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Modeling and Analysis of Connecting Rod with Comparision of Aluminium Alloy

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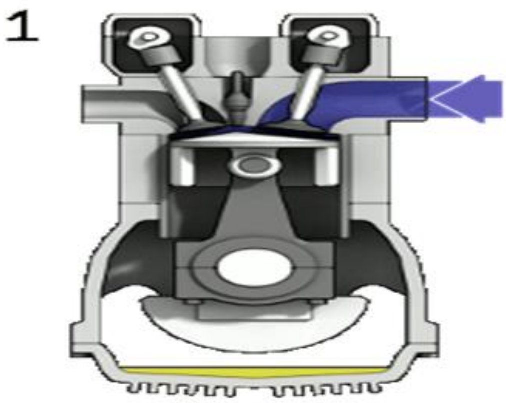
ABSTRACT:
The project MODELLING OF CONNECTING ROD IN IC ENGINE is and Assembly of a IC engine according to the forces acting on it from the gases, which are released during the combustion. The piston head acts as a particular case and hence the piston is analyzed for the stresses developed due to the conditions. At first, the piston is designed according to the specifications. After the designing, the model is subjected to certain conditions. According to the conditions we have checked the stresses acting on it and checked the failures of the model. After the analyzing the changes are done to the model if required.In the analysis a model of connecting rod is generated using CATIA. the finite element model of the piston is generated using Ansys. It is applied with loads and boundary conditions. Thus solved for the engine response. The result are calculated and tabulated below and the stresses acting on the body are shown.

INTRODUCTION:
The Internal Combustion Engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine (ICE) the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The first commercially successful internal combustion engine was created by Étienne Lenoir.



Four-stroke
1. Intake
2. Compression
3. Power
4. Exhaust

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gas turbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described. The ICE is quite different from external combustion engines, such as steam or Sterling engines, in which the energy is delivered to a working fluid not consisting of, mixed with, or contaminated by combustion products. Working fluids can be air, hot water, pressurized water or even liquid sodium, heated in some kind of boiler. ICEs are usually powered by energy-dense fuels such as gasoline or diesel, liquids

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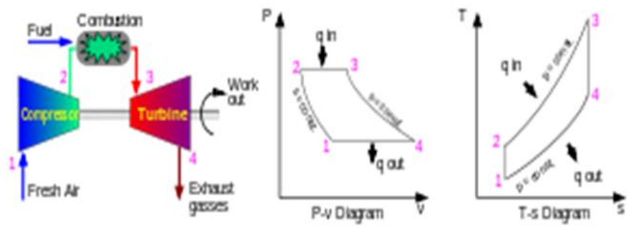
derived from fossil fuels. While there are many stationary applications, most ICEs are used in mobile applications and are the dominate power supply for cars, aircraft, and boats.

Six-Stroke Engine:

The six-stroke engine was invented in 1883. Four kinds of six-stroke use a regular piston in a regular cylinder (Griffin six-stroke, Bajulaz six-stroke, Velozeta six-stroke and Crower six stroke), firing every three crankshaft revolutions. The systems capture the wasted heat of the four-stroke Otto cycle with an injection of air or water. The Bearer Head and "piston charger" engines operate as opposed-piston engines, two pistons in a single cylinder; firing every two revolutions rather more like a regular four-stroke.

Bray Ton Cycle



A gas turbine is a rotary machine somewhat similar in principle to a steam turbine and it consists of three main components: a compressor, a combustion chamber, and a turbine. The air after being compressed in the compressor is heated by burning fuel in it, these heats and expands the air, and this extra energy is tapped by the turbine, which in turn powers the compressor closing the cycle and powering the shaft. Gas turbine cycle engines employ a continuous combustion system where compression, combustion, and expansion occur simultaneously at different places in the engine—giving continuous power. Notably, the combustion takes place at constant pressure, rather than with the Otto cycle, constant volume.

LITERATURE SURVEY

1.In the paper done by AbhinavGautam, K PriyaAjit , static stress analysis of connecting rod made up of SS 304 used in Cummins NTA 885 BC engine is conducted, It is observed that the area close to root of the smaller end is very prone to failure, may be due to higher crushing load due to gudgeon pin assembly. As the stress value is maximum in this area and stresses are repetitive in nature so chances of fatigue failure are always higher close to this region.

2. In the paper by Ram Bansal, it is noted that the The connecting rod deformation was mainly bending due to buckling under the critical loading. And the maximum deformation was located due to crush & shear failure of the big & small end bearings. So these areas prone to appear the fatigue crack. Base on the results, we can forecast the possibility of mutual interference between the connecting rod and other parts. The results provide a theoretical basis to optimize the design and fatigue life calculation.

3.In the paper by Kuldeep B, Arun L.R, Mohammed Faheem, it is concluded that Weight can be reduced by changing the material of the current al360 connecting rod to hybrid ALFASiC composites. The new optimised connecting rod is comparatively much stiffer than the former.

4.In the thesis by Pravardhan S. Shenoy and Ali Fatemi, Optimization was performed to reduce weight and manufacturing cost of a forged steel connecting rod subjected to cyclic load comprising the peak compressive gas load and the peak dynamic tensile load at 5700 rev/min, corresponding to 360^{o} crank angle.

5.In the thesis by GVSS Sharma and P SrinivasaRao, Statistical process control is an excellent quality assurance tool to improve the quality of manufacture and ultimately scores on end-customer satisfaction. SPC uses process monitoring charts to record the key quality characteristics (KQCs) of the component in manufacture. This paper elaborates on one such KQC of the manufacturing of a connecting rod of an internal combustion engine.

MATERIALS USED FOR CONNECTING ROD

The connecting rod is the intermediate member between the piston and the Connecting Rod. Its primary function the push and pull from the piston pin to the crank pin and thus converts the reciprocating motion of the piston into rotary motion of the crank. The connecting rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and being compressed with every rotation, and the load increases to the third power with increasing engine speed. Steel is normally used for construction of automobile connecting rods because of its strength, durability, and lower cost. However, steel with its high mass density exerts excessive stresses on the crankshaft of a high speed engine. This in turn requires a heavier crankshaft for carrying the loads and, therefore, the maximum RPM of the engine is limited. Additionally, higher inertia loads, such as those caused by steel connecting rods and heavier crankshafts reduces the acceleration or declaration rates of engine speed. The automobile engine connecting rod is a high volume production, critical component. It connects reciprocating piston to rotating crankshaft, transmitting the thrust of the piston to the crankshaft.

METHODS GENERALLY USED FOR MANUFACTURING THE CONNECTING ROD

1 Wrought Forged Connecting Rods

It is unclear when the first wrought forged connecting rod was produced but the wrought forged connecting rod has long been the “standard” for the automotive industry. Plain carbon steel forgings were the initial material of choice. Since a finished connecting rod cannot be formed in one blow, the forging dies for connecting rods have several impressions, each step moving progressively toward the final shape. The metal billet, or starting material, is transferred from one impression to another between successive blows. Figure 6 shows a set of forging dies and the main steps in forging a connecting rod.

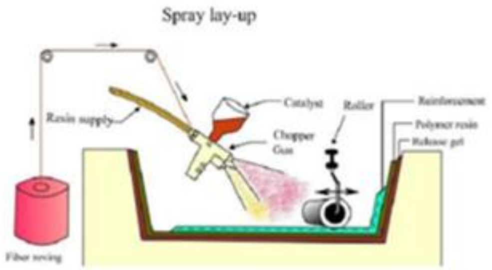


Fig 1: Resin Film Infusion Process and Fiberglass Spray Lay-up Process

2 Fiberglass Spray Lay-up Process:

Is very different from the hand lay-up process .The difference comes from the application of the fiber and resin material to the mold. Spray-up is an open-molding composites fabrication process where resin and reinforcements are sprayed onto a reusable mold. The resin and glass may be applied separately or simultaneously "chopped" in a combined stream from a chopper gun. Workers roll out the spray-up to compact the laminate. Wood, foam, or other core material may then be added, and a secondary spray-up layer embeds the core between the laminates. The part is then cured, cooled, and removed from the mold.

3 Hand Layup Method for Composite Material

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product.

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Applications:

Internal combustion engines are most commonly used for mobile propulsion in vehicles and portable machinery. In mobile equipment, internal combustion is advantageous since it can provide high power-to-weight ratios together with excellent fuel energy density. Generally using fossil fuel (mainly petroleum), these engines have appeared in transport in almost all vehicles (automobiles, trucks, motorcycles, boats, and in a wide variety of aircraft and locomotives). Where very high power-to-weight ratios are required, internal combustion engines appear in the form of gas turbines. These applications include jet aircraft, helicopters, large ships and electric generators.

THEORETICAL CALCULATIONS OF CONNECTING ROD

1. A connecting rod is a machine member which is subjected to alternating direct compressive and tensile forces. Since the compressive forces are much higher than the tensile force, therefore the cross-section of the connecting rod is designed as a strut and the Rankin formula is used.

2. A connecting rod subjected to an axial load W may buckle with x-axis as neutral axis in the plane of motion of the connecting rod, {or} y-axis is a neutral axis. The connecting rod is considered like both ends hinged for buckling about x-axis and both ends fixed for buckling about y-axis. A connecting rod should be equally strong in buckling about either axis.

Let A = cross sectional area of the connecting rod.

L = length of the connecting rod.

σc =compressive yield stress.

Wcr =crippling or buckling load.

Ixx and Iyy =moment of inertia of the section about x-axis and y-axis respectively.

Kxx and Kyy =radius of gyration of the section about x-axis and y- axis respectively.

Rankin formula = (Ixx=4Iyy).

PRESSURE CALCULATION FOR 150CC ENGINE Specifications

Engine type air cooled

4-stroke Bore × Stroke (mm) = 57×58.6

Displacement = 149.5CC

Maximum Power = 13.8bhp@8500rpm

Maximum Torque = 13.4Nm@6000rpm

Compression Ratio = 9.35/1

Density of Petrol C8H18 = 737.22kg/m3 = 737.22E-9kg/mm3

Temperature = 60F = 288.855K

Mass = Density × Volume = 737.22E-9×149.5E3 = 0.1 1Kg Molecular Weight of Petrol 114.228 g/mole

From Gas Equation,

PV=Mrt R = R*/Mw = 8.3143/.114228 = 72.76

P = (0.11x72.786x288.85) / 149.5E3 P = 15.469 Mpa.

DESIGN CALCULATION FOR STEEL

Thickness of flange & web of the section = **t** Width of section **B= 4t** The standard dimension of I SECTION.

Standard dimension of I - Section.

Height of section H=5t

Area of section A= 2(4t×t) +3t×t A=11t²

MI of section about x axis: Ixx=1\12 (4t (5t) 3-3t (3t) 3) = 419\12t4

MI of section about y axis: IYY = (2+1\12t(4t)3+1\12(3t) t3)

= 131\12 t4

IXX\ IYY= 3.2

Length of connecting rod (L) = 2 times the stroke L = 117.2 mm

Buckling load w B = maximum gas force × F.O.S WB = σC×A

= 37663 N 1+ a(L\KXX)2

σC= compressive yield stress = 415MPa

Kxx = IXX\A

Kxx = 1.78t

a= σc \π2E

a = 0.0002

By substituting σC, A, a, L, KXX on WB then 4565t4-37663t2-81639.46=0

t2 =10.03

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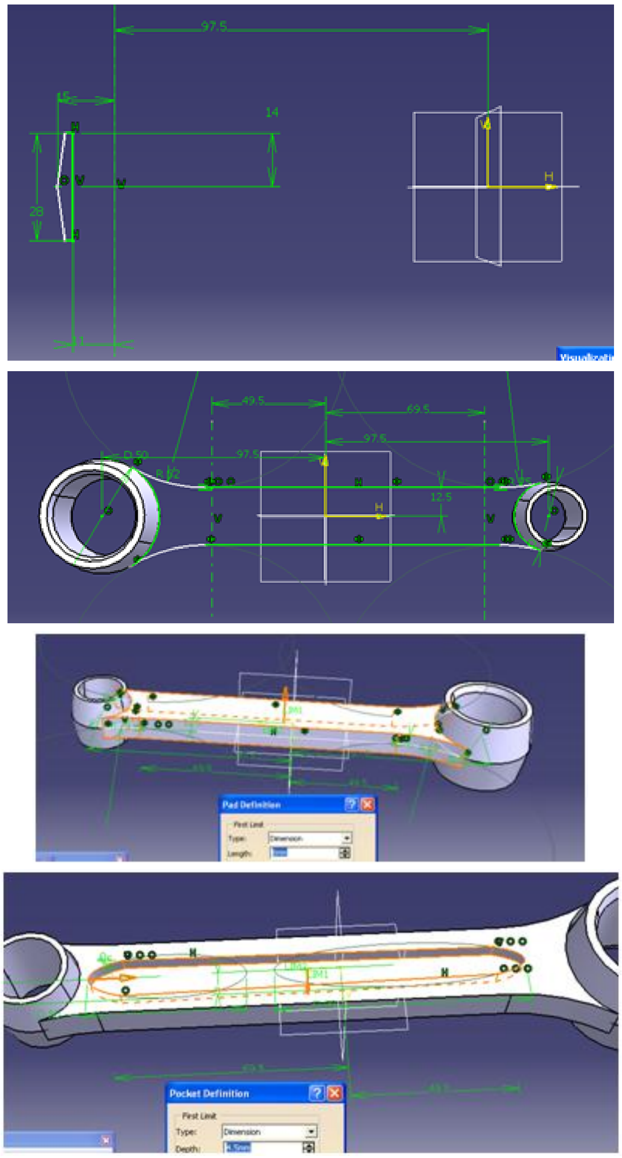
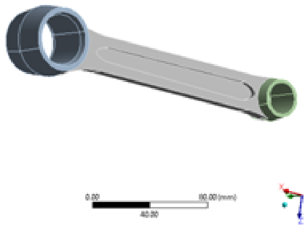
t=3.167mm
t=3.2mm
Width of section B = 4t =12.8mm
Height of section H = 5t = 16mm
Area A = 11t2 = 112.64mm2
Height at the big end (crank end) = H2 = 1.1H to 1.25H H2 =17.6mm
Height at the small end (piston end) = 0.9H -0,75H H1 =12mm

SKETCHER OF CONNECTING ROD



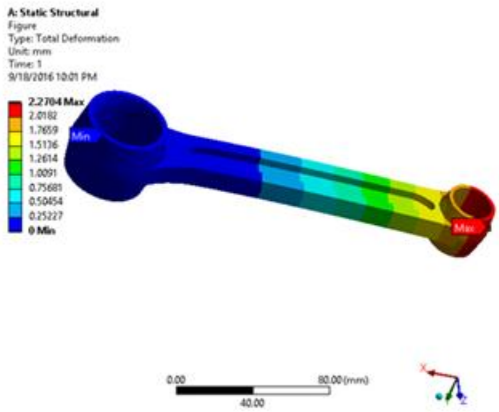
ANALYSIS OF CONNECTING IN ANSYS:



ANALYSIS OF CONNECTING ROD WITH STRUCTURAL STEEL

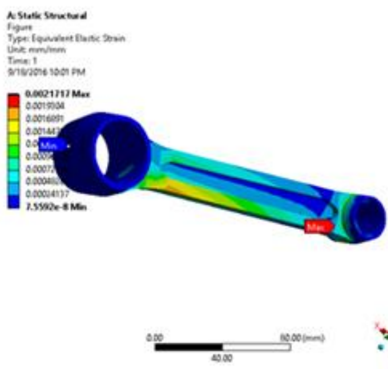
OTAL DEFORMATION (Structural Steel**)**

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	0	2.2704



STRAIN (Structural Steel)

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	7.5592e-008	2.1717e-003



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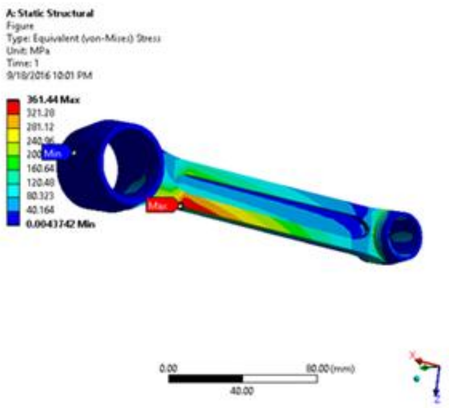
STRESS (Structural Steel)

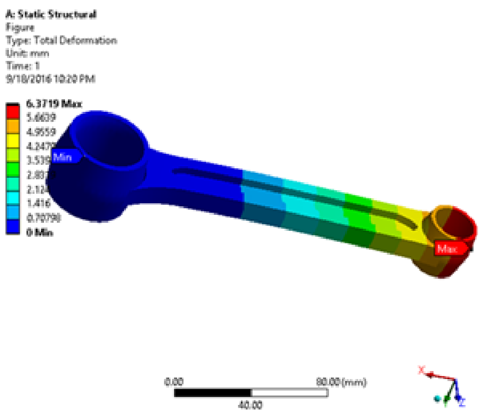
Time [s]	Minimum [MPa]	Maximum [MPa]
1.	4.3742e-003	361.44



Results			
Minimum	0. mm	2.1717e-003 mm/mm	4.3742e-003 MPa
Maximum	2.2704 mm	7.5592e-008 mm/mm	361.44 MPa

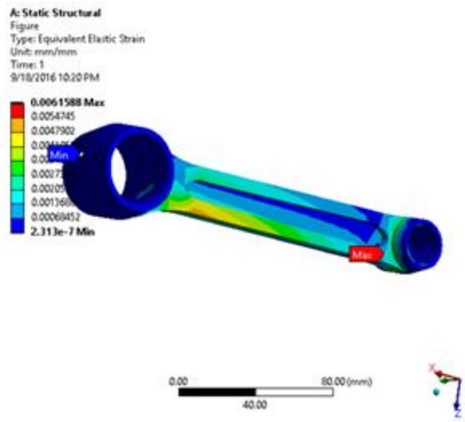
ANALYSIS OF CONNECTING ROD WITH ALUMINUM ALLOY TOTAL DEFORMATION (Aluminum Alloy)

Time [s]	Minimum [mm]	Maximum [mm]
1.	0.	6.3719



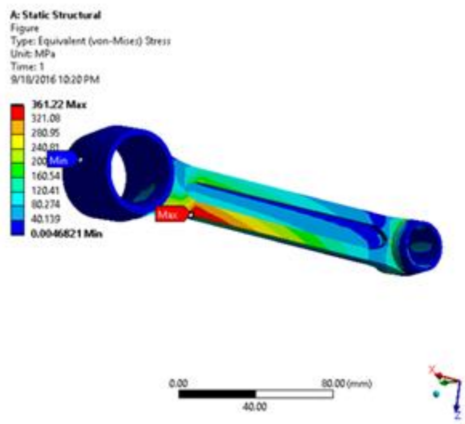
STRAIN (Aluminum Alloy)

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	2.313e-007	6.1588e-003



STRESS (Aluminum Alloy)

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	4.6821e-003	361.22



Results			
Minimum	0. mm	2.313e-007 mm/mm	4.6821e-003 MPa
Maximum	6.3719 mm	6.1588e-003 mm/mm	361.22 MPa

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RESULTS

RESULT FOR WEIGHT OF CONNECTING ROD

Structural Steel
Density of steel = 7.87e-6 Kg/mm3
Volume of connecting rod = 70175 mm3
Weight of connecting rod = Density × Volume =7.87e-6×70175 mm3 = 0.552277 kg
Aluminum Alloy
Density of Al = 2.685e-6 kg/mm3
Volume of connecting rod =70175mm3
Weight of connecting rod =Density × Volume = 0.188419 kg
Percentage of reduction in weight = W of steel-W of Aluminum /W of steel
=0.552277-0.188419/0.552277=0.65883

RESULT FOR STRESS, STRAIN OF CONNECTING ROD

Structural Steel

Results			
Total Deformation		Strain	Stress
Minimum	0. mm	2.1717e-003 mm/mm	4.3742e-003 MPa
Maximum	2.2704 mm	7.5592e-008 mm/mm	361.44 MPa

Aluminum Alloy

Results			
Total Deformation		Strain	Stress
Minimum	0. mm	2.313e-007 mm/mm	4.6821e-003 MPa
Maximum	6.3719 mm	6.1588e-003 mm/mm	361.22 MPa

CONCLUSIONS:

 The existing and modified design is modeled using modeling software and various parameters are obtained and the results are taken and compared.

 A truss type connecting rod modeling is done using CATIA software and the feasible parameters are been obtained.

 From the above analysis it is clear that the stress and strain obtained by the modified design is less when compared to the existing design.

 Weight reduction can be clearly viewed in the comparison graph between the solid and truss design.
 The obtained design life cycle for modified design is cycles, which is same as that of the existing design.

 Thus, we can conclude that in all the materials, modified design is much better than the existing solid type of design.

FUTURE SCOPE:

Further development can be made by manufacturing the modified design using the method of forging and also by inducing composite materials. Select various grades of material, take its chemical composition and mechanical properties as input details for obtain the stress, strain, displacement and volumetric efficiency of the machined connecting rod.

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