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# Static and Thermal Analysis of Position and Connecting Rod by Using Different Materials

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## ABSTRACT:

A piston is a disc which reciprocates within a cylinder. It is either moved by the fluid or it moves the fluid which enters the cylinder. The main function of the piston of an IC engine is to receive the impulse from the expanding gas and to transmit the energy to the crankshaft through the connecting rod. The piston must also disperse a large amount of heat from the combustion chamber to the cylinder walls. In this Project we describe the stress distribution of the piston by using FEA. The finite element analysis is performed by using computer aided design (CAD) software. The aim of our project is to design a piston for a two wheeler using Creo software and analyses with Ansys in this case we analyses our piston with existing material and different material and finally we conclude which material is more suitable for manufacturing of the piston. In this project we took steel as existing material and then analyzed model at high pressure values

The piston investigate and analyze the Thermal Stress (Couple Field) analysis of piston at the real engine condition during combustion process.. The optimization is carried out to reduce the stress concentration on the upper end of the piston. With using computer aided design (CAD), Creo software the structural model of a steel and Aluminum piston will be developed. Furthermore, the finite element analysis performed with using software ANSYS

Connecting rod is replaced by aluminium based composite material reinforced with silicon carbide and fly ash. And it also describes the modelling and analysis of connecting rod. Fea analysis was carried out by considering two materials. The parameters like von misses stress, safety factor and displacement were obtained from ansys software. Compared to the former material the new material found to have less weight and better stiffness. It resulted in reduction of weight, reduction in displacement.

## INTRODUCTION

In every engine, piston plays an important role in working and producing results. Piston forms a guide and bearing for the small end of connecting rod and also transmits the force of explosion in the cylinder, to the crank shaft through connecting rod.

The piston is the single, most active and very critical component of the automotive engine. The Piston is one of the most crucial, but very much behind-the-stage parts of the engine which does the critical work of passing on the energy derived from the combustion within the combustion chamber to the crankshaft. Simply said, it carries the force of explosion of the combustion process to the crankshaft.

Apart from the critical job that it does above, there are certain other functions that a piston invariably does -- It forms a sort of a seal between the combustion chambers formed within the cylinders and the crankcase. The pistons do not let the high pressure mixture from the combustion chambers over to the crankcase.

## CONSTRUCTION OF PISTON

Its top known by many names such as crown, head or ceiling and thicker than bottom portion. Bottom portion is known as skirt. There are grooves made to accommodate the compression rings and oil rings. The groove, made for oil ring, is wider and deeper than the grooves made for compression ring. The oil ring scraps

the excess oil which flows into the piston interior through the oil return holes and thus avoiding reaching the combustion chamber but helps to lubricate the gudgeon pin to some extent. In some designs the oil ring is provided below the gudgeon pin boss.

The diameter of piston always kept smaller than that of cylinder because the piston reaches a temperature higher than cylinder wall and expands during engine operation. The space between the cylinder wall and piston is known as piston clearance. The diameter of the piston at crown is slightly less than at the skirt due to variation in the operating temperatures. Again the skirt itself is also slightly tapered to allow for unequal expansion due to temperature difference as we move vertically along the skirt the working temperature is not uniform but slightly decrease.

## CONNECTING ROD DESCRIPTION

Connecting rod is the intermediate link between the piston and the crankshaft. 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 crankshaft. Connecting rod, automotives should be lighter and lighter, should consume less fuel and at the same time they should provide comfort and safety to passengers, that unfortunately leads to increase in weight of the vehicle. This tendency in vehicle construction led the invention and implementation of quite new materials which are light and meet design requirements. Lighter connecting rods help to decrease lead caused by forces of inertia in engine as it does not require big balancing weight on crankshaft. Application of metal matrix composite enables safety increase and advances that leads to effective use of fuel and to obtain high engine power. Honda Company had already started the manufacturing of aluminium connecting rods reinforced with steel continuous fibers. By carrying out these modifications to engine elements will result in effective reduction of weight, increase of durability of particular part, will lead to decrease of overall engine weight, improvement in its traction parameters, economy and ecological conditions such as reduction in fuel consumption and emission of harmful substances into atmosphere. In his project carbon steel connecting rod is replaced by aluminium boron carbide connecting rod. Aluminium boron carbide is found to have working factory of safety is nearer to theoretical factory of safety, to increase the stiffness by 48.55% and to reduce stress by 10.35%. Connecting rod are greater than the stresses induced at the bigger end, therefore the chances of failure of the connecting rod may be at the fillet section of both end. Optimization was performed to reduce weight. Weight can be reduced by changing the material of the current forged steel connecting rod to crack able forged steel (C70). And the software gives a view of stress distribution in the whole connecting rod which gives the information that which parts are to be hardened or given attention during manufacturing stage, using FEA. In this analysis of connecting rod were performed under dynamic load for stress analysis and optimization. Dynamic load analysis was performed to determine the in service loading of the connecting rod and FEA was conducted to find the stress at critical locations.

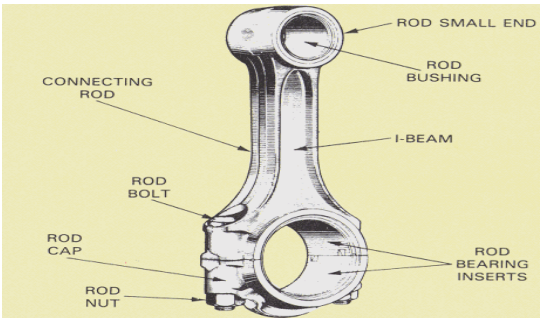


Fig. Typical view of Connecting rod

## FEA

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

By the early 70's, FEA was limited to expensive mainframe computers generally owned by the

aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

**Heat Transfer** analysis models the conductivity or thermal fluid dynamics of the material or structure. This may consist of a steady-state or transient transfer. Steady-state transfer refers to constant thermo properties in the material that yield linear heat diffusion.

## Results of Finite Element Analysis

FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would accrue if each sample was actually built and tested.

In practice, a finite element analysis usually consists of three principal steps:

1. **Preprocessing**: The user constructs a model of the part to be analyzed in which the geometry is divided into a number of discrete sub regions, or elements," connected at discrete points called nodes." Certain of these nodes will have fixed displacements, and others will have prescribed loads. These models can be extremely time consuming to prepare, and commercial codes vie with one another to have the most user-friendly graphical “preprocessor" to assist in this rather tedious chore. Some of these preprocessors can overlay a mesh on a preexisting CAD file, so that finite element analysis can be done conveniently as part of the computerized drafting-and-design process.

2. **Analysis**: The dataset prepared by the preprocessor is used as input to the finite element code itself, which constructs and solves a system of linear or nonlinear algebraic equationswhere u and f are the

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displacements and externally applied forces at the nodal points. One of FEA's principal advantages is that many problem types can be addressed with the same code, merely by specifying the appropriate element types from the library.

3. **Postprocessing**: In the earlier days of finite element analysis, the user would pore through reams of numbers generated by the code, listing displacements and stresses at discrete positions within the model. It is easy to miss important trends and hot spots this way, and modern codes use graphical displays to assist in visualizing the results. A typical postprocessor display overlays colored contours representing stress levels on the model, showing a full field picture similar to that of photo elastic or moiré experimental results.

## CONNECTING ROD MATERIAL PROPERIES

- **Al-3600**

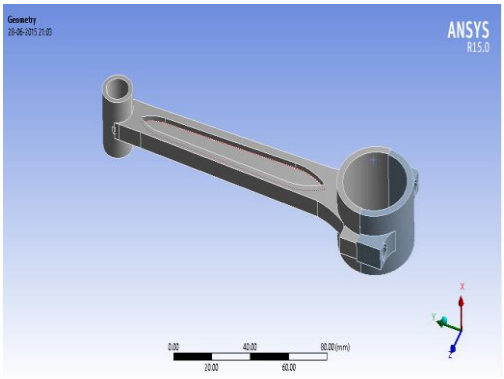
  Ex: - 60*10^9 pa
  Poison ratio: 0.33
  Density: 2800 kg/m^3
  Yield strength: 170*10^6 pa

- **Al-silicon-fly-ash**

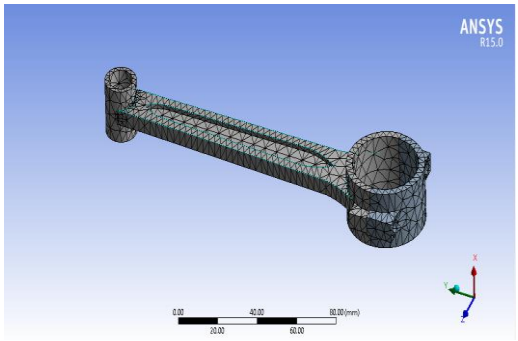
  Ex: - 70*10^9 pa
  Poison ratio: 0.33
  Density: 2611 kg/m^3
  Yield strength: 363*10^6 mpa

Geometry→ right click→ import geometry→ import iges format model

Model imported from pro-e tool in IGES format.




Imported Model connecting rod View In Ansys.




Tet Volume Mesh

**Static Analysis on Connecting rod at pressure 8*10^6 pa**

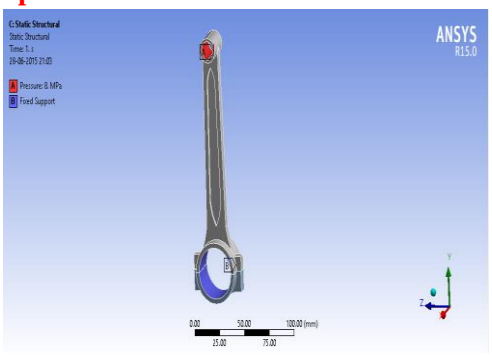


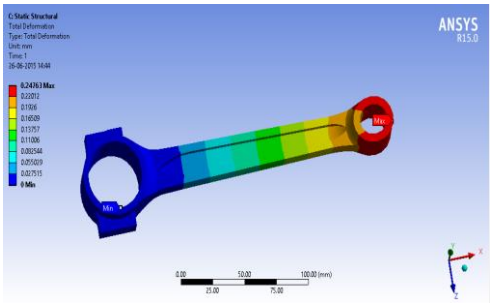

Fig. (m) Static Analysis on Connecting rod at pressure 8*10^6 pa

Select geometry assign material properties
Click on static structural → supports→ fixed supports→select areas
→ loads→pressure→ 8*10^6 pa→ apply

## RESULTS

### a. MATERIAL: Al-3600

- **Deformation**




Deformation Analysis of Connecting rod on Al-3600 at pressure 8*10^6 pa

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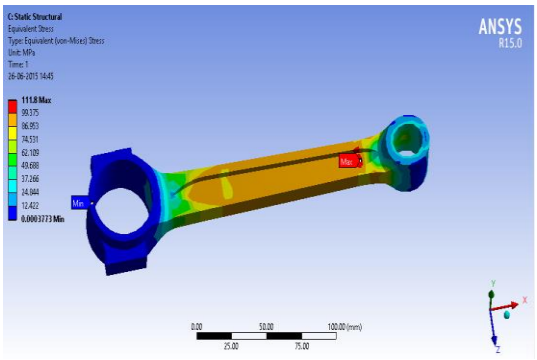
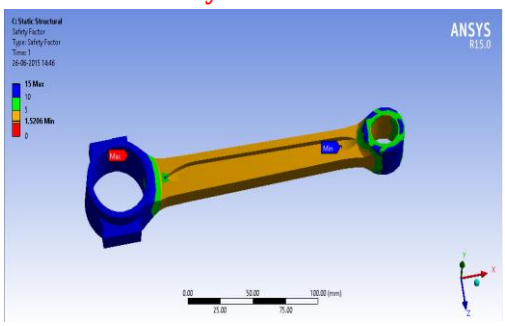
➢ **Stress**




Stress Analysis of Connecting rod on Al-3600 at pressure 8*10^6 pa

➢ **Factor of safety**




Factor of safety Analysis of Connecting rod on Al-3600 at pressure 8*10^6 pa

## CONCLUSION

In this project we design one piston with existing material steel and checking maximum limits for that object in static structural condition from this we got maximum von-mises stress values 261.22 Mpa and this is very high stress and we don't have chance to eliminate stress but we have choice to reduce the stress values

To reduce stress values we changing material from steel to al-alloy by this changes we reduced nearly 5Mpa stress at the same the weight also reduced 34%

In this process we also changing dimensions of this object by this change we got 159.3 Mpa stress and this value is very less when compare existing model with existing material and now we can say this changing dimension model with al-alloy material perform very well at high pressure conditions.

But when we want to manufacture one object we can't go with single analysis that's why am doing another analysis on this object which is called **Couple Field Analysis**

From the above results 2nd piston al-alloy material have maximum temperature is 304.39 *c. when we compared to other models with different material it is very less and it having total heat flux value 0.056028 w/mm^2

From the all results we can say 2nd piston with al-alloy material most suitable for manufacturing piston

## Advantages of aluminum alloy piston.

(a) lighter in weight, allowing higher rpm (6) better thermal conductivity, and hence suitable for higher compression ratio

For connecting rod weight can be reduced by changing the material of the current al360 connecting rod to Al-Sic-Fly-Ash composites. The optimised connecting rod is 46.42% lighter than the current connecting rod. The new optimised connecting rod is comparatively much stiffer than the former.

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