International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
ETEDM - 2019 Conference Proceedings

Finite Element Analysis and Optimization of Piston Head for Automotive Vehicle

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***Abstract*:- In this paper we have performed design optimization of piston by using global sensitivity study along with finite element analysis through ANSYS. First a piston has been modeled and then finite element analysis has been performed to know about the structural and thermal loading effects. Then design optimization is performed to get the optimum mass by determining the optimum value of crown thickness and skirt length of the piston by limiting various conditions like maximum temperature, maximum principle stress, von misses stress and maximum strain energy.**

INTRODUCTION

Piston is one of the most vital component of I.C engine. Piston is contained by the engine cylinder. Its function is to transfer the force from the expanding gases is the cylinder to the crankshaft through connecting rod. Its service requires great attention. The material of the piston is chosen according to its strength, wear properties, density and thermal expansion properties. Hotter engines require more stable alloys to maintain close tolerances without scuffing. Many pistons used to be made from hypoeutectic aluminum alloys. Now days we see hypereutectic alloys (Carleyet).

The modeling of piston is done using ANSYS software according to the environmental and structural conditions. Then the modeled was imported to ANSYS Mechanical module of ANSYS software to perform Finite Element Analysis (FEA) to know about the structural and thermal loading effects. Then the design optimization is carried out to have optimum mass of the piston by limiting various conditions like maximum temperature, maximum principle stress, von misses stress and maximum strain energy.

Graphs have been obtained for each parameter after global sensitivity study and equations are developed for each of the graph. Using these equations the optimum value of crown thickness has been obtained.

MATERIAL CHARACTERISTIC

The materials chosen for this analysis is alloy of Aluminum-AL-390 (Dmitri Kopeliovich, 2012; and Understanding Cold Finished Aluminum Alloys). Al-390 is a medium high strength heat treatable alloy. Good flow characteristics provided by high silicon content leads to both structural and automotive applications.

METHODOLOGY

1. DESIGN

To perform thermal analysis study, piston was designed in CATIA V5 software. Details of the engine and piston dimensions.

Item	Specification
Make	Krloskar engine
Type of engine	Four stroke, single cylinder, water cooled,constant speed engine
Bore, mm	80
Stroke, mm	110
Compression ratio	16.5:1
Rated power	3.7kw at 1500rpm
Type of Fuel	Diesel
Fuel injection pressure, bar	200
No.of.nozzle holes	3
Nozzle diameter	0.26mm
Inlet valve open (IVO)	15Btdc
Inlet valve closes(IVC)	45Abdc
Exhaust valve open(EVO)	45Bbdc
Exhaust valve closes(EVC)	10Atdc

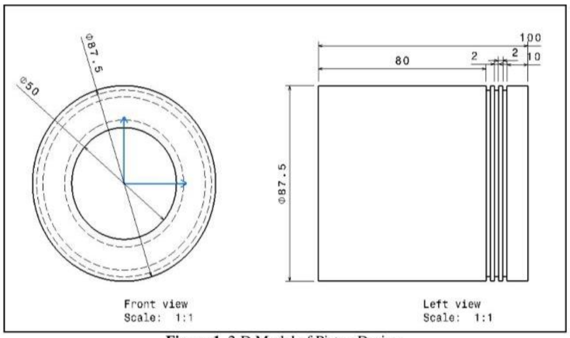


Figure 1. 2-D Model of Piston Design.

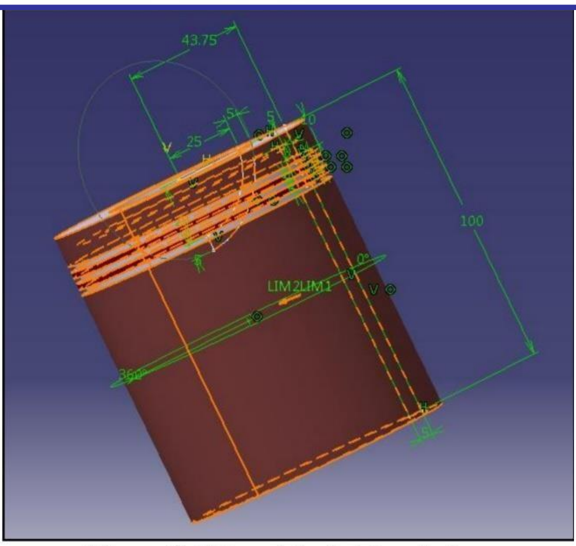


Figure 2. 3D model of piston design.

TYPES OF MODEL PISTON

1. Center Tapered

3. Center crown

4. Center ball crown

Are designed using CATIA V5 Software.

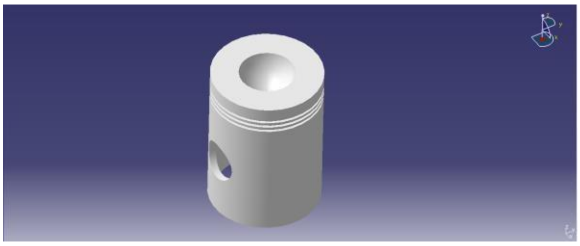


Fig 3.0

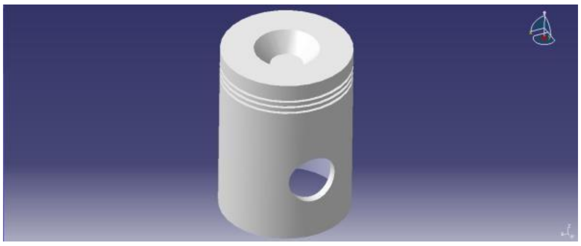


Fig 3.1

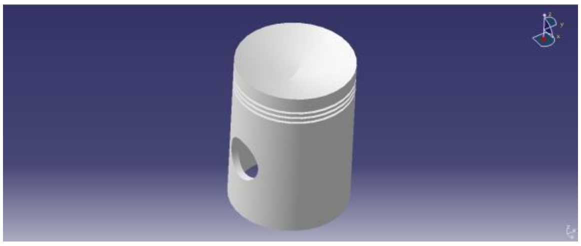


Fig 3.2

The model was imported to ANSYS software, where after defining the Boundary conditions and mesh models are given below.

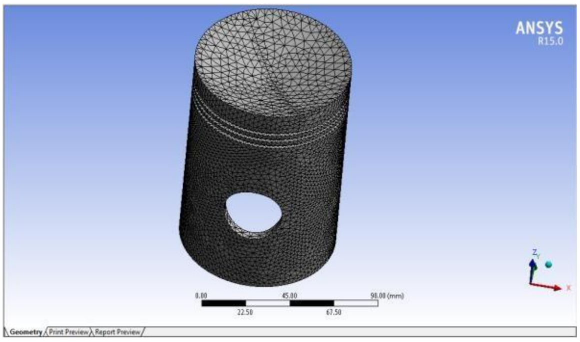


Fig 3.3

CENTER CROWN

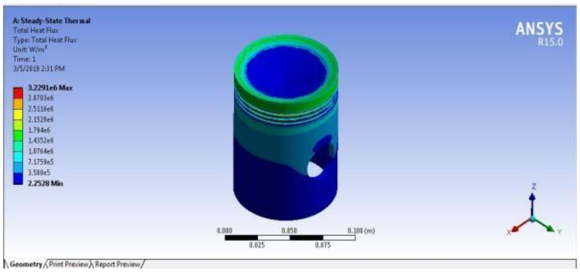


Fig 4.0

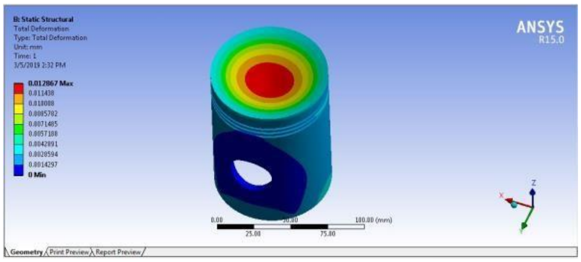


Fig 4.1

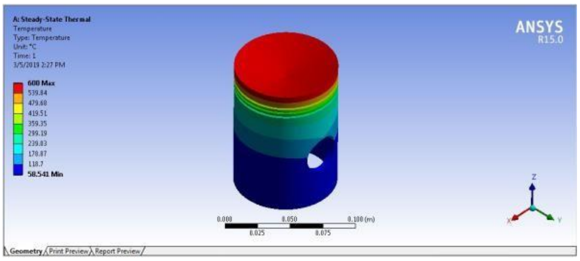


Fig 4.2

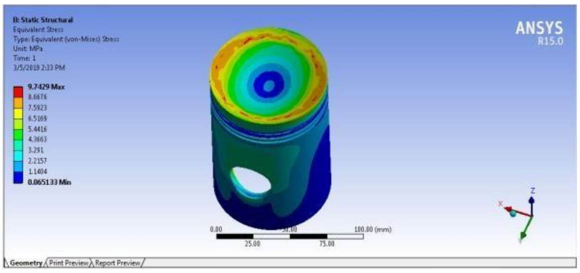


Fig 4.3

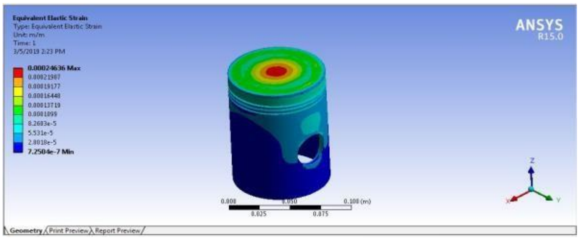


Fig 4.4

FLAT ENGINE HEAD:

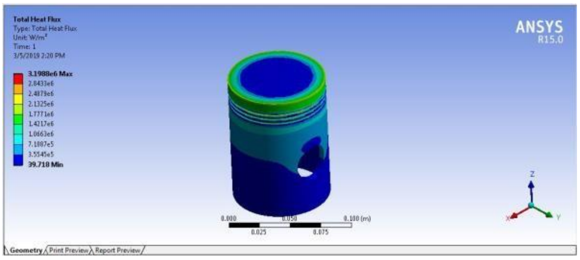


Fig 5.0

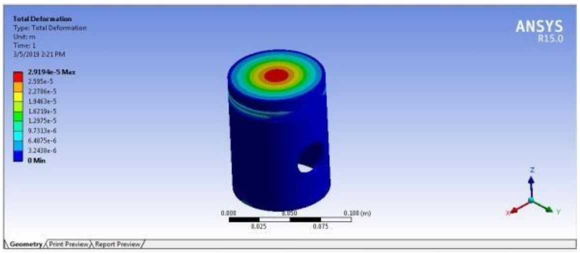


Fig 5.1

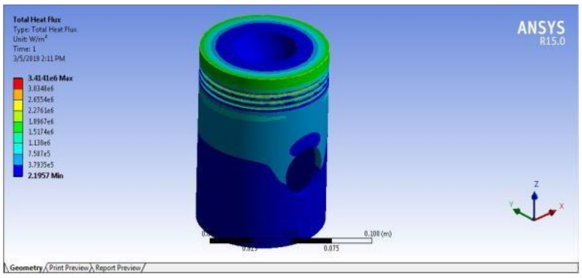


Fig 5.2

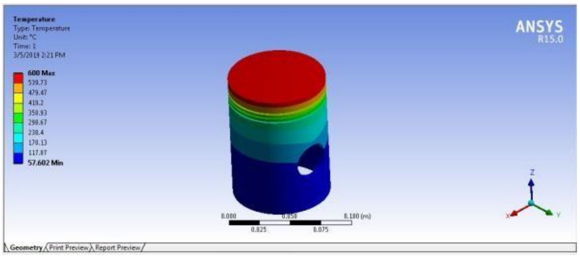


Fig 5.3

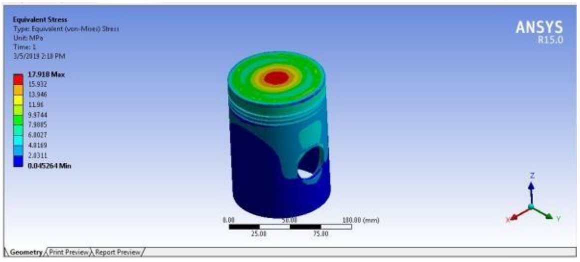


Fig 5.4

NORMAL PISTON BALL CROWN:

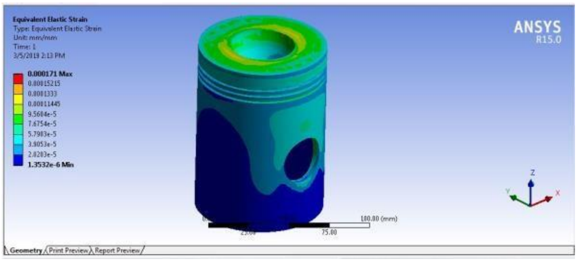


Fig 6.0

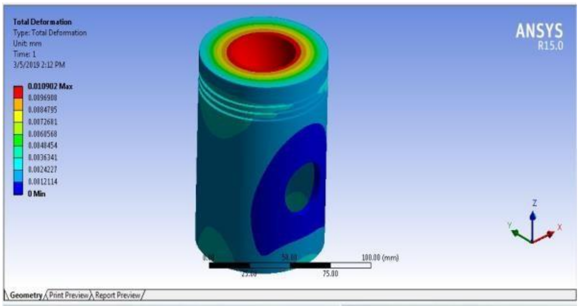


Fig6.1

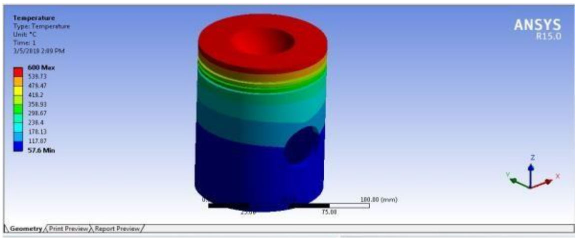


Fig 6.2

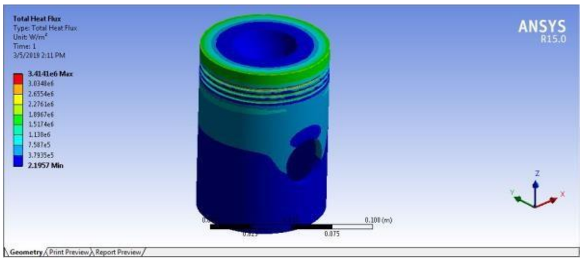


Fig 6.3

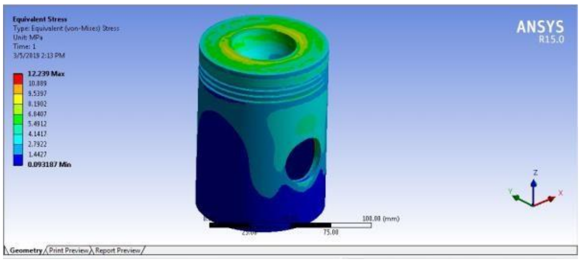


Fig 6.4

TAPERED CENTER CROWN

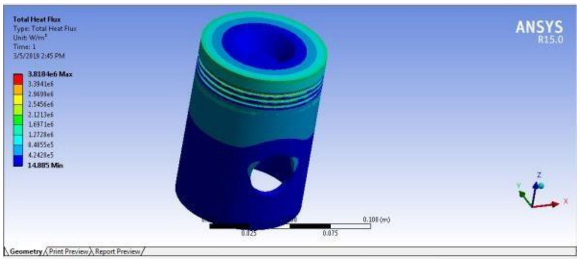


Fig 7.0

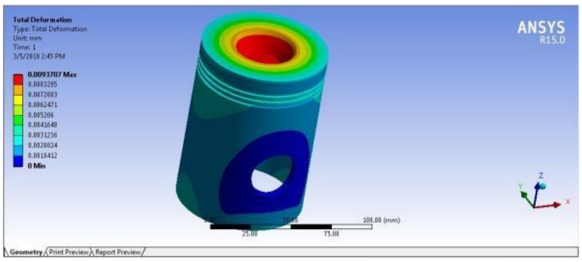


Fig 7.1

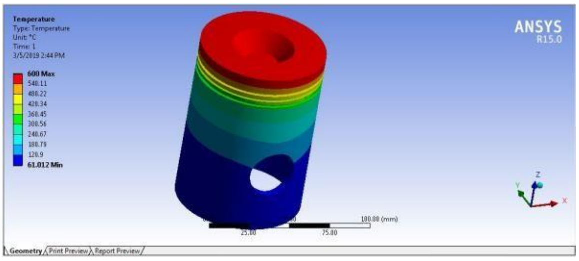
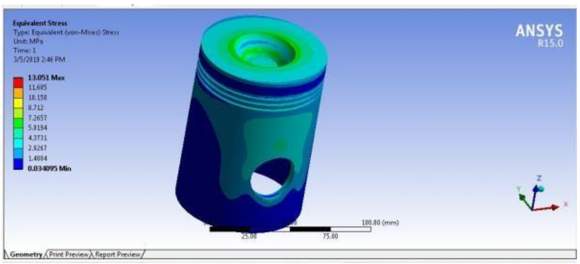


Fig 7.2



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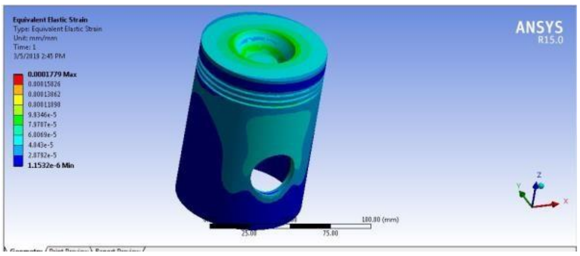
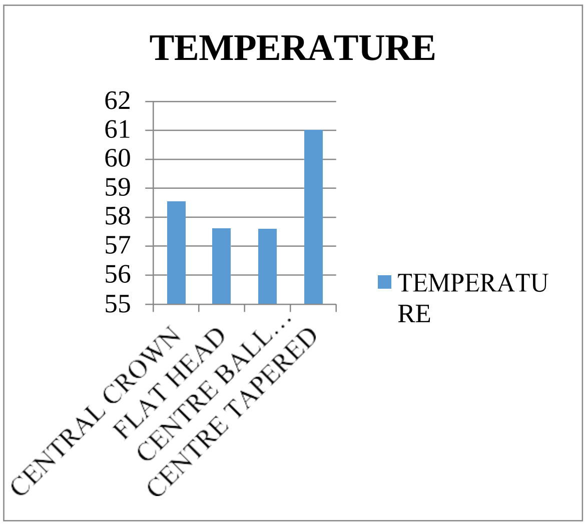


RESULTS

Types	Temperature
Center crown	58.541^{0}C
Flat Head	57.608^{0}C
Center ball crown	57.6^{0}C
Center tapered	61.012^{0}C

TAB: 1

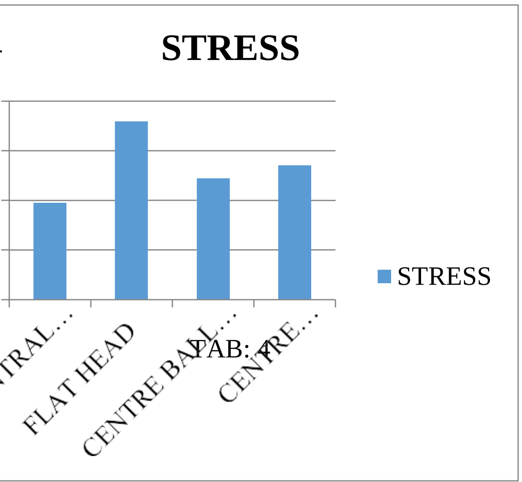


TAB: 2

Types	Stress(MPA)
center crown	9.7429
flat head	17.918
center ball crown	12.239
center tapered	13.51

TAB: 3

Fig 7.4



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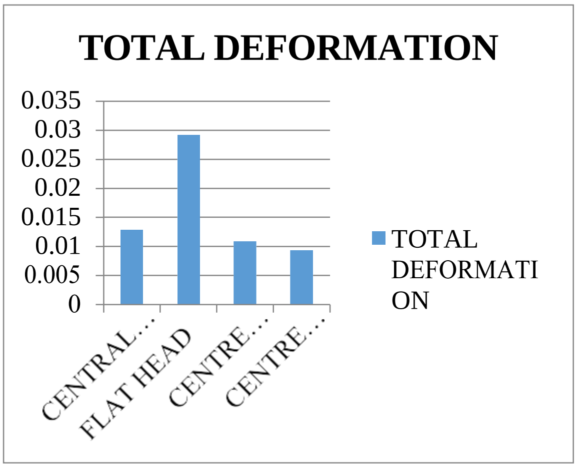

TAB: 5

ADVANTAGES

- It has maximum heat resistance.
- It has high efficiency.
- It produce less stress compare to other shapes.

CONCLUSION

From the analysis of the piston optimization is done for

- The various shape engine piston head with flat piston head, full crown model, centre crown ball model and centre tapered piston head models are modeled
- In CATIA V5 software in Ansys – Workbench software is used to find the maximum stress and temperature distribution of the piston in engine operating conditions the centre full

Types	Total deformation(mm)
center crown	0.012867
flat head	0.029194
center ball crown	0.010902
center tapered	0.0093707

- TAB: 6
- crown models are produce the less stress compare to the all other shapes and temperature also produce The maximum heat resistance in the surfaces
- From this shape optimization center full crown model is the optimized piston design.

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