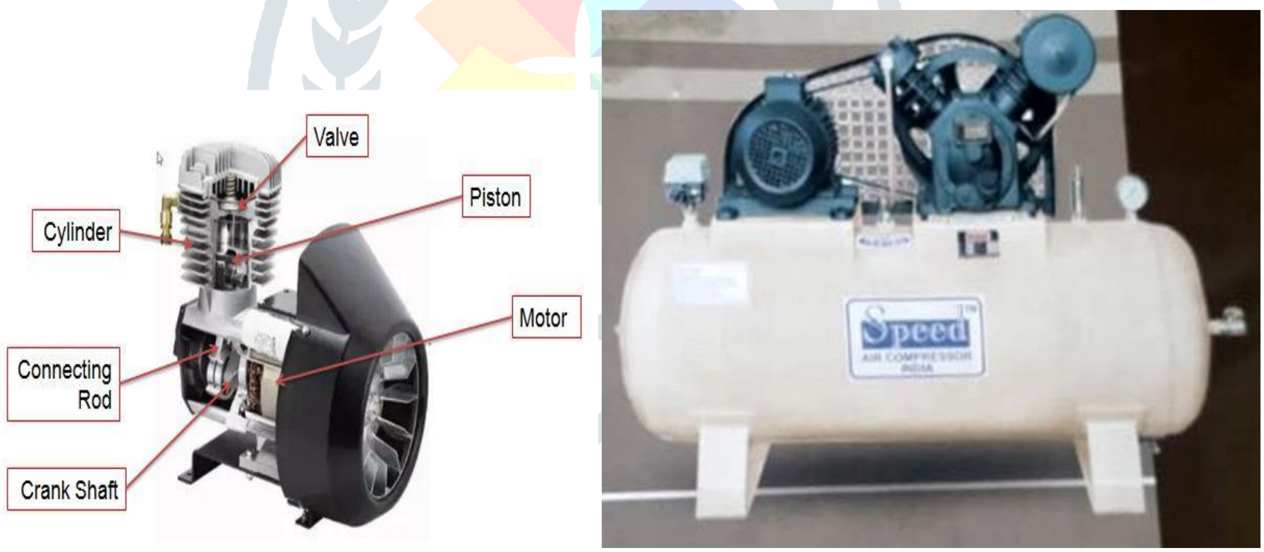


Fig. 1.1) Air Compressor

The function of connecting rod in compressors is to transmit the power from crankshaft to the piston to compress the air. The role of connecting rod in the conversion of rotary motion into reciprocating motion. The lighter connecting rod and the piston, greater resulting compression and less the vibration because of the reciprocating weight is less. There are different types of materials and production methods used in the creation of connecting rods. The most common types of Connecting rods material are steel and aluminum. The most common types of manufacturing processes are casting, forging and powdered metallurgy. A connecting rod consists of a pin-end, a shank section, and a crank-end. Pin-end and crank-end pinholes at the upper and lower ends are machined to permit accurate fitting of bearings.

Fig. 1.2) Connecting Rod

Buckling is the instable phenomenon. The buckling happens only at one load, and that load is called as critical buckling load which is given by, Euler formula for columns,

$Pcr = \pi^2 EI/ le^2$

Where,

E- Young's modulus

I-Moment of Inertia

Le-Effective length of the column

When the maximum stress of the structure is less than ultimate strength and it is said to be safe, at that time critical buckling load becomes design driver i.e. if the applied load is greater than the critical buckling load, the structure will fail even though it is designed with respect to its strength. The ratio of critical buckling load to applied load is called as Buckling Factor (B.F) which is used to know whether the structure is buckled or not.

1.1 PROBLEM STATEMENT

Each day consumers are looking for the best from the best. That's why the optimization is really important in industry. Optimization of the component is to make the less time to produce the product that is stronger, lighter and less cost. The design and weight of the connecting rod influence on performance. Hence, it is effect on the manufacture credibility. The tensile and compressive stresses are produced due to pressure, and bending stresses are produced due to centrifugal effect & eccentricity. So the connecting rods are designed generally of I-section to provide maximum rigidity with minimum weight. Change in the structural design and also material will be significant increments in weight and performance.

Pneumatic Compressors are subjected to less dynamic loads as compared to automotive engines. Exercise work has been done on automotive Connecting Rods in terms of thermal and structural optimization. Connecting rod of pneumatic Compressor can be optimized topologically is similar way which form basis of the project.

Lifting mechanism for carrying loads includes connecting rod as the base structure. Traditional techniques used for designing results into overdesigned structure. Base design and analysis of connecting rod done using FEA and experimental stress analysis techniques.

II. METHODOLOGY

A virtual model of crane hook is created using solid work software and then model was imported to ANSYS for Finite element stress analysis and the result of stress analysis of different materials are compared with each other.

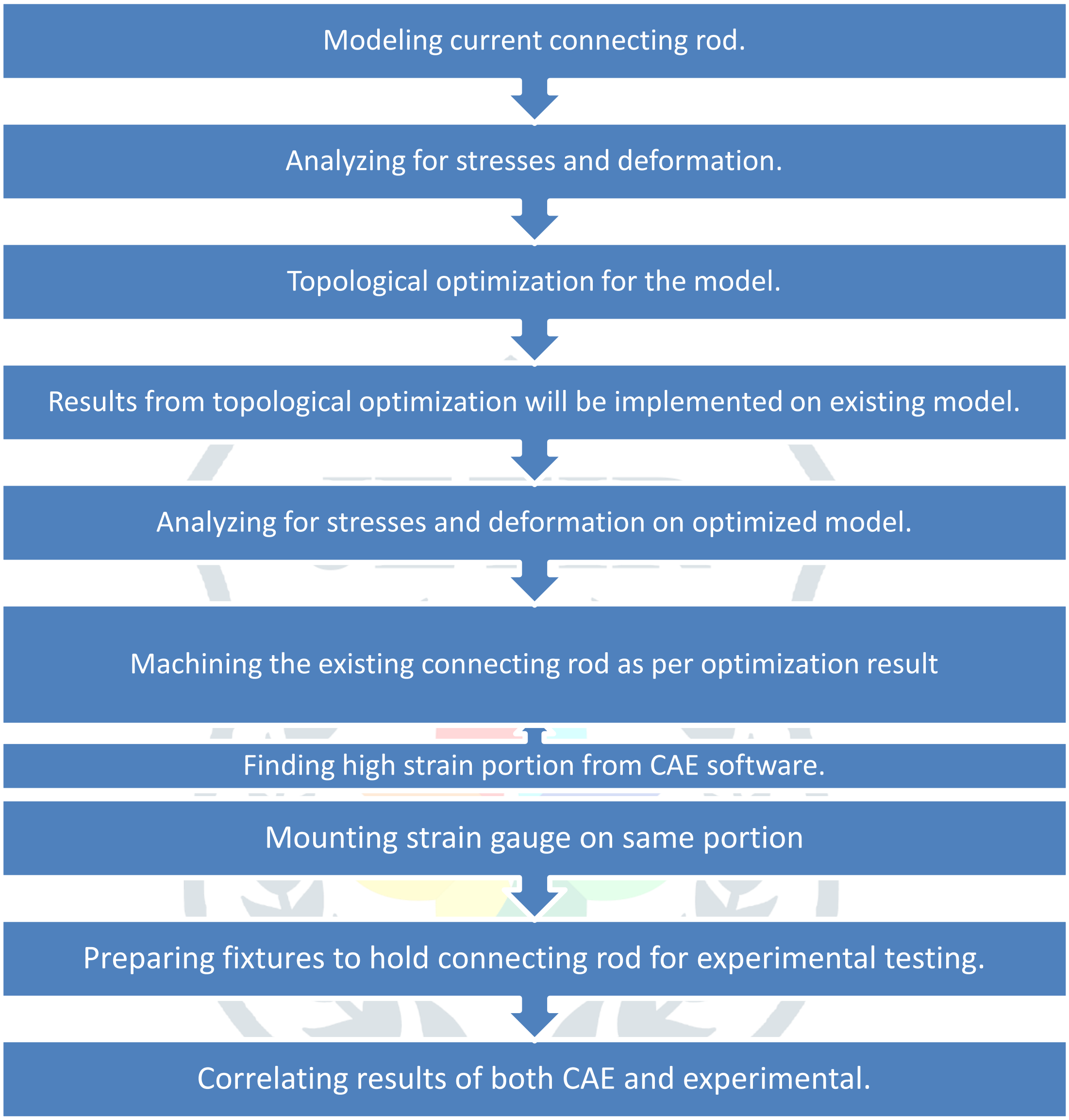


Chart 1.2.1) Flowchart of Methodology

1.3) FINITE ELEMENT ANALYSIS

Modeling in Catia V5

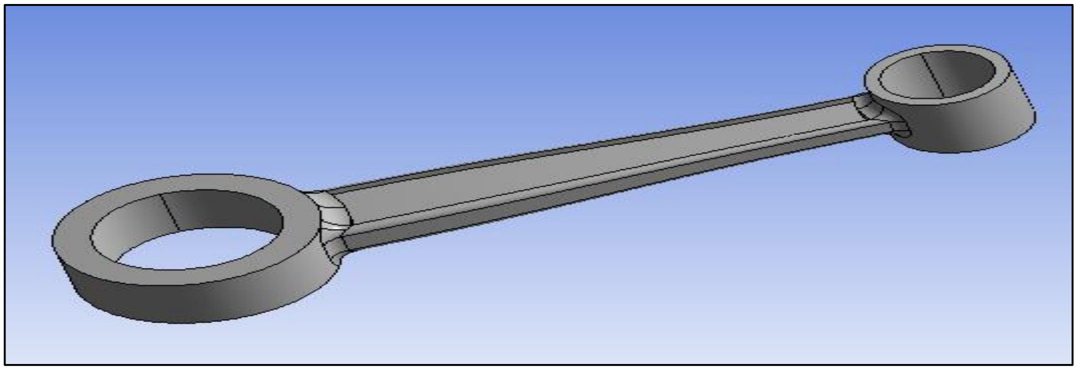


Fig. 1.3.1) Solid Model

The Finite Element Method is a numerical approximation method, in which complex structure divided into number of small parts that is pieces and these small parts are called as finite elements. These small elements connected to each other by means of small points called as nodes. As finite element method uses matrix algebra to solve the simultaneous equations, so it is known as structural analysis and it's becoming primary analysis tool for designers and analysts.

The three basic FEA process are

a) Pre processing phase
b) Processing or solution phase
c) Post processing phase

Modal analysis is done to determine the natural frequencies and mode shapes of a structure. The natural freq. and mode shapes are important parameters in the design of a structure for dynamic loading conditions.

2) MATERIAL PROPERTIES

The values of young's modulus, poisons ratio, density, and yield strength for steel are taken from material library of the FEA package.
Material properties
Material- Structural Steel
Young's Modulus- 200 GPa
Poisons Ratio- 0.3
Density- 7850 kg/m3
Yield Strength- 520 MPa.

Properties of Outline Row 3: Aluminum Alloy

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	2770	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulu...	
8	Young's Modulus	7.1E+10	Pa
9	Poisson's Ratio	0.33	
10	Bulk Modulus	6.9608E+10	Pa
11	Shear Modulus	2.6692E+10	Pa
12	Alternating Stress R-Ratio	Tabular	
16	Tensile Yield Strength	2.8E+08	Pa
17	Compressive Yield Strength	2.8E+08	Pa
18	Tensile Ultimate Strength	3.1E+08	Pa
19	Compressive Ultimate Strength	0	Pa

Fig. 2.1) Material Property

Ansys Meshing

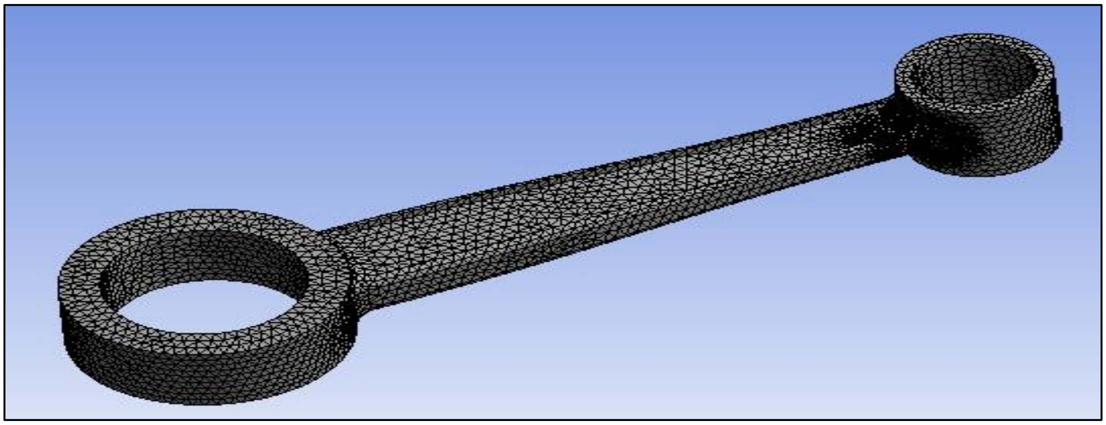
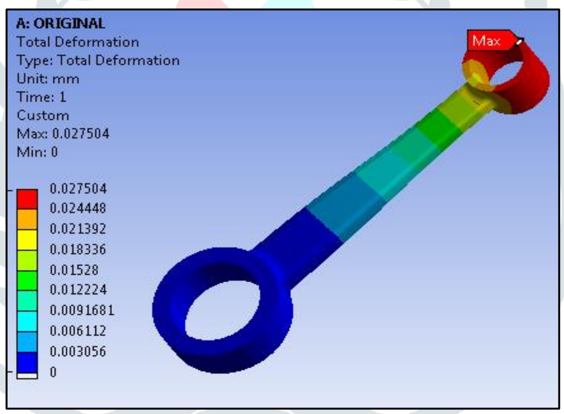


Fig.2.2) Meshing object

- Element Type: Second order Tetrahedron
- Elements count: 60456
- Nodes count:92034

- **2.1.1 Analyzing Deformation of object**



- Fig. 2.1.1) Total Deformation of Object

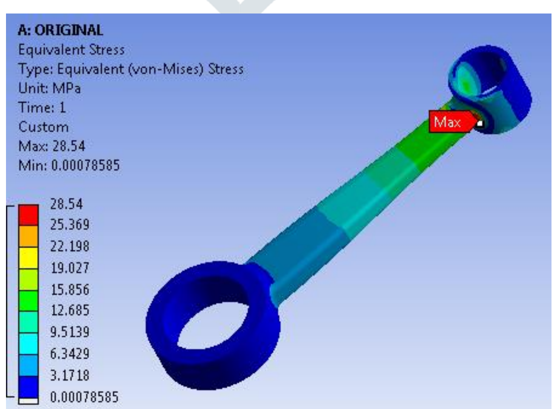


Fig. 2.1.2) Analyzing equivalent stresses

- **TOPOLOGICAL OPTIMIZATION FOR THE MODEL**

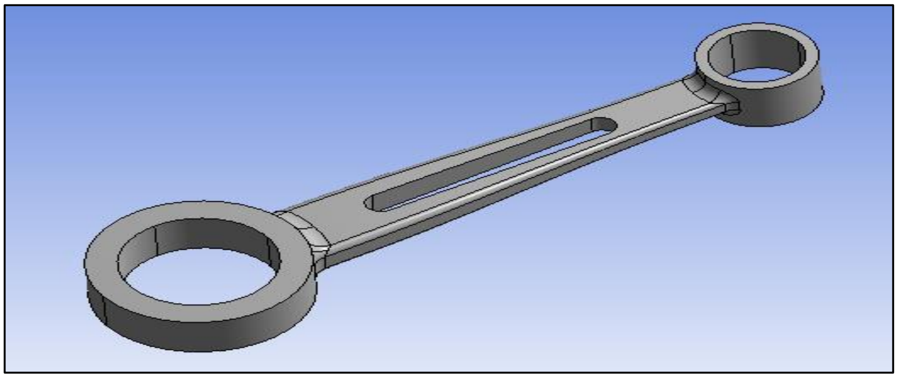


Fig. 2.2.3) Solid Model (optimized)

3) Material Properties of solid Model to be optimized

Properties of Outline Row 3: Aluminum Alloy

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	2770	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulu...	
8	Young's Modulus	7.1E+10	Pa
9	Poisson's Ratio	0.33	
10	Bulk Modulus	6.9608E+10	Pa
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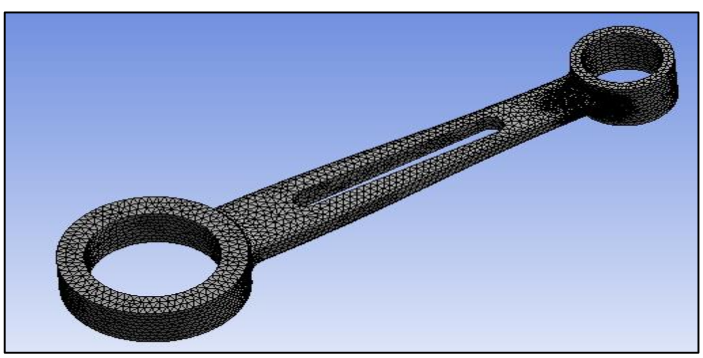
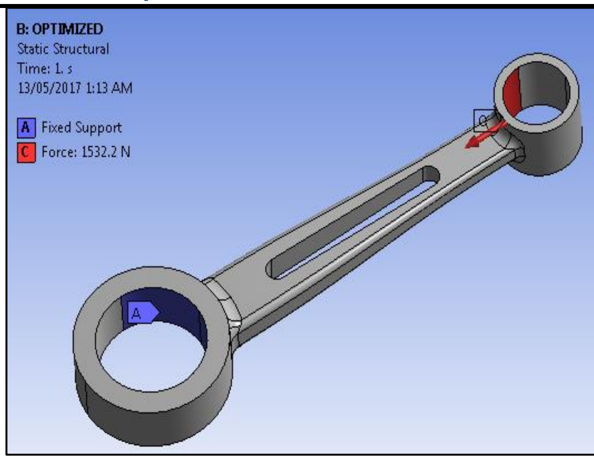
12	Alternating Stress R-Ratio	Tabular	
16	Tensile Yield Strength	2.8E+08	Pa
17	Compressive Yield Strength	2.8E+08	Pa
18	Tensile Ultimate Strength	3.1E+08	Pa
19	Compressive Ultimate Strength	0	Pa

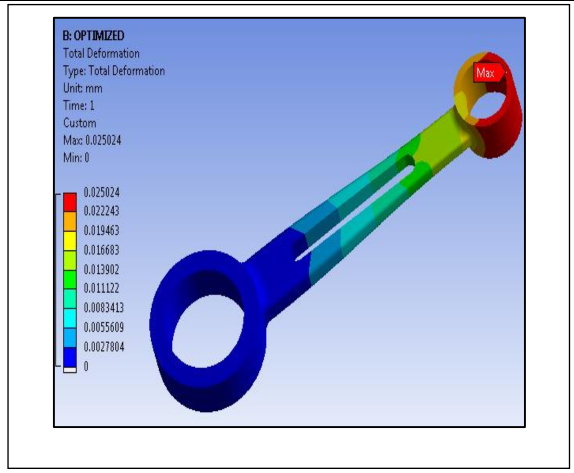
Chart – 3.1.1) Material Property

- Element Type: Second order Tetrahedron
- Elements count: 66501
- Nodes count:99698

Fig. 3.1.2 Mesh Optimized Model







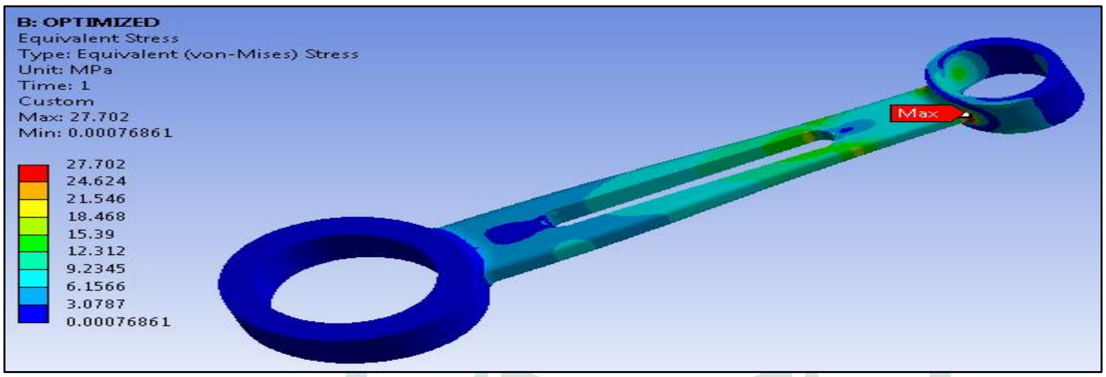


Fig. 3.1.2 Equivalent (Von-Mises) Stress

IV. RESULT

- Both design produces stress are within yield limit of material i.e 280 MPa
- Total mass reduction of 6.35 % has been achieved due to optimization of part
- (Original mass- 256.79 g)
- (Optimised Part Mass -240.5 g)

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