Design and Optimization of Piston and Determination of its Thermal Stresses using Unigraphicsand Ansys

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Abstract

The main objective of this paper is to analyze the stress distribution and deflections of piston at the real engine condition during combustion process. The piston is designed according to the forces acting on it from the gases, which are released during the combustion. The piston head acts as a particular case and hence the thickness of the piston is optimized in order to reduce the weight of the piston by design and optimization method.

At first, the piston is designed according to the specifications. After designing, the model is subjected to certain conditions. According to the conditions we have checked the stresses acting on it and checked the failures of the model. The optimization is carried out to reduce the stress concentration on the upper end of the piston i.e. (piston head/crown). With using computer aided design (CAD), UNI-GRAPHICS software the structural model of a piston will be developed. Furthermore, the finite element analysis is performed by using ANSYS software.

Keywords: *Optimization, Design, Vonmisses and Thermal stresses, Unigraphics, ANSYS*

INTRODUCTION

Engine pistons are one of the most complex components among all automotive or other industry field components. There are significant research works proposing, for engine pistons designs, new geometries, materials and manufacturing techniques, and this evolution has undergone with a continuous improvement over the last decades and required thorough examination of the smallest details. The piston damage mechanisms have different origins and are mainly wearing, temperature, and fatigue related. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role. In the present work, thermal and structural analysis of a two stroke petrol engine piston has performed numerically by thermal load conditions, i.e., convections and heat fluxes for temperature and thermal stress values. The geometry of the model is unchanged throughout the analysis and the results so obtained are consistent with expectations, in the sense that the temperature and thermal stresses increase with applied heat flux and decrease with applied heat transfer coefficients. The material used for piston at one time was cast iron, because of good wearing qualities. As the technology developed, aluminum alloy replaced cast iron as piston material due to its light weight, high thermal conductivity, easier to machine during production and attractive in appearance. The major drawback of the aluminum piston is its softness and is costly Design Analysis and Optimization of Piston using CATIA and ANSYS by Ch.Venkata Rajam1, P.V.K.Murthy2*, M.V.S.Murali Krishna3, G.M.Prasada Rao in this paper he says that the piston is reduced by 24% the thickness of the barrel is reduced by 31%, width of the other ring land of the piston is reduces by 25%, vonmisses stress is increased by 16% and deflection such increased after optimization .but all at The parameters are within the conclusion.[1]. Design Analysis and Optimization of Piston for 4-Stroke Petrol Engine byV.Jose ananth vino, Dr. J. Hameed Hussain says that by designing the piston using solid works software and analysis was done on ANSYS software the volume of the piston is reduced by 20%, vonmisses stress by 24%, thickness of barrel is reduced by 30%width of the other ring land of the piston is reduced by 20%and also deflections is increased and the design is safe [2]. Design analysis and optimization of piston using CAE tools 1vaibhav v. mukkawar, 2abhishek d. bangale, 3nitin d. bhusale, 4ganesh m. surve he says that by considering the different materials like aluminum alloy and from that the results were taken like vonmisses stress ,deflections ,factor of safety ,weight reduction of the piston ,initially the CAE tools were taken and the analysis were taken from the analysis software, hence the design is safe and within the limits[3] Design Analysis and Optimization of Internal Combustion Engine Piston using CAE tool ANSYS Aditya Kumar Gupta 1 , Vinay Kumar Tripathi 2.in this paper he considered to optimized the piston in order to get the best results in vonmisses stress ,deflection, weight, for the this he is taking the piston specification according to the standards and specifications and drawing the using CAE tools and analyses is done using ASYS software[4].

Methodology

- Create 3D model of the existing piston using UG NX software.
- Perform thermal analysis on the existing piston using Ansys.
- Perform structural analysis on the existing piston by applying temperature distribution from the thermal analysis as body loads using Ansys.
- Optimize the existing piston to reduce the weight.
- Perform thermal analysis on the modified piston using Ansys.
- Perform structural analysis on the modified piston by applying temperature distribution from the thermal analysis as body loads using Ansys.
- Compare the weights and stresses and check if the modified piston is safe or not.

Results and Discussion

Dimensions of the Piston before optimization

Sno	Dimensions	Size in mm
1	Length of the piston(L)	152
2	Cylinder bore outside dia(d)	140
3	Thickness of the piston head	9.036
4	Radial thickness of the ring	5.24
5	Axial thickness	5
6	Width of the top load	10
7	Width of the other ring	4

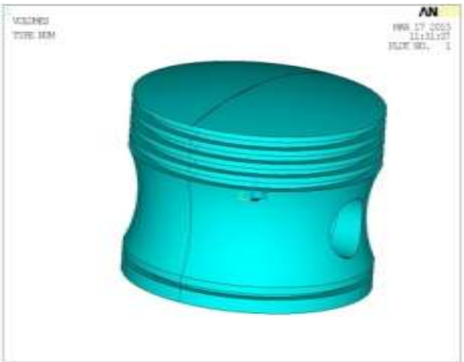


Fig-1. Piston 3D model isometric view

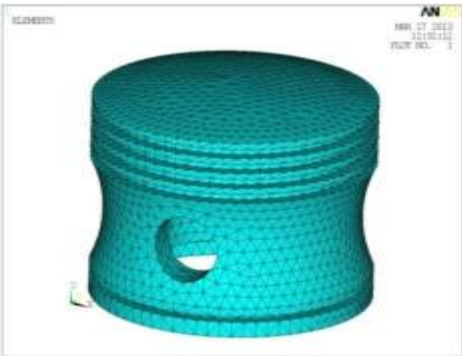
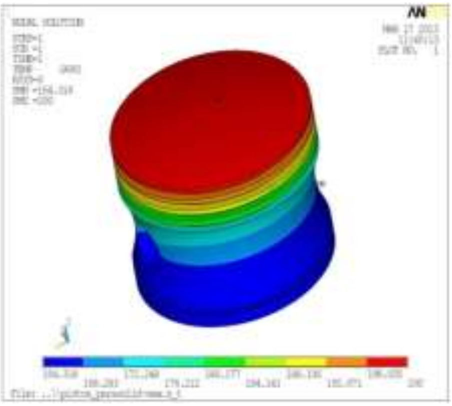
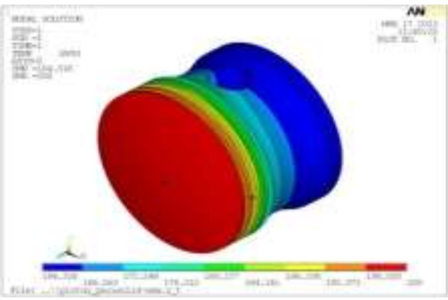


Fig2. Piston mesh model

TEMPERATURE RESULTS





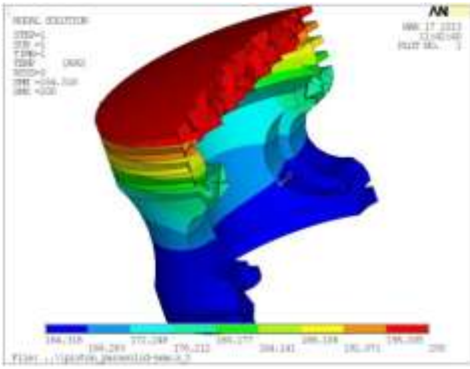


Fig3. Temperature distribution on Piston on front, rear side and along the thickness

DEFLECTION RESULTS

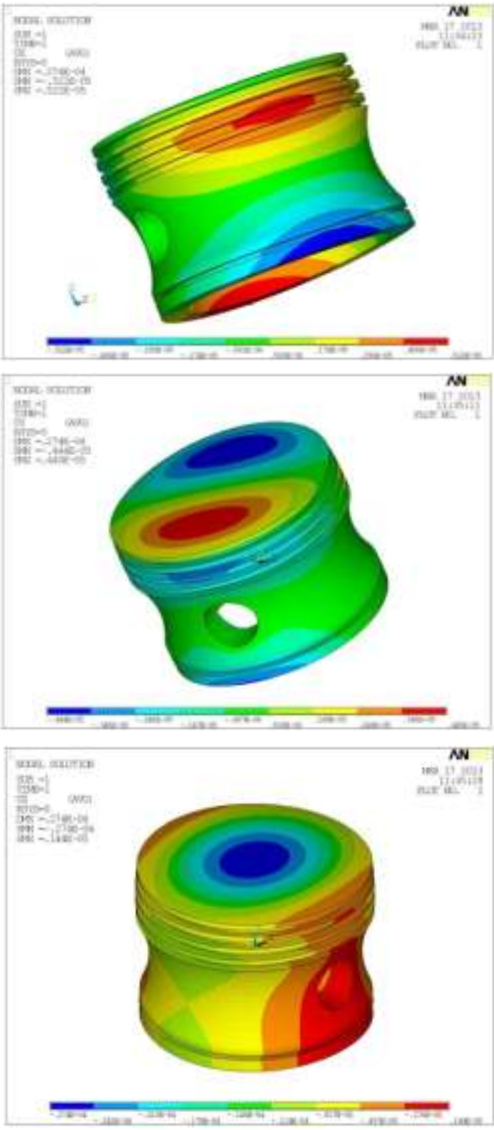


Fig-4 Deflection in X, Y and Z direction

STRESS RESULTS

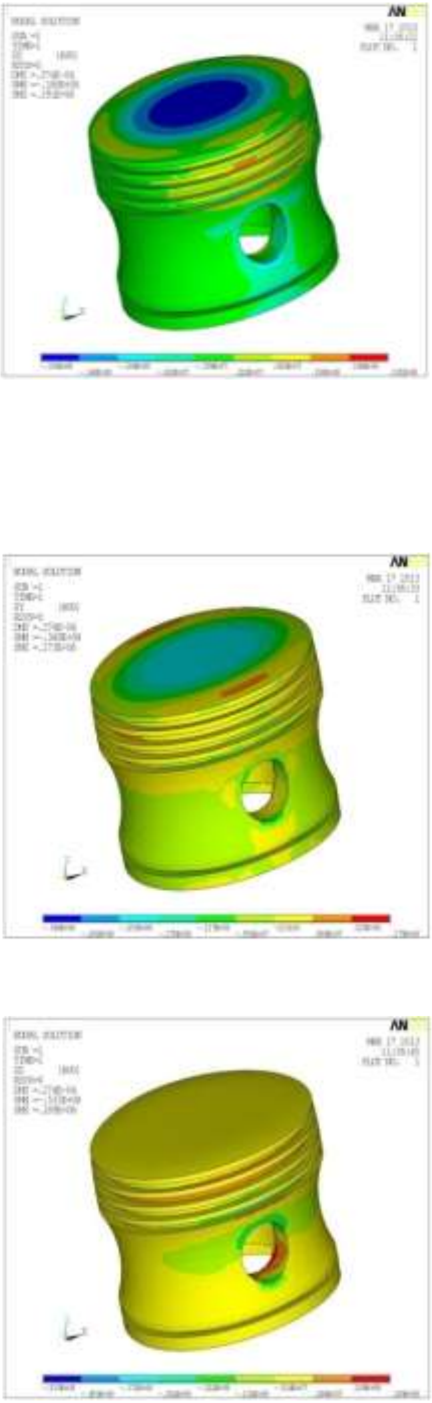


Fig-5.stress in X, Y and Z-direction

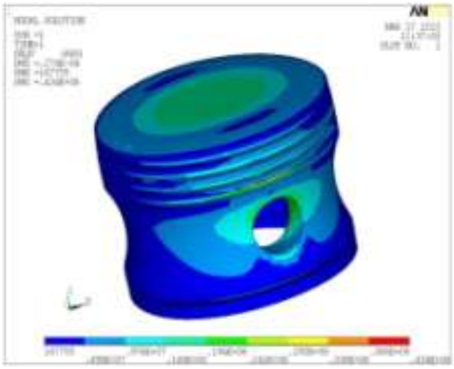


Fig-6 Von Misses stress on Piston

Dimensions of the Piston after Optimization

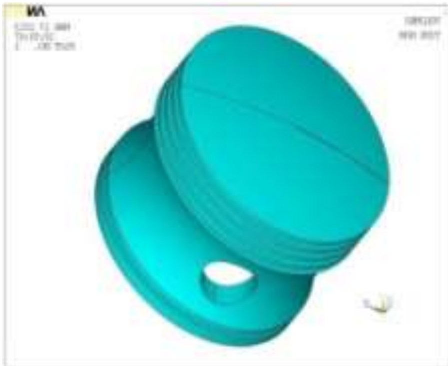


Fig-7 Modified piston 3D model

Modified mesh

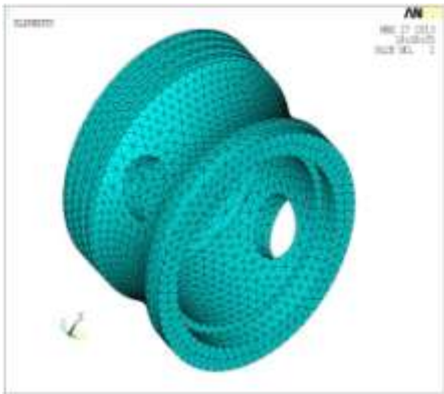
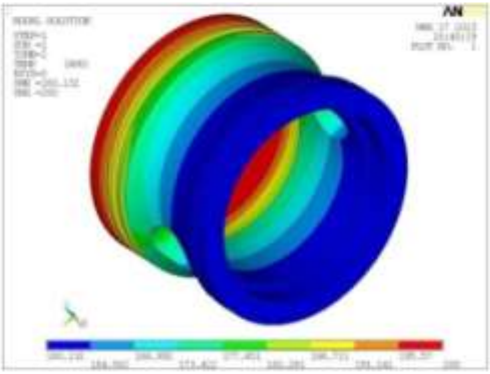


Fig-8 piston model

isometric

S.No	Dimensions	Before Optimization Size in mm	After Optimization Size in mm
1	Radial thickness of the ring (t1)	5.24 mm	3.46 mm
2	Axial thickness of the ring (t2)	5 mm	3.52 mm
3	Maximum Thickness of Barrel (t3)	14.34 mm	9.08 mm
4	Width of the top land (b1)	10.84 mm	9.36 mm
5	Width of other ring lands (b2)	4 mm	3.24 mm



TEMPERATURE RESULTS

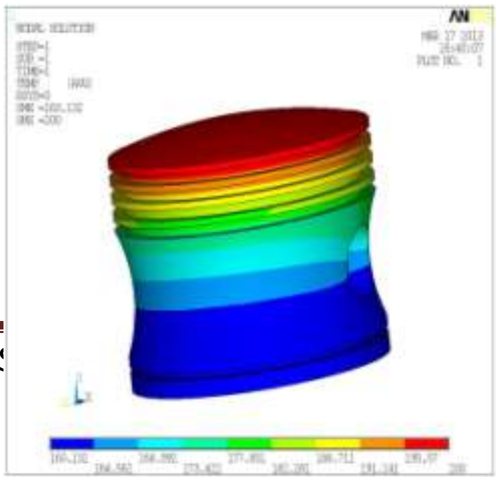


Fig-10. Temperature distribution on Modified Piston on the rear side

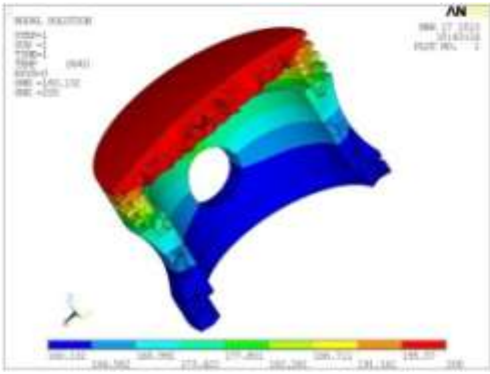
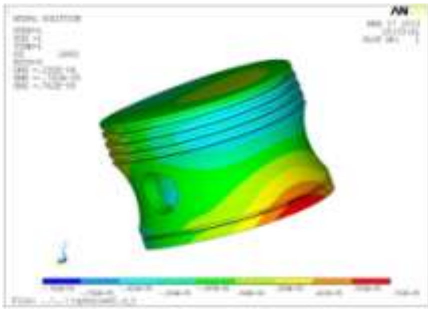
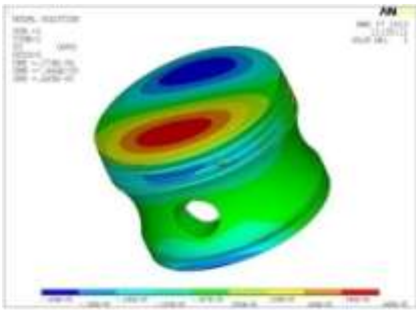


Fig-11. Temperature distribution on Modified Piston along the thickness

Deflection Results





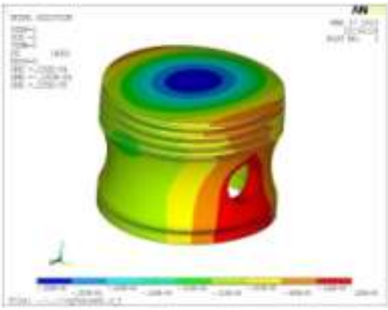
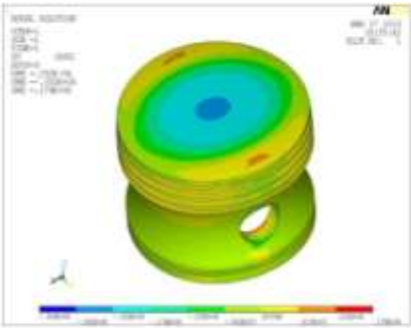
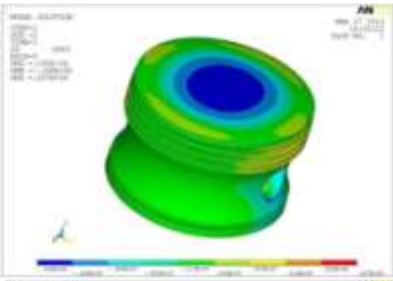


Fig-12 Deflection in X, Y and Z direction

STRESS RESULTS IN MODIFIED PISTON





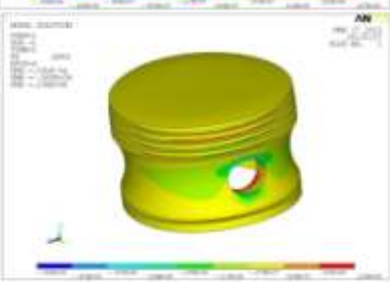


Fig-13 X and Y and Z-dir stress on Modified Piston

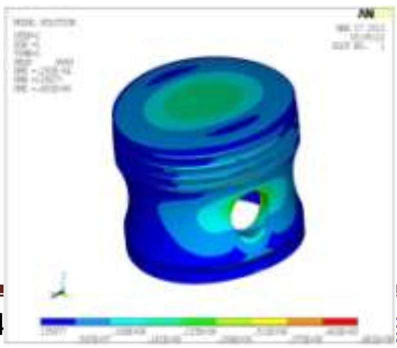


Fig-

14. VonMises stress on Modified Piston on front side

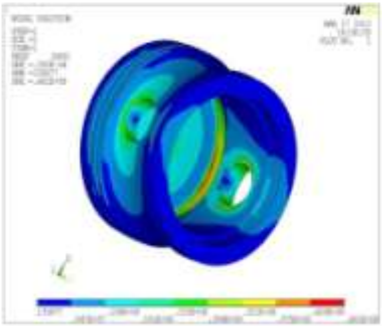


Fig-15VonMises stress on Modified Piston on rear side

Discussion

Design and optimization of piston brought out to compare maximum stress, deflection and von misses stress with the materials for this the UNIGRAPHICS software package and ANSYS has been used to analyze the optimized values of the piston.

Thus the optimized values results of the piston and its internal thermal stresses values also was calculated from the software package like UNIGRAPPHICS and ANSYS and the results were displayed in the below table

Conclusions

The present study can provide a useful design tool and improve the performance of piston. From the below Table we can say that all the values obtained from the analysis are less than their allowable values. Though we have observed a slight increase in deflection and stresses of the optimized model the factor of safety is well above 1.5.The weight of the piston is also reduced from 760Grams to 561 Grams. Hence the piston design is safe based on the strength and rigidity criteria. Comparing the different results obtained from analysis. It is concluded that Modified piston is the best Suitable for the present application.

	Original	Modified
Weight in grams	760	561
Total Deflection in (mm)	0.0274	0.0292
Vonmises Stress (Mpa_	43.4	48.1

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