Modeling & Analysis of a 100cc I.C. Engine Piston

Sudhanshu Maurya[1], Er. Akhil Vikram Yadav[2], Er. Anurag Singh[3]

[1]M. Tech Student, Mechanical Engineering, IET Dr. R.M.L Avadh University, Ayodhya, India
[2]Assistant Professor, Mechanical Engineering Dept., IET Dr. R.M.L Avadh University, Ayodhya, India
[3]Assistant Professor, Mechanical Engineering, IET Dr. R.M.L Avadh University, Ayodhya, India

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Abstract - *This present work describes the stress distribution of two different aluminum alloys piston by using finite element method (FEM).Recent advancement of technology leads to complex decision in the Engineering field. Thus this paper entails the design and analysis of an IC engine piston using different size of topland thickness of aluminum materials that are competitive in market. Piston plays a main role in energy conversation. Failure of piston due to various thermal and mechanical stresses is common and so expensive to replace. The specifications used for this work is related to four stroke single cylinder engine of 100cc motorcycle. Design of the piston is carried out using SOLIDWORKS software, thermal and stress analysis is performed using Finite Element Analysis (FEA).The best size for topland thickness of aluminum alloy material is selected based on thermal and stress analysis results. The analysis results are used to optimize piston geometry of best aluminum alloy.*

Key Words: Piston, Solid works, thermal, stress analysis.

1. INTRODUCTION

A heat engine is a device which transforms the chemical energy of a fuel into thermal energy and uses this energy to produce mechanical work. It is classified into two types-

- External combustion engine
- Internal combustion engine

The internal combustion engines (briefly written as I. C. engines) are those engines in which the combustion of fuel takes place inside the engine cylinder. The I.C. engines use either petrol or diesel as their fuel. In petrol engines (also called spark ignition engines or S.I engines), the correct proportion of air and petrol is mixed in the carburetor and fed to engine cylinder where it is ignited by means of a spark produced at the spark plug. In diesel engines (also called compression ignition engines or C.I engines), only air is supplied to the engine cylinder during suction stroke and it is compressed to a very high pressure, thereby raising its temperature from 600°C to 1000°C. The desired quantity of fuel (diesel) is now injected into the engine cylinder in the form of a very fine spray and gets ignited when comes in contact with the hot air.

Piston is an important component of reciprocating engine. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, the purpose of piston is to transfer force from expanding gases in the cylinder to the crankshaft via a piston rod and/or connecting rod. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall. Piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston, such as piston side wear, piston head cracks and so on. Piston in an IC engine should possess characteristics such as strength to resist gas pressure, minimum weight, reciprocate with minimum noise, seal the gas from top and oil from the bottom, disperse the heat generated during combustion, and have good resistance to distortion under heavy forces and high temperatures.

2. MATERIALS & METHODS

For analysis of the connecting rod, previous study models and data with some practical information is taken into consideration.

2.1 INPUT PARAMETERS

The connecting rod model which is used for analysis is of a 100cc commercial motorbike (Bajaj Discover). Measurements for which were taken practically with the help of a Caliper Scale. The engine specifications of Hero Honda CD Deluxe 100cc are below in the table.

Table - 1 Specifications of Hero Honda CD Deluxe.

Specification	Value
Engine type	4 stroke
Compression Ratio	9:1
Displacement	97.2 cc
Cylinders	1
Max. Power	6.15 kW @ 8000 rpm
Max. torque	8.05 Nm @ 5000 rpm
Bore	50 mm
Stroke	49.5 mm
Valves per cylinder	2
Fuel delivery system	Carburetor
Fuel type	Petrol

Ignition	Digital CDI
Spark Plugs	1
Cooling system	Air cooled
No. of gears	4
Gear box type	Manual
Transmission type	Chain drive
Clutch	Wet multiplate

Fig -1 Actual photograph of Hero Honda CD Deluxe 100cc piston.

Table -2: Dimensions of the connecting rod used for analysis.

Dimension	Size(mm)
Cylinder bore	50
Thickness of the piston head	2.5
Radial thickness of ring	1.710
Axial thickness of ring	2.183
Width of top land	8.03
Width of other land	2.18
Maximum thickness of barrel	8.575
Length of the skirt	44.50
Piston pin diameter	18.34

The material for piston is mostly steel for production engines but now it is generally made of aluminum alloys for light weight and high impact absorbing ability and less costly or it can be made of titanium for lightness with strength at higher cost for high performance engines. Cast iron is also used but due to its heavy weight manufacturers often avoid it. The material used in this analysis is Aluminum Alloy 2024-T3, which is also the default material applied to model in ANSYS software.

The model of piston is designed in SOLIDWORKS 2018 software and is then exported to the ANSYS WORKBENCH19.2 software.

Fig - 2 Final extruded Isometric view of the connecting rod
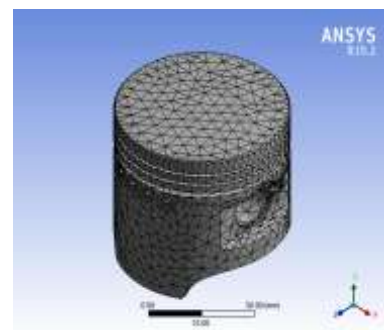
Fig - 3 Meshing of the model in ANSYS.
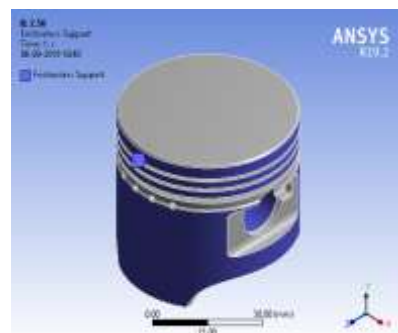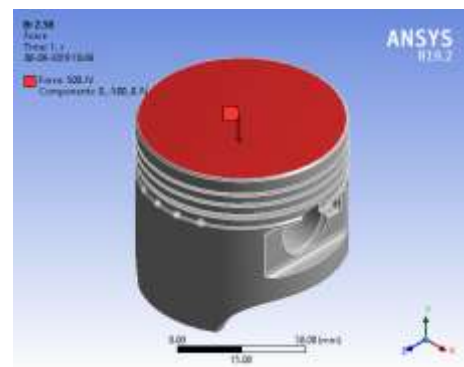

Fig - 4 Applying fixed support to the model.

Fig - 5 Applying load to the model.

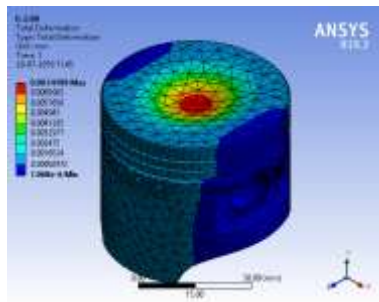**2.2 Analysis with topland thickness as 2.00mm with Al 2024-T3 material.**

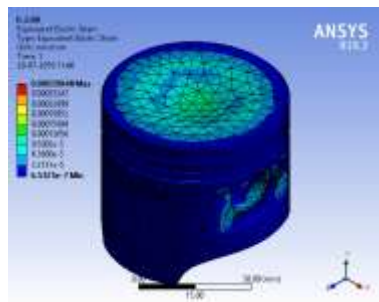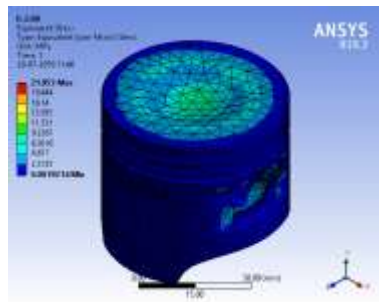**Fig - 6** Total Deformation.

Fig - 7 Equivalent Elastic Strain.

Fig - 8 Equivalent Stress.

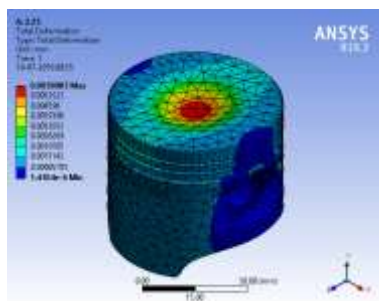**2.3 Analysis with topland thickness as 2.25mm with Al 2024-T3 material.**
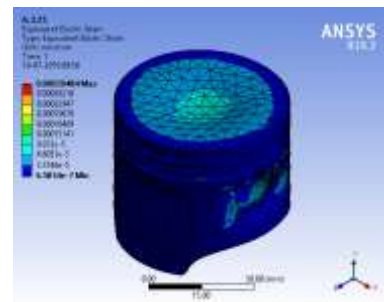

Fig - 9 Total Deformation.
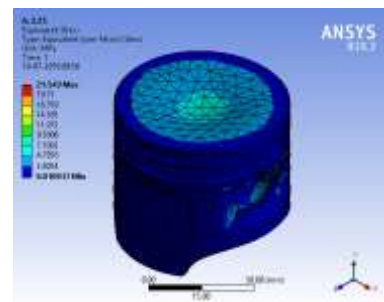

Fig. - 10 Equivalent Elastic Strain.

Fig - 11 Equivalent Stress.

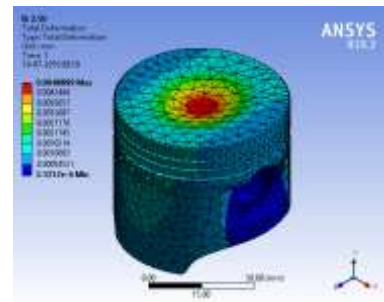**2.4 Analysis with topland thickness as 2.50mm with Al 2024-T3 material.**
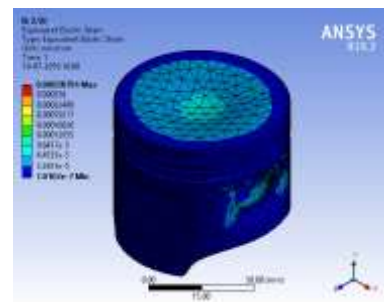

Fig - 12 Total Deformation.

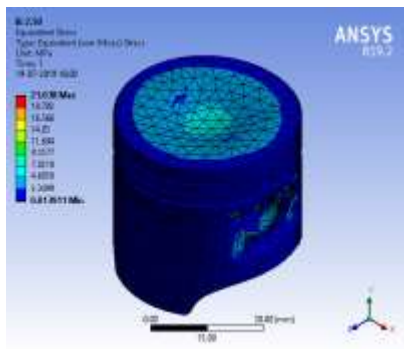**Fig - 13** Equivalent Elastic Strain.

Fig -14 Equivalent Stress.

2.5 Analysis with topland thickness as 2.75mm with Al 2024-T3 material.
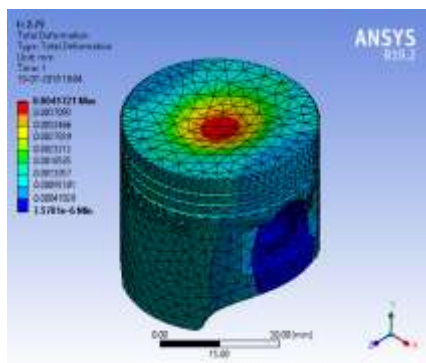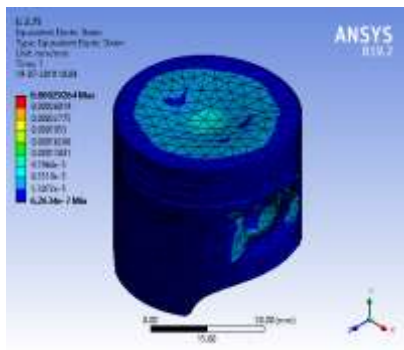

Fig - 15 Total Deformation.

Fig - 16 Equivalent Elastic Strain.
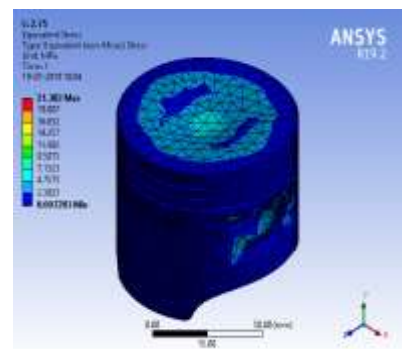

Fig - 17 Equivalent Stress.

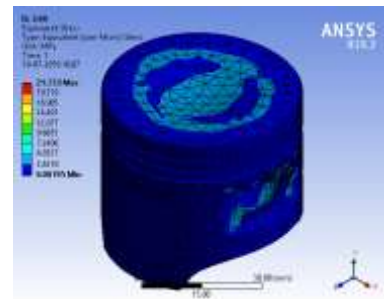**2.6 Analysis with topland thickness as 3.00mm with Al 2024-T3 material.**

Fig - 18 Total Deformation.
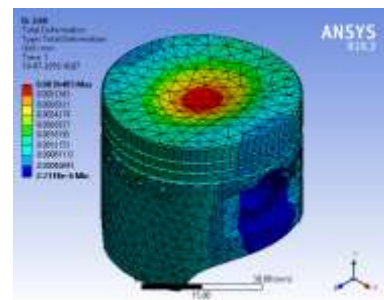

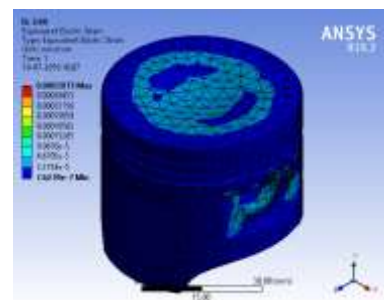**Fig - 19** Equivalent Elastic Strain.

Fig - 20 Equivalent Stress.

3. RESULT AND DISCUSSION: The side walls of the piston model were fixed whereas a load of 500N was applied on the top head, then Meshing of the model was performed. Different topland thickness model were applied one by one and solution was obtained for Total Deformation, Equivalent Elastic Strain and Equivalent Stress.

Table - 3. Statistics of Meshing used for analysis.

Parameters	Value
Physics Preference	Mechanical
Element Order	Quadratic
Smoothing	High
Nodes	24336
Elements	12944

Table - 4. Comparison table of all the applied topland thickness.

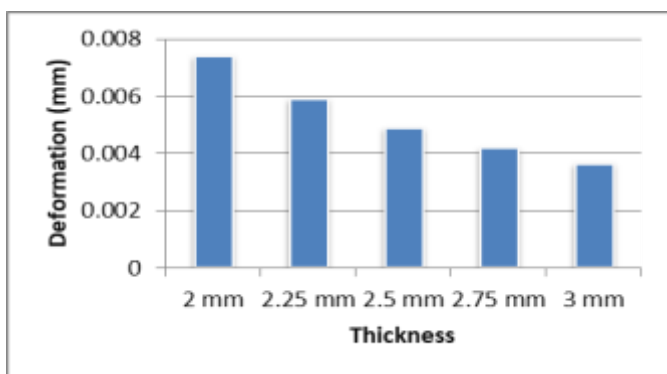| Topland thickness (mm)	Total Deformation (mm)	Max. Equivalent Elastic Strain (mm/mm)	Max. Equivalent Stress (MPa)
2.00	0.0074109	0.000295	21.953
2.25	0.0059087	0.000294	21.543
2.50	0.0048899	0.000287	21.038
2.75	0.0041721	0.000292	21.382
3.00	0.0036405	0.000297	21.733

For a better understanding of the differences in results, graphs are given below with comparison of parameters of different topland thickness:

Graph – 1 Comparison of Total Deformation of different topland thickness of piston.
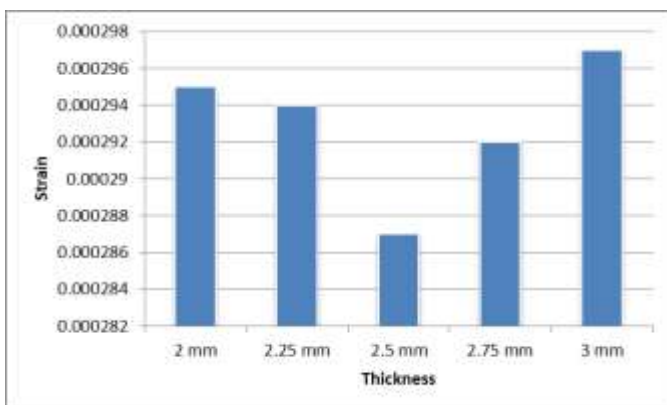
Graph - 2 Comparison of Max. Equivalent Elastic Strain of different topland thickness of piston.

Graph - 3 Comparison of Max. Equivalent stress of different topland thickness of piston.

3. CONCLUSIONS

This research project analyzed the stress, strain and deformation that piston with different topland thickness offers. The piston which is made of aluminum alloy chosen for this project belongs to Hero Honda CD Deluxe 100cc bike. First, the piston model was made with SOLIDWORKS 2018 software. Load analysis was performed based on the input data in ANSYS WORKBENCH 19.2. The results obtained after performing the analysis shows the difference in the structural behavior of the piston. It is concluded that topland thickness with 2.50mm shows least strain and stress on same static load condition. But in the case of total deformation its gradually decreases with increase in the topland thickness of the piston.

Scope for Future Work: Due to limitations of computer processing hardware, a very high setting of mesh could not be obtained. Also, because of the same reason explicit dynamic analysis could not be performed which could have shown a more close real to life analysis of the piston. So, for future work, a higher mesh setting can be applied for analysis and explicit dynamic analysis can also be performed.

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