



# Design and Analysis of Four Stroke Engine Piston

Mr.K.Sivaramakrishnan<sup>1</sup>, G.Jithendra<sup>2</sup>, V. Ajith kumar<sup>3</sup>Department of Mechanical Engineering  
Prathyusha Engineering College, India**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 air in the system. In the external combustion engine the ignition will due to steam. The exteranal 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 cm <sup>3</sup> |
| Compression Ratio           | 9.5+/-0.5:1            |
| Number of Revolutions/Cycle | 2                      |
| Stoke                       | 9.5cm <sup>3</sup>     |

**III. PHYSICAL AND MECHANICAL PROPERTIOES**

| PROPERTIES           | VALUES                 |
|----------------------|------------------------|
| Elastic Modulus      | 73.5 GPa               |
| Poisson's Ratio      | 0.33                   |
| Shear Modulus        | 29 GPa                 |
| Density              | 2780 kg/m <sup>3</sup> |
| 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

$\eta_m$  = Mechanical efficiency of the engine = 0.8

N = Engine speed

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

**Density of Petrol:**

$C_8H_{18} = 737.22 \text{ kg/m}^3$  at  $60^\circ F = 0.00073722 \text{ kg/cm}^3 = 0.00000073722 \text{ kg/mm}^3$

$T = 60^\circ F = 288.855 K = 15.55^\circ C$

Mass = Density  $\times$  Volume

$m = 0.00000073722 \times 145310$

$m = 0.107 \text{ kg} \dots$

Molecular weight for petrol 144.2285 g/mole

R = Gas constant.

$PV = mRT$

$P = (0.107 \times 8.31430 \times 288.855) / (0.00002015483)$

$P_{max} = 12.70 \times 10^6 \text{ N/m}^2$  or  $12.70 \text{ MPa}$

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

$th = \sqrt{(3P_{max}D^2) / (16\sigma_t)}$  in mm

$th = \sqrt{(3 \times 12.70 \times 58^2) / (10 \times 220)}$

$th = 6.76 \text{ mm}$

Where,  $\sigma_t$  = Allowable tensile strength for piston = 197 MPa

Factor of safety for the design is 2.5

**4.2 Piston Rings:**

Radial Thickness,

$b = D \sqrt{(3P_w / \sigma_p)}$

$P_w$  = Allowable pressure on the cylinder wall = 0.025 MPa

$\sigma_p$  = Permissible tensile strength for the ring material = 110 N/mm<sup>2</sup>

$b = 58 \times \sqrt{(3 \times 0.025 / 110)} = 1.514 \text{ mm}$

Axial Thickness,

$h = 0.7b = 0.7 \times 1.514 = 1.06 \text{ mm}$

Width of Top Land,

$h_1 = 1.2th$

$h_1 = 1.2 \times 6.4 = 7.68 \text{ mm}$

Width of other ring lands i.e.,

distance between the ring grooves

$h_2 = 0.75h$  to  $h$

$h_2 = h = 1.06 \text{ mm}$

Number of rings,  $n_r = 3$

**4.3 Maximum thickness of piston barrel at the top end, t1:**

Radial depth of the piston grooves,

$d_g = 0.4 + b$   $d_g = 0.4 + 1.514 = 1.914$

$t_1 = 0.03 \times D + d_g + 4.5$

$t_1 = 0.03 \times 58 + 1.914 + 4.5 = 8.154 \text{ mm}$

**4.4 Thickness of piston barrel at open end,**

$t_2: t_2 = 0.25t_1$  to  $0.35t_1$   $t_2 = 0.25 \times 8.154 = 2.038 \text{ mm}$

**4.5 Piston Skirt:**

Maximum gas load on the piston

$P \text{ load} = P_{max} \times \pi D^2 / 4$

$P \text{ load} = 12.7 \times \pi \times 58^2 / 4 = 33554.4 \text{ N}$

Diameter of Piston Pin,  $d_o = 16 \text{ mm}$

The centre of piston pin should be 0.02D to 0.04D above

the centre of skirt. Maximum side thrust on the cylinder  $R = P$

$\text{load} / 10 = 3355.44 \text{ N}$   $\sigma_b = R / D \times l_s$

$\sigma_b = 3355.44 / 58 \times 34.2 = 1.7 \text{ N/mm}^2$  Where

$\sigma_b$  = Bearing Pressure

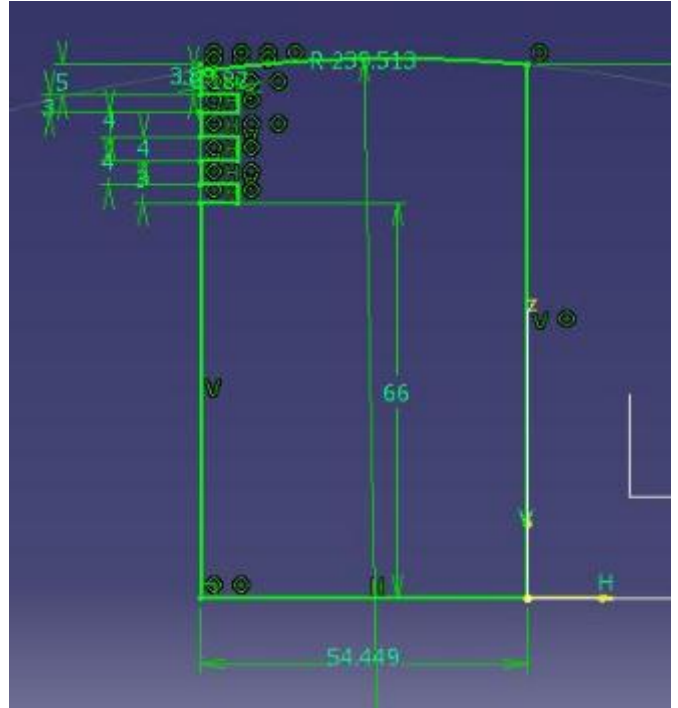
$l_s$  = Length of skirt Total length of piston,

$L$  = Length of skirt + Length of ring section + Top land

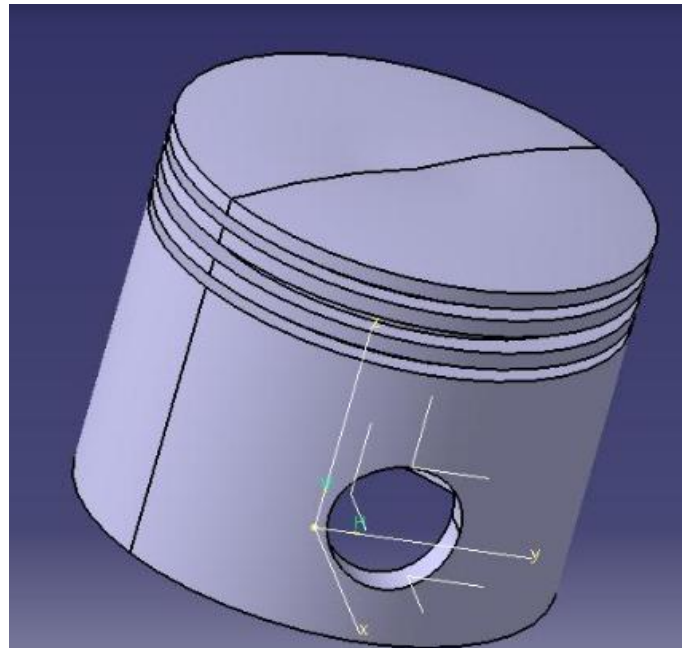
Length of ring section =  $5 \times h_2 = 5.3 \text{ mm}$

$L = 34.2 + 5.3 + 7.56 = 47.06 \text{ mm}$

**V. PISTON MEDELLING**



**VI. 3D MODEL OF THE PISTON**

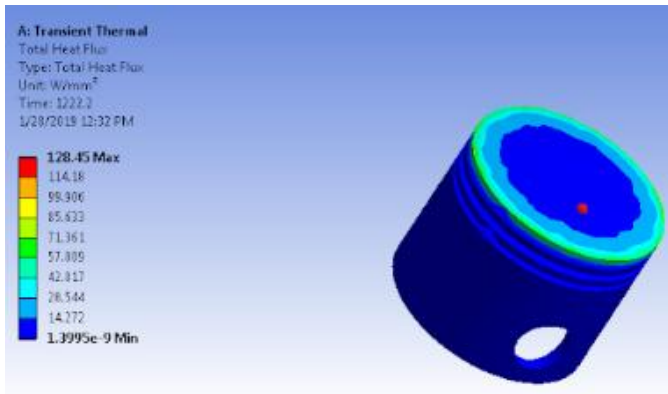


**VII. MESH INFORMATION**

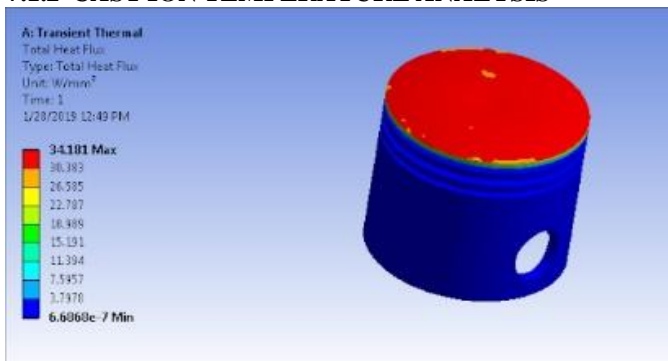
| Mesh type                | Solid Mesh    |
|--------------------------|---------------|
| Mesher Used              | Standard mesh |
| Proximity                | On            |
| Include Mesh Auto Loops: | On            |
| Jacobian points          | 2             |
| Element Size             | 3.466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

## 7.1 Temperature analysis

### 7.1.1 Aluminum temperature analysis

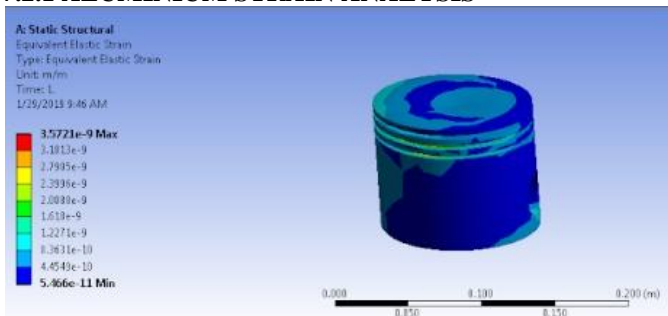


### 7.1.2 CAST IRON TEMPERATURE ANALYSIS

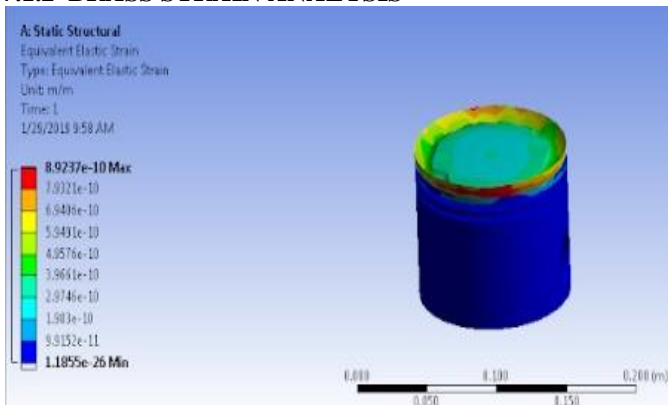


## 7.2 STRESS ANALYSIS

### 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

## X. REFERENCE

- [1]. Vaibhav V. Mukkavar, Abhishek D. Bangale, Nitin D. SurBhusale,Ganesh M.ve, “DesignAnalysis And Optimization Of Piston Using Cae Tools”, IJRET: International Journal of Research in Engineering and Technology e ISSN: 2319-1163 | pISSN: 2321-7308
- [2]. Ch. Venkata Rajam, P.V. K. Murthy, M.V.S.Murali Krishna, G.M.Prasada Rao, Design Analysis and Optimization of Piston using CATIA and ANSYS”, International Journal of Innovative Research in Engineering & Science ISSN 2319-5665 (January 2013, issue 2 volume 1)
- [3].V.Ganesan, Internal Combustion Engines”, Second Edition 11th reprint 2006 Tata McGraw Hill ISBN 0-07- 049457-6
- [4]. Sheikh Naim Sheikh Yusuf, Nikhil D. Raut, Nitin D. Bhusale, Abhijeet A. Sarnaik, “Finite Element Analysis And Optimization Piston Using Cae Tools”, Proceedings of 19th IRF International Conference, 25th January 2015, Chennai, India, ISBN: 978-93-84209-84-1
- [5] S. Bhattacharya, A. Basu, S. Chowdhury, Y.S. Upadhyaya, “Analysis Of Piston Of Two Stroke Engine”, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308
- [6].A. Karthick, "Design, Analysis and Optimization of Silumin Piston by using Pro-E and Ansys”, International Journal of Advanced Scientific Research & Development (IJASRD) p-ISSN: 2394-8906 | e-ISSN: 2395-6089 Volume 02, Issue 02 (Apr – Jun’ 2015), PP 20 – 33
- [7].Vinod Yadav, Dr. N. D. Mittal, “Design and Analysis of Piston Design for 4 Stroke Hero Bike Engine”, International Journal of Engineering Innovation & Research Volume 2, Issue 2, ISSN: 2277 – 5668
- [8]. Mirosław Wendeker, Paweł Magryta Adam Majczak,

Michaá Biaáy, "Modeling The Thermal Loads in the Subaru EJ25 Engine" journal ofONES Powertrain and Transport, Vol. 18, No. 1, pp. 683-688, 2011.

[9]. R. Bhagat, Y. M. Jibhakate, Thermal Analysis and Optimization of I.C. Engine Piston Using Finite Element Method, International Journal of Modern Engineering Research (IJMER), Vol.2, Issue.4, pp.2919-2921, 2012.

[10]. P. Carvalheira<sup>1</sup>, and P. Gonçalves, FEA of Two Engine Pistons Made of Aluminium Cast Alloy A390 and Ductile Iron 65-45-12 Under Service Conditions, 5thInternational Conference on Mechanics and Materials in Design Porto-Portugal, 24-26, pp .1-21, 2006.