FOUR STROKE ENGINE PISTON DESIGN AND ANALYSIS

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Abstract:
Piston is a important part in the reciprocating engine system. It is used to the transfer the power from the piston to the crank. The crank is used transfer the power from piston to the engine by the using of the connecting rods .Piston is the major part of an internal combustion engine which converts the chemical energy of the fuel into the mechanical energy. In this design analysis the is analysis in the different materials by is the using of the same piston dimensions the of the piston is analysis in the two different type of materials like Aluminum, cast ion materials. In the design analysis of the piston the piston is design in catia v5 and analysis in the workbench software .In this process the piston is tested in temperature, pressure, stress, train analysis

Keywords: CATIA V5, ANASYS WORKBENCH 15.0, TEMPERATURE, PRESSURE, STRESS

I. INTRODUCTION

Any engine which is used for the transferring of the power From the one place to another it can be done by the using of the piston. In the engine design there two types of combuston process will occur in this system one internal combustion engine another one is enternal combustion engine. In the internal combustion engine the ignition will occurs due to airin the system. In the external combustion engine the ignition will due to steam. The exteranl combustion engine is mainly occur in the heavy loaded machines. In the engine system the ignition will occur due to the fuels like petrol,diesel,stem for the engine running process

1. In this the piston will produce more heat
2. The efficiency of fuel consumption in less
3. It requires less space compared to diesel engine
4. The cost of the fuel consumption is less
5. It requires less cost

A piston is a component of reciprocating engines,reciprocating pumps, and gas compressors among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from increasing gas in the cylinder to the crankshaft via a piston rod and/or 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.This pin is mounted within the piston: unlike the steam engine, there is no piston rod or crosshead (except big two stroke engines). The pin itself is of hardened steel and is fixed in the piston, but free to move in the connecting rod. A few designs use a 'fully floating' design that is loose in both components.

The major forces acting on the piston:

- Friction acts between the piston and the cylinder
- Load acts on the piston head
- Over heat acts on the piston

Main objective of the piston:

- To with stand load at the high pressure
- To reduce the cracks on the piston
- To increase the high cooling capacity in the piston

II. ENGINE SPECIFICATION

PARAMETERS	VALUES
Piston type	Four stroke piston
Diameter of the piston	54mm
Cylinder height	89mm
Number of piston	Single piston
Length of Connecting Rod	120mm
Displacement Volume	145.31 cm3
Compression Ratio	9.5+/-0.5:1
Number of Revolutions/Cycle	2
Stoke	9.5cm^3

III. PHYSICAL AND MECHANICAL PROPERTIOES

PROPERTIES	VALUES
Elastic Modulus	73.5 GPa
Poisson's Ratio	0.33
Shear Modulus	29 GPa
Density	2780 kg/m3
Tensile Strength	499 MPa
Yield Strength	396 MPa
Thermal Conductivity	120 W/m-K

IV. PISTON DESIGN CALCULATIONS

The design calculations for the piston are considered under the maximum pressure condition over the piston are as follows
D = Bore or Diameter of piston
L = Stroke
I.P. = Indicated Power
B.P = Brake power
ηm = Mechanical efficiency of the engine = 0.8
N = Engine speed

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H.C.V. = High Calorific value of piston = 47000 kJ/kg

Density of Petrol:
C_8H_{18} = 737.22 kg/m3 at 60^{0}F = 0.00073722 kg/cm3 = 0.00000073722 kg/mm3
T = 60^{0}F = 288.855K = 15.55^{0}C
Mass = Density × Volume
m = 0.00000073722 × 145310
m = 0.107 kg . . .
Molecular weight for petrol 144.2285 g/mole
R = Gas constant.
PV = mRT
P = (0.107×8.31430×288.855)/ (0.00002015483)
Pmax= 12.70×106 N/m2or 12.70MPa
Where, m = mass/molecular weight
R = Gas constant

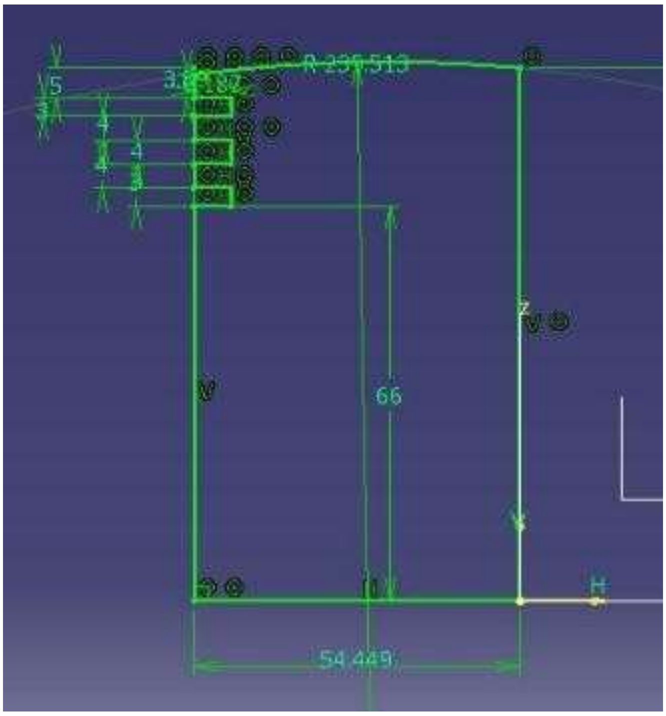
4.1 Thickness of Piston head, th:
The piston thickness of piston head calculated using the following Grashoff's formula
, th = √(3PmaxD2)/ (16σt) in mm
th = √(3×12.70×582)/(10×220)
th = 6.76 mm
Where, σt = Allowable tensile strength for piston = 197 MPa Factor of safety for the design is 2.5

4.2 Piston Rings:
Radial Thickness,
b = D√ (3Pw/σp)
Pw = Allowable pressure on the cylinder wall = 0.025 MPa
σp = Permissible tensile strength for the ring material = 110 N/mm2
b = 58×√ (3×0.025/110) = 1.514 mm
Axial Thickness,
h h = 0.7b = 0.7×1.514= 1.06 mm
Width of Top Land,
h1 = 1.2th
h1 = 1.2×6.4 = 7.68 mm
Width of other ring lands i.e.,
distance between the ring grooves
h2 = 0.75h to h
h2 = h = 1.06 mm
Number of rings, nr = 3

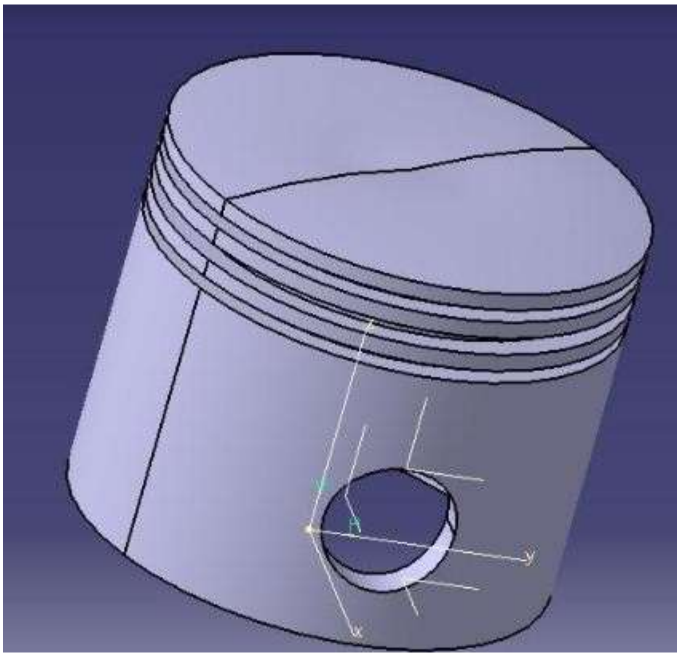
4.3 Maximum thickness of piston barrel at the top end, t1:
Radial depth of the piston grooves,
dg = 0.4+b dg = 0.4+1.514 = 1.914
t1 = 0.03×D+dg+4.5
t1 = 0.03×58+1.914+4.5 = 8.154 mm

4.4 Thickness of piston barrel at open end,
t2: t2 = 0.25t1 to 0.35t1 t2 = 0.25×8.154 = 2.038 mm
4.5 Piston Skirt:
Maximum gas load on the piston
P load = Pmax×πD2 /4
P load = 12.7×π×582 /4 = 33554.4 N
Diameter of Piston Pin, do = 16 mm
The centre of piston pin should be 0.02D to 0.04D above the centre of skirt. Maximum side thrust on the cylinder R = P load/10 = 3355.44 N σb = R/D×ls
σ b = 3355.44/58×34.2 = 1.7 N/mm2 Where
σ b = Bearing Pressure
ls = Length of skirt Total length of piston,
L = Length of skirt+ Length of ring section+ Top land
Length of ring section = 5×h2 = 5.3 mm
L = 34.2+ 5.3+ 7.56 = 47.06 mm

V. PISTON MEDELLING



VI. 3D MODEL OF THE PISTON



VII. MESH INFORMATION

Mesh type	Solid Mesh
Mesher Used	Standard mesh
Proximity	On
Include Mesh Auto Loops:	On
Jacobian points	2
Element Size	3.466
Tolerance	0.128268 mm
Mesh Quality	High
Total Nodes	49129
Total Elements	31466

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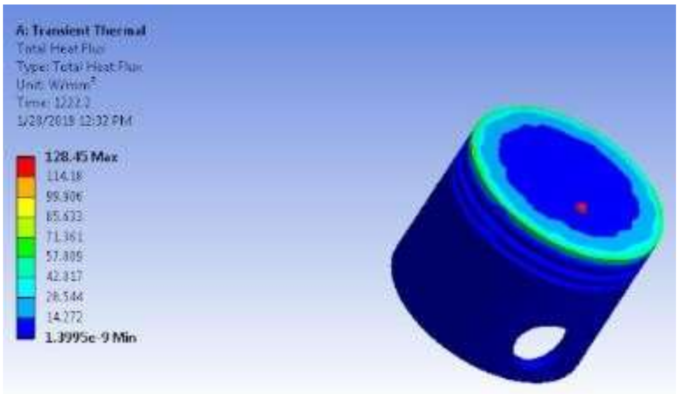
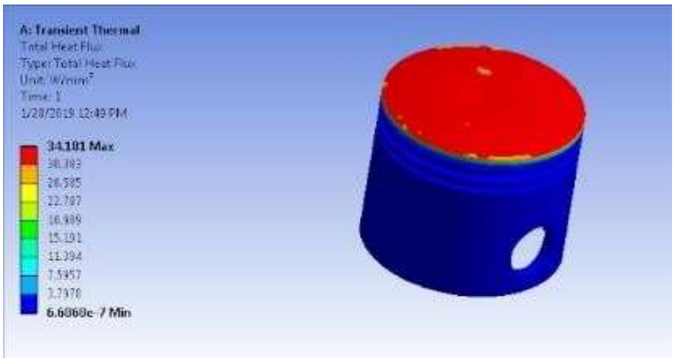
7.1 Temperature analysis

7.1.1 Aluminum temperature analysis

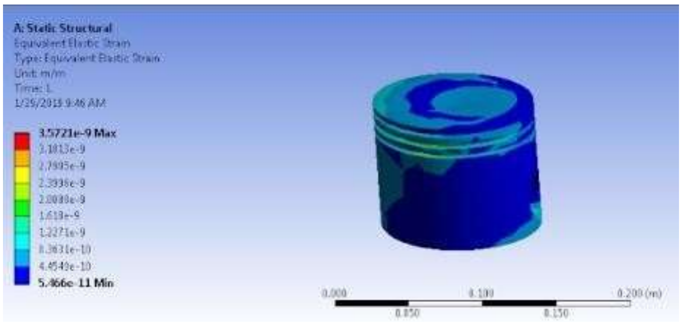


7.1.2 CAST ION TEMPERATURE ANALYSIS

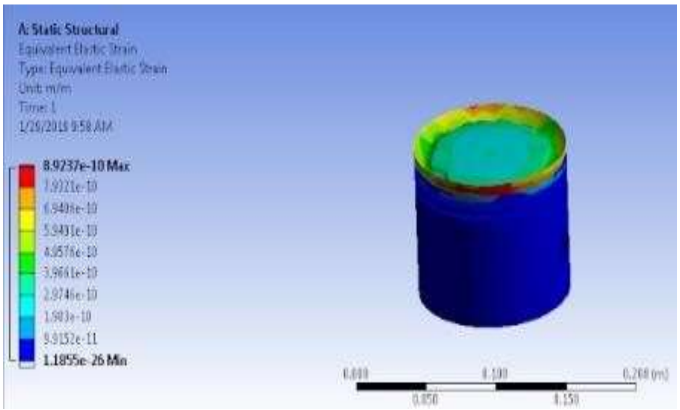


7.2 STRESS ANALYSIS

7.2.1 ALUMINIUM STRAIN ANALYSIS



7.1.2 BRASS STRAIN ANALYSIS



VIII. CONCLUSION

- The piston is designed for the 4 stroke petrol engine for bike of displacement approximately 220 cc.
- The results shows that the max shear stress is small than the allowable design stress for the material
- Max shear stress < Allowable design shear stress
- According to the software the factor of safety is around 2.5 which is almost similar to the design consideration of the system
- Piston which lies between the 2.0 to 3.0 so, factor of safety of 2.5 is taken into consideration.
- There is changes of the material removal from the bottom side of piston skirt and some material from the piston pin
- The design of the piston is done in the catia v5 software
- The analysis is done in the workbench software 15.0 for the analysis of the Temperature ,pressure, stress, strain
- Therefore it is analyzed that there is scope of future advancements in the changes design by examine the stress and strain concentration in the piston
- the piston pin taking its constraint with proper material selection

IX. RESULT AND DISCUSSION

The analysis of the design software is done by the using of the CATIA V5, WORKBENCH software. The design is done in the CATIA V5 .and analysis is done in the workbench software

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