RESEARCH ARTICLE OPEN ACCESS

Design and Assembly Analysis of Piston, Connecting Rod & Crankshaft

[1*]Prasanna Nagasai Bellamkonda, [2]Satish Kasagani, [3]Srikanth Sudabathula
[1*]PG student, Dept of MECH, Gudlavalleru Engineering College, Gudlavalleru, Krishna District, AP 521356
[2]PG student, Dept of MECH, A.K.R.G College of Engineering & Technology, Nallajerla, West Godavari, AP 534112
[3]Assistant Professor, Dept of MECH, Gudlavalleru Engineering College, Gudlavalleru, Krishna District, AP 521356
Corresponding Author: [1*]Prasanna Nagasai Bellamkonda

Abstract:

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 thesis is to Model & Assemble the Piston, Connecting Rod & Crankshaft for a 4-stroke air- cooled 150cc Engine by theoretical calculations & also to Compare the Structural Analysis & Modal Analysis on two different materials such as (Aluminum Alloy – Cast iron) for Piston, (Aluminum Alloy – Manganese steel) for Connecting Rod & (Nickel Chromium steel – High carbon steel) for Crankshaft. Modeling, Assembly of Piston, Connecting rod and Crankshaft is done in Creo/Engineering software & Analysis is done in ANSYS. Structural analysis is used to determine displacements & stresses under static. Modal Analysis is used to determine the Vibration characteristics (natural frequencies & mode shapes) of the three components. Thermal analysis is to determine the heat flux and temperature distribution. By comparing the displacement & stress results, using Cast Iron for Piston, Manganese Steel for Connecting rod and High Carbon Steel for crankshaft is best combination for assembly.

Keywords — **Piston, Connecting rod and Crankshaft, Aluminum Alloy – Cast iron, Aluminum Alloy – Manganese steel, Nickel Chromium steel – High carbon steel, Creo/Engineering software, ANSYS.**

I. INTRODUCTION

An internal combustion engine is defined as an engine in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel. The internal combustion engine was conceived and developed in the late 1800s. It has had a significant impact on society, and is considered one of the most significant inventions of the last century.

A piston is a cylindrical plunger that moves within a metal cylinder through the four strokes of the engine cycle: intake, compression, power and exhaust. While their motion is predicated on other engine parts and the mixture of air and fuel, the motion of a piston is central to the functioning of an engine. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston and Connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In a reciprocating piston engine, connecting rod connects the piston to the crank or crankshaft. In modern automotive internal, the connecting rods are most usually made of steel for production engines, but can be made of aluminum (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of strength and lightness at the expense of affordability) for high performance engines, or of cast iron for applications such as motor scooters. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft. Condors', especially in racing engines, may be called "billet" rods, if they are machined out of a solid billet of metal, rather than being cast. 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.

The crankshaft, sometimes casually abbreviated to crank, is the part of an engine which translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach.

Crankshafts can also be machined out of a billet, often using a bar of high quality vacuum remelted steel. Even though the fiber flow (local in homogeneities of the material's chemical composition generated during casting) doesn't follow the shape of the crankshaft (which is undesirable), this is usually not a problem since higher quality steels which normally are difficult to forge can be used. These crankshafts tend to be very expensive due to the large amount of material removal which needs to be done by using lathes and milling machines, the high material cost and the additional heat treatment required. However, since no expensive tooling is required, this production method allows small production runs of crankshafts to be made without high costs.

II. LITERATURE SURVEY

In this study, the modal analysis results are verified by a modal testing experiment C. Azoury et al [1] presented a report on the experimental and analytical modal analysis of a crankshaft. The effective material and geometrical properties are measured, and the dynamic behavior is investigated through impact testing. The three dimensional finite element models are constructed and an analytical modal analysis is then performed to generate natural frequencies and mode shapes in the three-orthogonal directions. The finite element model agrees well with the experimental tests and can serve as a baseline model of the crankshaft. R. J. Deshbhratar, et al [2] analyzed 4- cylinder crankshaft and model of the crankshaft were created by using Pro/E Software and then imported to ANSYS software. The maximum deformation appears at the centre of crankshaft surface. The maximum stress appears at the fillets between the crankshaft journal and crank cheeks, and near the central point. The edge of main journal is high stress area. The crankshaft deformation was mainly bending deformation under the lower frequency. And the maximum deformation was located at the link between main bearing journal and crankpin and crank cheeks. So this area prone to appear the bending fatigue crack. Abhishek choubey, and et al [3] have analyzed crankshaft model and 3-dimentional model of the crankshaft were created by SOLID WORKS Software and imported to ANSYS software. The crankshaft maximum deformation appears at the centre of crankpin neck surface. The maximum stress appears at the fillets between the crankshaft journals and crank cheeks and near the central point journal. The edge of main journal is high stress area. Rinkle garg et al. [4] Analyzed crankshaft model and crank throw were created by using Pro/E Software and then imported to ANSYS software. The result shows that the improvement in the strength of the crankshaft as the maximum limits of stress, total deformation, and the strain is reduced. The weight of the crankshaft is reduced .There by, reduces the inertia force. As the weight of the crankshaft is decreased this will decrease the cost of the crankshaft and increase the I.C engine performance. Sanjay B Chikalthankar et al [5] investigated stresses developed in crankshaft under dynamic loading. In this study a dynamic simulation was conducted on crankshaft, Finite element analysis was performed to obtain the variation of stress magnitude at critical locations. This load was then applied to the FE model, and boundary conditions were applied according to the engine mounting conditions. The analysis was done for different engine speeds and as a result critical engine speed and critical region on the crankshaft were obtained. Stress variation over the engine cycle and the effect of torsional load in the analysis were investigated. Results obtained from the analysis are very useful in optimization of the crankshaft.

III. OBJECTIVE AND SCOPE OF THE WORK

The objectives of this project is to design and analysis of Piston, connecting rod and crank shaft assembly by using **CREO** design software and Ansysis for requirement of better engine performance with different alloy materials.

The following scopes of the project are determined in order to achieve the objectives of the project:
Design the flexible raw materials for automobile components.
Analysing best strength of the raw materials

IV. CALCULATIONS

Design calculations of piston

Density of diesel = 820 to 950 kg/cm at 15˚c
= 0.00095 kg/cm³
Density = 0.00000095 kg/mm³
Diesel $C_{10}H_{22}$ to $C_{15}H_{28}$ = $C_{15}H_{28}$
Molecular weight of $C_{15}H_{28}$ =208g/mole
Mass =density × volume
m = 0.00000095× 130000
m =1.235
R = 8.3143 J/mol K

$$P = \frac{mrt}{v} = \frac{1.235\times8.3143\times288}{0.208\times0.001300}$$

=10936107.69 J /m³
P = 10.936 N/mm²
Piston Head
Gas pressure p = 10.936 N/mm²
Outside diameter of piston = 72.5
σ_t = bending tensile stress = 35-40Mpa
Temperature at the centre of the piston head T_c = 425˚c to 450˚c
Temperature at the edge of the piston head T_e = 200˚c to 225˚c

$$T_c - T_e = 220^\circ c \quad t_h = \sqrt{\frac{(3P\times D^2)}{16\sigma t}}$$

$$= \sqrt{\frac{(3\times10.936\times72.5^2)}{16\times40}}$$

= 16.41mm
Thickness of the ribs = $t_h/2 = t_h/3$
= 5.47 (or) 8.20 mm
Piston Rings
Radial thickness of the ring

$$t_1 = D\times\sqrt{\frac{3xpw}{\sigma t}}$$

P_w = pressure of gas on the cylinder wall
P_w = 0.025 to 0.042 N/mm²
σ_t = 85 Mpa to 110 Mpa for CI rings

$$t1 = 72.5\times\sqrt{\frac{3\times0.042}{110}} = 2.45 \text{ mm.}$$

Axial thickness $t_2 = D/10n_R$
n_R = no. of rings = 3

$$t2 = \frac{72.5}{10\times3} = 2.41 \text{ mm.}$$

Width of top land $b_1 = t_h$ to $1.2\, t_h$ =16.41 to 19.692 mm

The width of other ring land (distance between the ring grooves)
$b_2 = 0.75t_2$ to t_2 =1.8075 to 2.41 mm
The gap between the free ends of the ring = $3.5t_1$ to $4t_1$
= 8.575 to 9.8 mm
Piston Barrel (Cylindrical portion of the Piston)
Thickness of piston barrel
t_3 = radial depth of piston ring groove
b= t_1+0.4 =2.85mm
t_3 = 0.03× 69.6+2.75+4.5 = 9.525mm
The piston wall thickness towards the open end
$t_4 = 0.25t_3$ to $0.35t_3$
t_4 = 3.33mm
Piston Skirt
Maximum gas load on the piston

$$P = P\times\frac{\pi}{4}D^2$$

P= maximum gas pressure

$$P = 10.936\times\frac{\pi}{4}72.5^2$$

P= 45226.79866 N
Maximum side thrust on the cylinder

$$R = \frac{p}{10} = 4522.67\text{N}$$

Length of the piston skirt
L= 0.65D to 0.8D = 58 mm
Length of ring section = 7× b_2=16.87
Total length of the piston
L = length of the skirt +length of the ring section +top land
= 58 + 16.84 +19.692
= 94.532 mm.

Piston pin (gudgeon pin or wrist pin)

d_0 = outside diameter of the piston pin
l_1 =length of the piston pin in the bush of the small end of the connecting rod
= 0.45D = 0.45× 69.6
l_1 = 32.625 mm
Load on the piston due to gas pressure
p = 45226.79866N
Load on the piston pin due to bearing pressure or bearing load = bearing pressure × bearing area
$P = p_{b1}\times d_0\times l_1$
p_{b1} = bearing pressure at the small end of the connecting rod bushing

$$d_0 = \frac{p}{pb1\times l_1}$$

Bearing pressure of tin bronze =50Mpa

$$d_0 = \frac{45226.7986}{50\times32.625}$$

$d_i = 0.6d_0$ = 16.635mm
Length between the supports

$$l_2 = \frac{l1+D}{2} = \frac{32.625+72.5}{2}$$

l_2 = 52.56mm
The mean diameter of the piston bosses = 1.4 d_0
= 38.815mm

Design calculations of connecting rod

Dimensions of cross section of connecting rod
Thickness of flange & web of the section = t
Width of section B= 4t
Height of section H=5t
Area of section A= 2(4t×t)+3t×t
$A=11t^2$
MI of section about x axis
$I_{xx}=1\backslash12\ (4t(5t)^3-3t(3t)^3)=419\backslash12t^4$
MI of section about y axis
$I_{YY}=(2+1\backslash12t(4t)^3+1\backslash12(3t)\ t^3) = 131\backslash12\ t^4$
$I_{XX} \backslash I_{YY} = 3.2$
Length of connecting rod = 2 times the stroke
L = 2×80.5 =161mm
Buckling load W_B = maximum gas force × F.O.S
W_B = 70924.49978×6 = 425546.9987
$W_B = \frac{\sigma C \times A}{1+ a(L\backslash KXX)^2}$
σ_C = compressive yield stress=386 Mpa
$Kxx= I_{XX}\backslash A \frac{419\backslash12t^4}{114^2}$
= 3.17t2
kxx = 1.78t
f_c= maximum load
f_c = p = 70924.49978
$a = f_c \backslash\pi^2E$
$a = 70924.49978\ \backslash\pi^2\ 68900$
a = 0.1044
$425546.9987 = \frac{386\ \times11t^2}{1+0.1044(161\backslash1.78t)^2}$
11t4-1102.4533t2-820135.3636=0
$t^2 = \frac{100.22 \pm \sqrt{((100.22)^2\ +4\times820135.3636)}}{2}$
$t^2 = \frac{100.22 \pm 1813.9983}{2}$
t = 30.93
Width of section B = 4t =123.74mm
Height of section H = 5t = 154.65mm
Area A = $11t^2$ = 10523.3139mm^2
Height at the big end (crank end) = H_2 = 1.1H to 1.25H
H_2 =170.115 mm
Height at the small end (piston end) = 0.9H
H_1 = 139.185mm
Dimensions of crank pin
Load on the crank pin = projected area × bearing pressure
$F_L = d_c \times l_c \times p_{bc}$
$l_c = 1.25\ d_c$ to $1.5d_c$
$F_L = 1.5\ d_c^2 \times p_{bc}$
p_{bc} = allowable bearing pressure at the crank pin bearing
p_{bc} = 12.5N\mm^2
$FL = \frac{\pi D^2}{4} \times p = 70924.49978$
70924.49978 = 1.5 dc2× 12.5
d_c^2 = 2750.7708
d_c = 61.503
$l_c = 1.5d_c$ = 78.66
Design of crankshaft

Specifications

Tata Indica vista 1.3 diesel engine specifications
Bore diameter or cylinder bore = D = 69.6mm
Stroke = 82mm
Explosion pressure gas pressure = P =15.454 N/mm^2
Maximum torque = 200 N-m @1750-3000 rpm
Design of crank shaft when the crank is at the dead centre
We know that piston gas load
$F_p = \frac{\pi}{4} \times D^2\ \times\ P = \frac{\pi}{4}\ \times 69.6^2 \times 15.454$ = 41585.951N

Now the various parts of the crank shaft are design as discussed below:

Design of Crank Pin for Crank shaft

Let d_c = diameter of crank pin mm
L_c = length of the crank pin = 0.8 d_c considering the crank pin in bearing taking p_b = 15 N/mm^2
We have = $F_p = d_c \times l_c \times p_b = 41585.951 = d_c \times 0.8d_c \times 15 = 8d_c^2$
d_c = 72 mm
$l_c = 0.8d_c$= 58mm
Let us now the included bending stress in the crank pin
We know that bending moment at the crank pin
$M = \frac{3}{4} F_p \times l_c = \frac{3}{4}\ \times 41585.951 \times 58$ = 1808988.869N/mm
Section modules of the crank pin $Z = \frac{\pi}{32} d_c^3 = \frac{\pi}{32}\ \times 72^3 = 36624.96mm^3$
Bending stress induced $\frac{M}{Z} = \frac{1808988.869}{36624.96}$ = 49.39N/mm^2
The induced bending stress is within in the permissible limits of 560 Mpa, therefore design of crank pin is safe
Design of bearings for Crank shaft
Let d_1 = diameter of the bearing
Let us take thickness of the crank web
$t=0.6d_c = 0.6 \times 72$ = 43mm
Length of bearing $l_1 = 1.7d_c = 1.7\times72$ = 122.4mm
WKT bending moment at centre of bearing

$M = F_p(0.75l_c+t+0.5l_1) = 41585.951(0.75\times 58+43+0.5\times 122) = 6133927.773$

Bending moment (M) WKT

$6133927.773 = \frac{\pi}{32}\, d_1^3\, \sigma_b = \frac{\pi}{32}\, d_1^3 \times 560 = 54.95\, d_1^3$

$d_1 = 48mm$

Design of crank web for Crank shaft

Let w = width of the crank web in mm

WKT bending moment on the crank web

$M = F_p\,(0.75l_c+t+0.5l_1) = 41585.951(0.75\times 58+43+0.5\times 43) = 2703086.815$

Section modulus $Z = \frac{1}{6} \times w \times t^2 = \frac{1}{6} \times w \times 43^2 = 308.166wt$

Bending stress $\sigma_b = \frac{M}{Z} = \frac{41585.951}{w \times 43} = \frac{967.115}{w}$

Total stress on the crank web $\sigma_t = \sigma_b + \sigma_d = \frac{967.115}{w} + \frac{8771.509}{w} = \frac{9738.625}{w}$

Total stress should not exceed permissible limit of 560 Mpa

$560 = \frac{9738.625}{w}$

W = 17.390=20mm

V. MATERIALS AND PROPERTIES

Cast Iron, Aluminum Alloy and Cast Steel etc. are the common materials used for piston of an Internal Combustion Engine. Cast Iron pistons are not suitable for high speed engines due its more weight. These pistons have greater strength and resistance to wear. The Aluminum Alloy Piston is lighter in weight and enables much lower running temperatures due to its higher thermal conductivity. The coefficient of expansion of this type of piston is about 20% less than that of pure aluminum piston but higher than that of cast iron piston and cylinder wall. To avoid seizure because of higher expansion than cylinder wall, more piston clearance required to be provided.

Connecting rods are made with balancing bosses so that their weight can be adjusted to specifications.

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. Therefore, light alloy metals such as aluminum and titanium are currently being used in high speed engine connecting rods to circumvent the above-mentioned problems. Titanium has better mechanical properties than aluminum, at the expense of higher density and cost. This higher density and cost have made aluminum connecting rods more popular and attractive. However, they suffer from relatively low strength and fatigue life.

Crankshaft is usually made by steel. Generally medium –carbon steels alloys are composed of iron small percentage of carbon (0.25% to 0.45%), along with combinations of several alloying elements, the mix of which. The alloying elements typically used in these carbon steels are manganese, chromium, molybdenum, nickel, silicon, cobalt, vanadium, and sometimes aluminium and titanium. In addition to alloying elements, high strength steels are carefully refined so as to remove as many of the undesirable impurities as possible like sulphur phosphorous, calcium, etc. the highest quality steels are also used. The required purity can often only be achieved by melting in a vacuum, then re-melting in a vacuum to further refine the metal. Typical vacuum processing methods are VIM and VAR.

Used materials for piston

Aluminum 360, aluminum alloy 6061, cast iron

Used materials for connecting rod

Aluminum 360, aluminum alloy 6061 and manganese steel.

Used materials for crankshaft

Nickel chromium and high carbon steel.

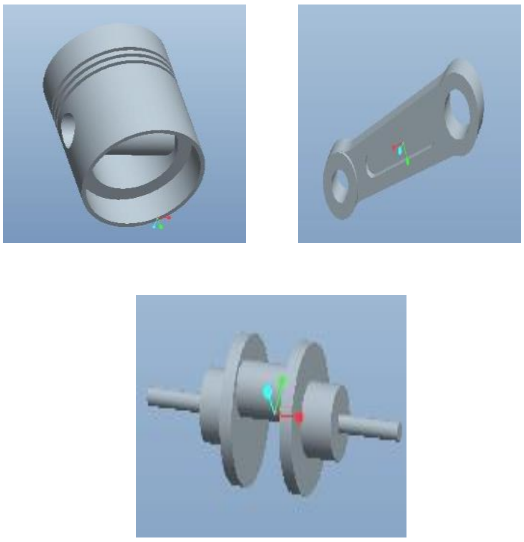
Properties of different alloy materials for piston, connecting rod and crank shaft

Table: 1 Properties of different alloy materials for piston, connecting rod and crank shaft

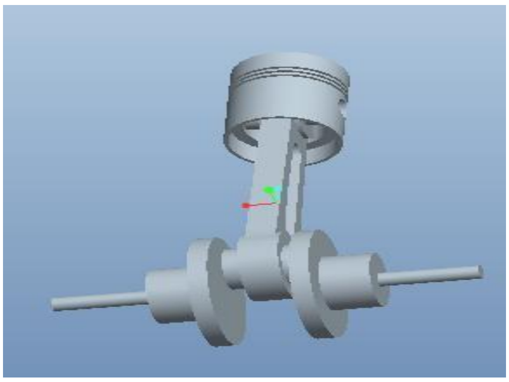
S.NO	NAME OF THE MATERIAL	DENSITY	YOUNGS MODULUS	POSION'S RATIO	THERMAL CONDUCTIVITY
1	ALUMINUM ALLOY 6061	2.70g/CC	68.9Gpa	0.33	180w/m-k
2	ALUMINUM ALLOY 360	2.68g/CC	71.0Gpa	0.33	113w/m-k
3	CAST IRON	7.81g/CC	240Gpa	0.24	113w/m-k
4	NICKEL CHROMIUM	8.42g/CC	207Gpa	0.36	30w/m-k
5	MANGANESE STEEL	8.0g/CC	210Gpa	0.29	50w/m-k
6	HIGH CARBON STEEL	7.8g/CC	200Gpa	0.295	52.0w/m-k

VI. MODELING

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself. PTC Creo says it can after a more efficient design experience than other modeling software because of its unique features including the integration of parametric and direct modeling in one platform. By using Creo software, I did modeling of piston, connecting rod and crankshaft. I assembled these all together in Creo software.



Modeling Parts of piston, connecting rod and crank shaft in 3D view

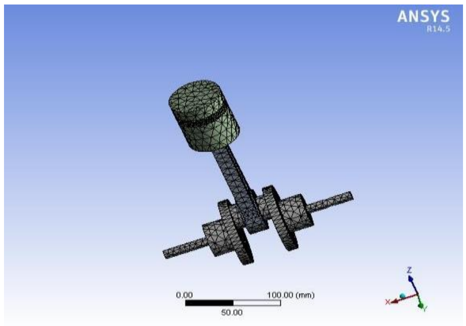


Assembly of piston, connecting rod and crank shaft in 3D view

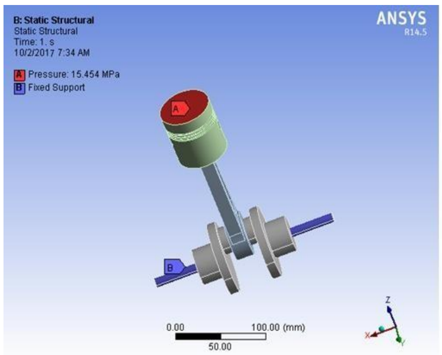
VII. ANALYSIS TOOL(ANSYS)

The software uses the finite element method (FEM). FEM is a numerical technique for analyzing Engineering designs.FEM divides the modal into many small pieces of simple shapes called elements effectively replacing a complex problem by many simple problems that need to be solved simultaneously. I did structural analysis, thermal analysis and model analysis with using ANSYSIS software. FEM is accepted as the standard analysis method due to generality and suitability for computer implementation.

MESHED MODEL

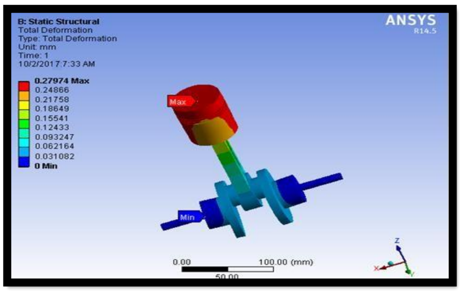


BOUNDARY CONDITIONS

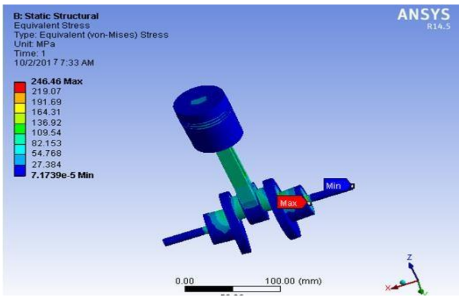


STATIC ANALYSIS

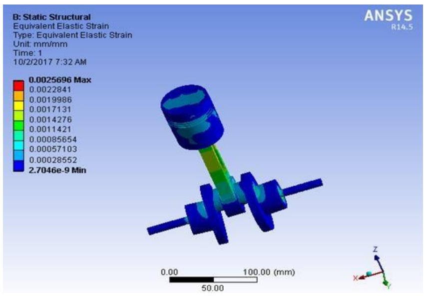
Materials for Piston and Connecting Rod Aluminum Alloy 360 and Crank Shaft Nickel Chromium



Total Deformation

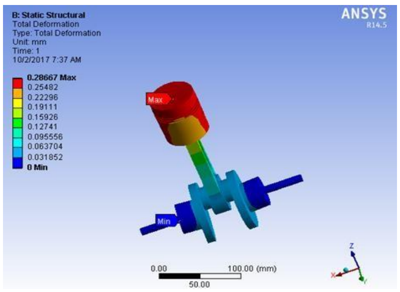


Equivalent stress

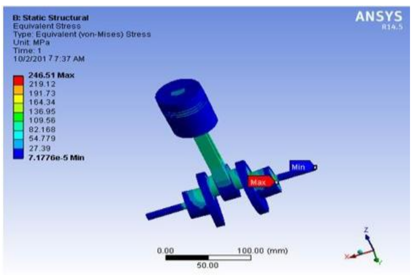


Equivalent strain

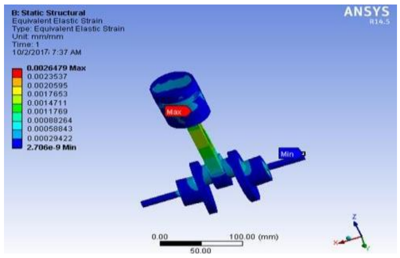
Materials for Piston and Connecting Rod Aluminum Alloy6061 and Crank Shaft Nickel Chromium



Total Deformation

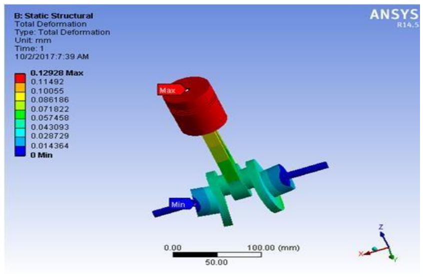


Equivalent stress

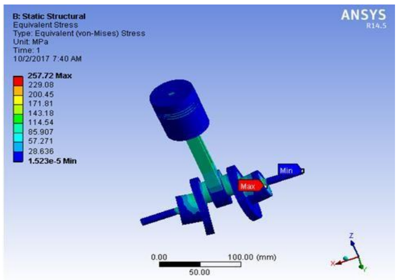


Equivalent strain

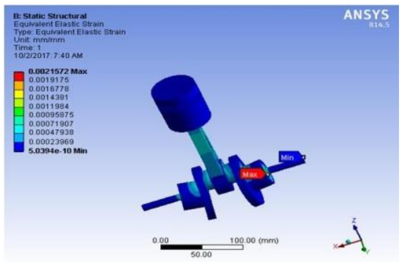
Materials for piston-cast iron and connecting Rod manganese for crankshaft high carbon Steel



Total Deformation



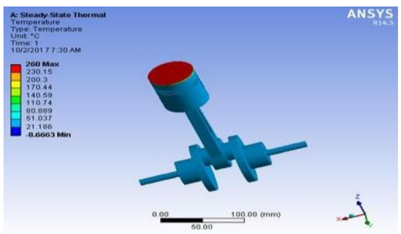
Equivalent stress



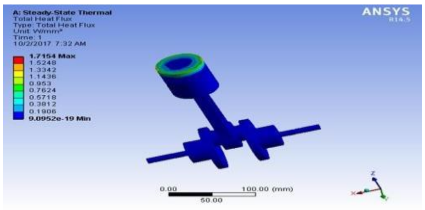
Equivalent strain

THERMAL ANALYSIS

Materials for piston and connecting rod aluminum alloy 360 for crank shaft nickel chromium

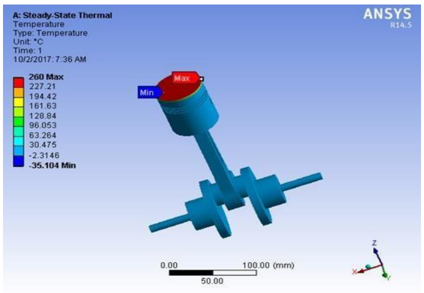


Temperature Distribution

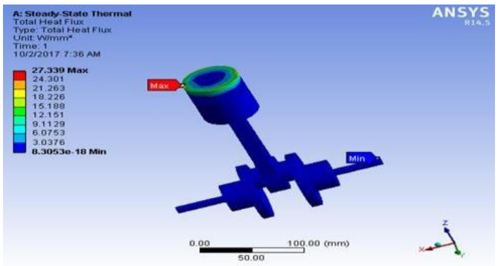


Heat flux

Materials for piston and connecting rod aluminum alloy 6061 for crank shaft nickel chromium

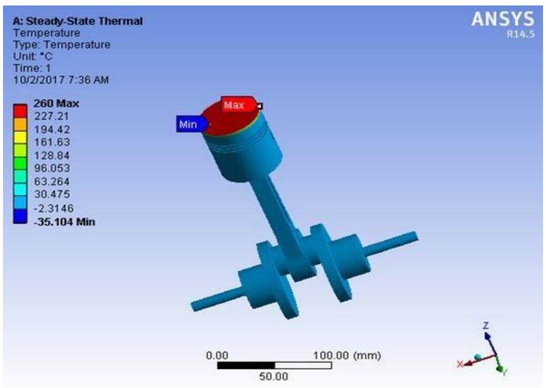


Temperature Distribution

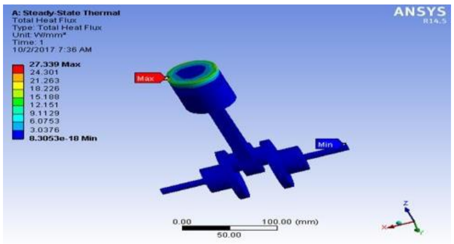


Heat flux

Materials for piston – cast iron and connecting rod manganese steel for crank shaft high carbon steel



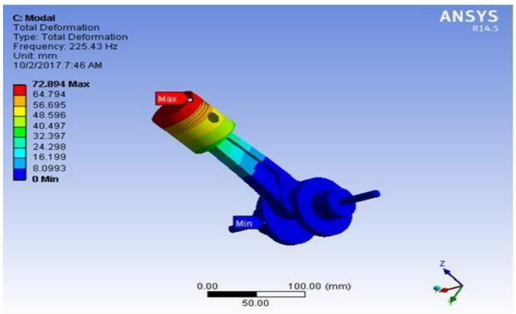
Temperature distribution



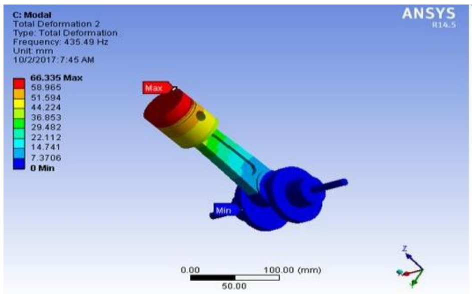
Heat flux

MODAL ANALYSIS

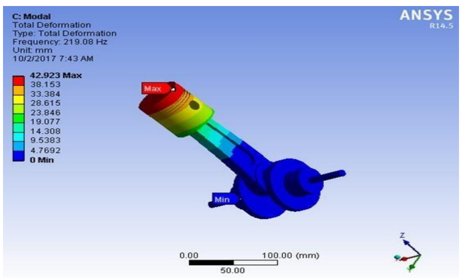
Materials for piston and connecting rod aluminum alloy 360 for crank shaft nickel chromium



Total Deformation-1

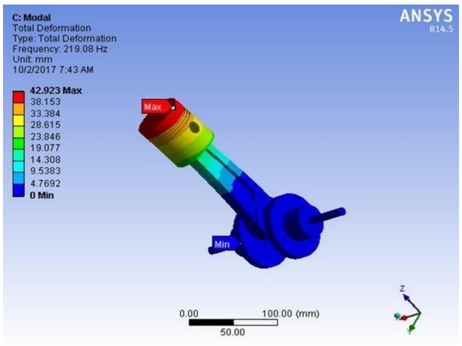


Total Deformation-2

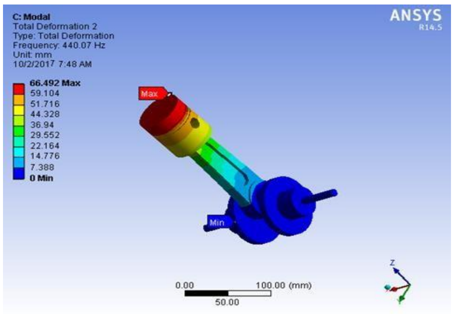


Total Deformation-3

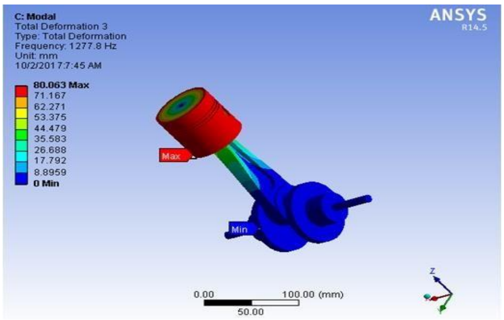
Materials for piston and connecting rod aluminum alloy6061 for crank shaft nickel chromium



Total Deformation-1

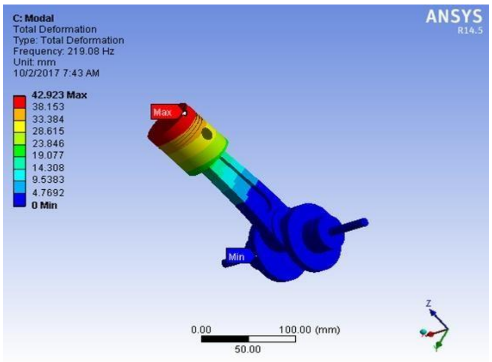


Total Deformation-2

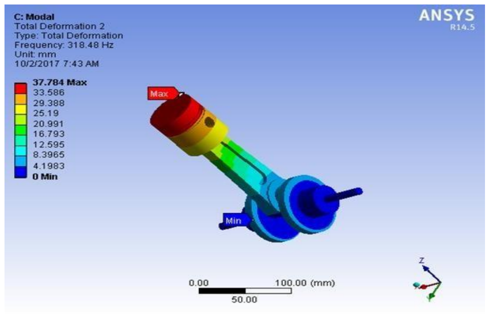


Total deformation-3

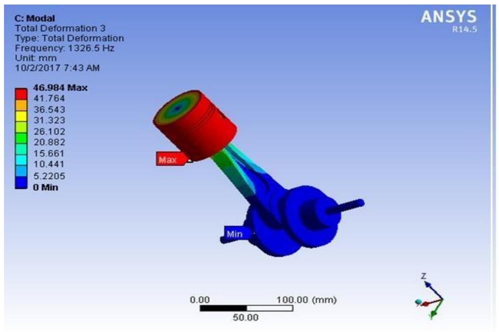
Materials for piston – cast iron and connecting rod manganese steel for crank shaft high carbon steel



Total Deformation-1



Total Deformation-2



Total Deformation-3

VIII. RESULTS

a) STATIC ANALYSIS RESULTS

Table: 2 Static analysis results

material	Deformation(mm)	Stress(MPa)	strain
Materials for piston and connecting rod aluminum alloy 360 For crank shaft nickel chromium	0.27974	246.46	0.0025696
Materials for piston and connecting rod aluminum alloy6061 For crank shaft nickel chromium	0.28667	246.51	0.0026479
Materials for piston – cast iron and connecting rod manganese steel For crank shaft high carbon steel	0.12928	257.72	0.0021572

b) THERMAL ANALYSIS RESULTS

Table: 3 Thermal analysis results

material	Temperature(^{0}C)	Heat flux(w/mm^2)
Materials for piston and connecting rod aluminum alloy 360 For crank shaft nickel chromium	260	1.7154
Materials for piston and connecting rod aluminum alloy6061 For crank shaft nickel chromium	260	27.339
Materials for piston – cast iron and connecting rod manganese steel For crank shaft high carbon steel	260	8.0922

c) MODEL ANALYSIS RESULTS

Table: 4 Modal analysis results

Mode shapes	Results	Materials for piston and connecting rod aluminum alloy 360 For crank shaft nickel chromium	Materials for piston and connecting rod aluminum alloy6061 For crank shaft nickel chromium	Materials for piston – cast iron and connecting rod manganese steel For crank shaft high carbon steel
Mode1	Deformation (mm)	73.191	72.894	42.923
	Frequency(Hz)	229.36	225.43	219.08
Mode2	Deformation (mm)	66.492	66.335	37.784
	Frequency(Hz)	440.07	435.49	318.48
Mode3	Deformation (mm)	80.36	80.063	46.984
	Frequency(Hz)	1302.18	1277.8	1326.5

CONCLUSION

- In this thesis is to Model & Assemble the Piston, Connecting Rod & Crankshaft for a 4-stoke air-cooled 150cc Engine by theoretical calculations & also to Compare the Structural Analysis & Modal Analysis on two different materials such as (Aluminum Alloy – Cast iron) for Piston, (Aluminum Alloy – Manganese steel) for Connecting Rod & (Nickel Chromium steel – High carbon steel) for Crankshaft.
- By observing the analysis results, the stress values are less than the respective yield stress values for both the materials. The stress values are less for Aluminum alloy 360.
- By observing the modal analysis, the deformation values are more for aluminum alloy 360 at mode 3.
- Thermal analysis, the heat transfer rate is more for aluminum alloy6061.
- So it can be concluded that using Aluminum alloy 360 for piston and connecting rod is better considering weight and analysis results.

REFERENCES

1. *Machine Design by R.S Khurmi.*
2. *Machine Design by R.K. Jain.*
3. *Internal Combustion Engines by Ganesan.*
4. *Engineering Thermodynamics by P.K. Nag.*
5. *Engineering Thermodynamics by Onkar Singh.*
6. *A Text book of Automobile Engineering by K. Raj put.*
7. *Azoury K "Design & Analysis Of Connecting Rod By Composite Material", Ijrdo, International-Journal Of Mechanical-And-Civil-Engineering , VOL 2 ISSUE 7 July 2015 Paper 1.*
8. *Deshbharatar B, Dr. Dilip S. Ingole, "Stress Analysis of I.C. Engine Connecting Rod by FEM and Photo elasticity", IOSR Journal of Mechanical and Civil Engineering, Volume 6, Issue 1 (Mar. - Apr. 2013), PP 117-125.*
9. *Abhishek choubey k, Dr. B. Sudheer Prem Kumar (Dec, 2013), Thermal Analysis and Optimization of I.C. Engine Piston using finite element method, International journal of innovative research in science, engineering and technology. (IJRISET) Vol. 2, Issue 12, Pg. 7834-7843.*
10. *Rinkle garg .c "Design Analysis and Optimization of Various Parameters of Connecting Rod using CAE Software's" International Journal of New Innovations in Engineering & Technology (IJNIET) Vol.1 Iss 1.*
11. *Sanjay B Chikalthankar, Dr P R Kulkarni "A Review on Design and Vibration Analysis of a Crank shaft by FEA and Experimental Approach" International Journal of Scientific Development and Research (IJSDR) ,Volume 1, Issue 11,2016.*

Author Profile:

Prasanna Nagasai Bellamkonda received B.Tech Automobile Engineering from Eswar College of Engineering in 2017 and now persuing M. Tech Machine Design in Gudlavalleru Engineering College. Attended one National and one international conferences. Published a paper in International journal on the topic Metal Matrix Composites.

Satish Ksagani received B.Tech Mechanical Engineering from SITE Engineering in 2013 and now persuing M. Tech Thermal Engineering in A.K.R.G College of Engineering & Technology.

Srikanth. S received B.Tech Mechanical Engineering from St. Ann's College of Engineering and Technology in 2008, M. Tech. Machine Design from Jawaharlal Nehru Technological University, Kakinada in 2014. Now working as a Assistant Professor in Gudlavalleru Engineering College. He had 4 years of teaching experience. He had attended one national and one international conferences. He had published 3 National and International journals.