RESEARCH ARTICLE OPEN ACCESS

Study on Stability of Honeycomb Structured Piston

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ABSTRACT

An avant- grade study is carried out to optimize inertial force in the piston of an internal combustion engine by optimizing design and weight of piston crown. Honey comb structures are considered than the cast iron and steel which were used on early slow speed engine to vice verse the speed of the engine. The geometrical model and analysis of piston was developed using CATIA-V5 by considering generative structural analysis.

***Keywords* -** Honey Comb Structure, IC Engine, Modeling, Piston Head, Structural Analysis

I. INTRODUCTION

Piston is the reciprocating part of the engine. Pressure force on piston is high during power stroke after combustion. In an engine, its purpose is to transfer force exerted by combusted expanding gas in the cylinder to the crankshaft via a piston rod. As Inertial forces are involved with reciprocating parts Honeycomb structures are natural or man-made structures that have the geometry of a honeycomb to allow the minimization of the amount of used material to reach minimal weight and minimal material cost. Innovations in aircraft design, motor vehicle technology and light-weight construction have formed the basis for the development of honeycomb structured panels. Their decisive advantage is low weight, combined with great structural strength. Because of their anti-shock properties, honeycomb structures are today used as shock-absorbent layers both in automobile construction and in sports gear and sport shoe production.

II. MODELING OF PISTON

The modeling of the piston is done using reverse engineering technique. Reverse Engineering can be defined as: 'Systematic evaluation of a product with the purpose of replication. This involves design of a new part, copy of an existing part, recovery of a damaged or broken part, improvement of model's geometry. Advantages of the technique include immediate feedback, data reduction, and direct generation of geometry of the final product.

Initially the used ambassador car's diesel variant piston is brought and measured for the dimensions. A solid 3D model is developed using the CATIA V5R20 software from obtained dimensions. The validity of the design is verified using designing of piston by mathematical formulas for designing piston.

Piston head

Thickness of crown is calculated from strength & heat dissipation consideration. The head is assumed to flat plate of uniform thickness fixed at edges 'L' subjected to a uniformly distributed load

Strength

$$t_h = \sqrt{\frac{3pD^2}{16\sigma_t}}$$

t_h = thickness of crown, mm
p = gas pressure, $N/_{mm^2}$
σ_t = tensile stress = 50-90 $N/_{mm^2}$ (Al alloys)

Heat dissipation

$$t_h = \frac{H}{12.56\,k(Tc - Te)}$$

$$H = C \times m \times H_{CV} \times BP$$

H = Heat flowing through piston head, kW
K = Heat conductivity factor, $\frac{W}{m\,C}$
Tc = Temp at center of piston head, ˚C
Te = Temp at end of piston head, ˚C
C = 0.05
(Portion of heat supplied to engine absorbed by piston)
H_{CV} = 45 x10^3 $\frac{kJ}{kg}$
m = Mass of fuel used, $\frac{kg}{B.P.\ s}$
B.P. = Brake Power

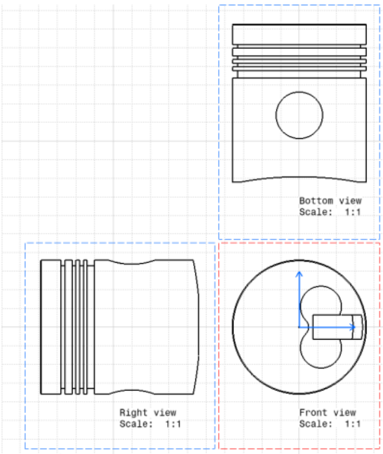


Figure 1. Base model

III. REDUCTION OF WEIGHT BY INTRODUCTION OF HONEYCOMB STRUCTURE

For effective performance of the engine, weight of piston has to be reduced. To satisfy the purpose the honeycomb structure is introduced into the piston. It is a well known that honeycomb structures use minimal material. Honey comb structures have very good load bearing capacity with minimum deformation when compared with other structures

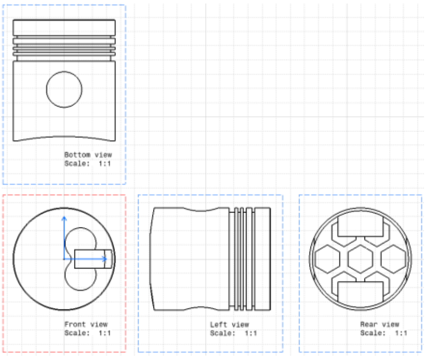


Figure 2. Developed Honeycomb Model

IV. COMPARISON OF VARIOUS DESIGN PARAMETERS

Physical Parameters:

Base Model:

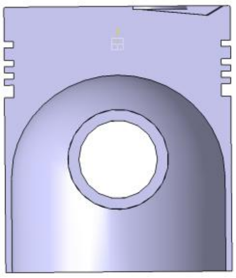


Figure 3.Base Model

Model I:

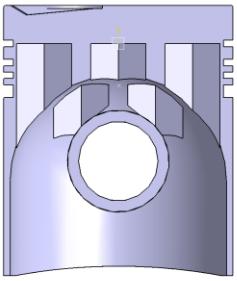
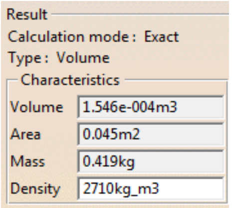
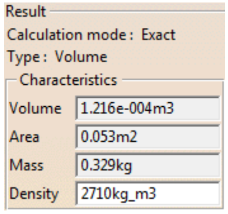


Figure 4. Model I



Result
Calculation mode : Exact
Type : Volume
Characteristics
Volume 1.546e-004m3
Area 0.045m2
Mass 0.419kg
Density 2710kg_m3

Figure 5. Property



Result
Calculation mode : Exact
Type : Volume
Characteristics
Volume 1.216e-004m3
Area 0.053m2
Mass 0.329kg
Density 2710kg_m3

Figure 6. Property I

Model I:

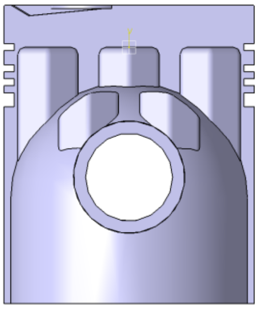


Figure 7. Model II

Model III:

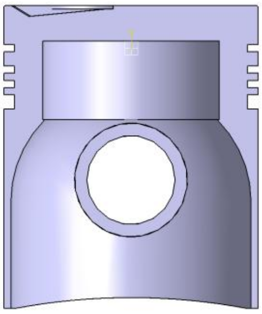
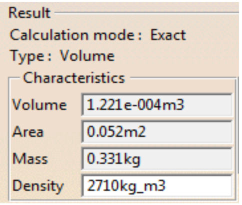
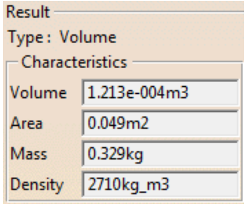


Figure 8. Model III



Result
Calculation mode : Exact
Type : Volume
Characteristics
Volume 1.221e-004m3
Area 0.052m2
Mass 0.331kg
Density 2710kg_m3

Figure 9. Property II



Result
Type : Volume
Characteristics
Volume 1.213e-004m3
Area 0.049m2
Mass 0.329kg
Density 2710kg_m3

Figure 10. Property III

Model IV:

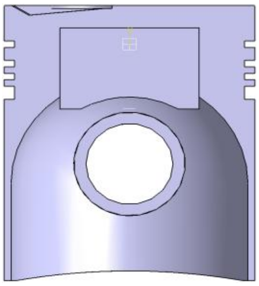


Figure 11. Model IV

Model V:

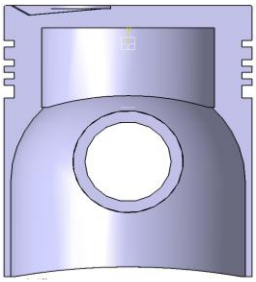
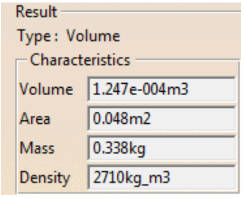
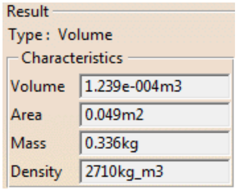


Figure 12. Model V



Result
Type : Volume
Characteristics
Volume 1.247e-004m3
Area 0.048m2
Mass 0.338kg
Density 2710kg_m3

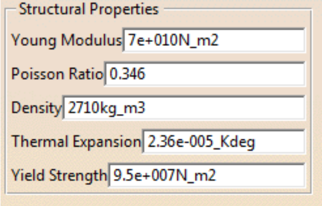
Figure 13. Property IV



Result
Type : Volume
Characteristics
Volume 1.239e-004m3
Area 0.049m2
Mass 0.336kg
Density 2710kg_m3

Figure14. Property V

Properties of aluminum:



Structural Properties
Young Modulus 7e+010N_m2
Poisson Ratio 0.346
Density 2710kg_m3
Thermal Expansion 2.36e-005_Kdeg
Yield Strength 9.5e+007N_m2

Figure15. Property of Aluminum

VON MISES STRESS

Base Model: (At 75bar Pressure) here the motion of piston is constrained by applying restrains and then a load of 75bar is applied to the top land or surface of piston. Below picture shows VON MISES STRESS values ranging from 30.4 MPa.

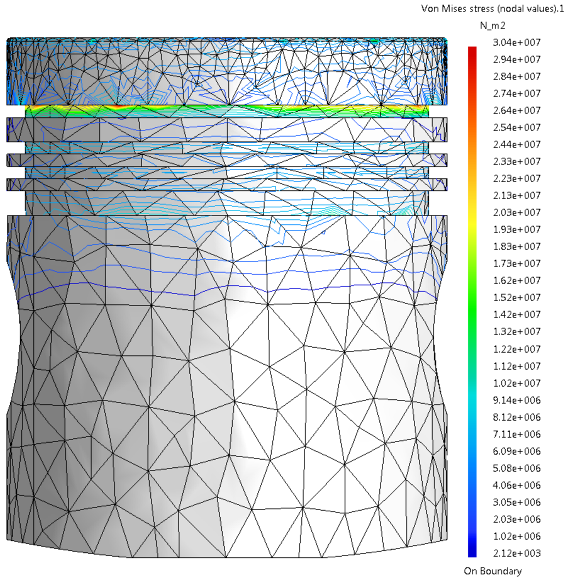


Figure16. Base model Von Mises Stress

Model I: (At 75 bar pressure) below picture shows stress values for model 1 with minimum modifications here stress ranges from 43 MPa.

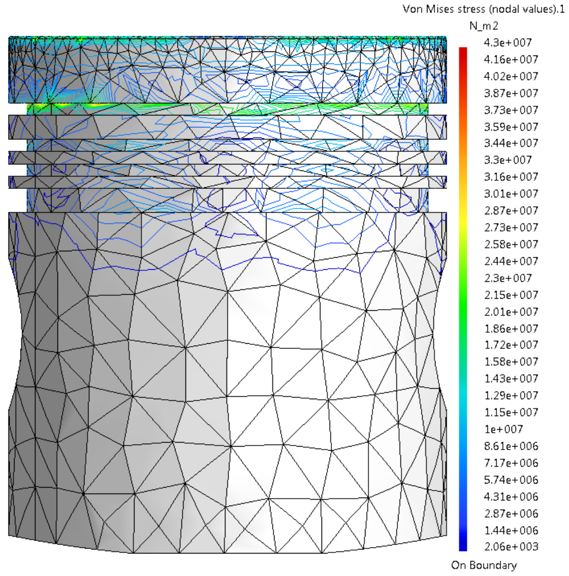


Figure17. Model I Von Mises Stress

Model II: (At 75 bar pressure) picture shown below displays stress values for model2 with drastic reduction weight and having comparable values of pressure ranging from 34.1 MPa.

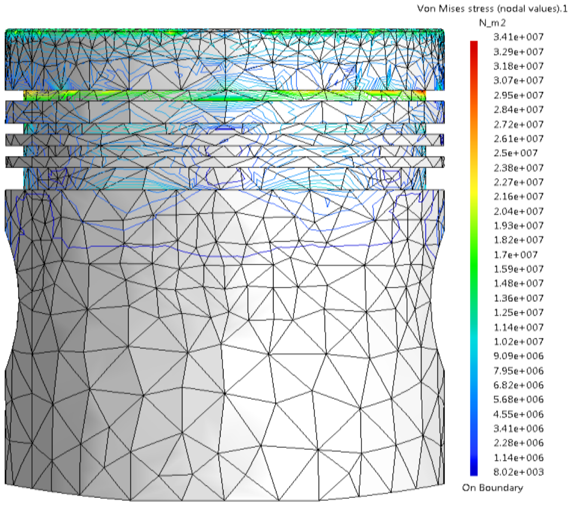


Figure18. Model II Von Mises Stress

Model III: (At 75 bar pressure) below picture shows stress values for model 1 with circular cavity. Here stress ranges from 46.1 MPa.

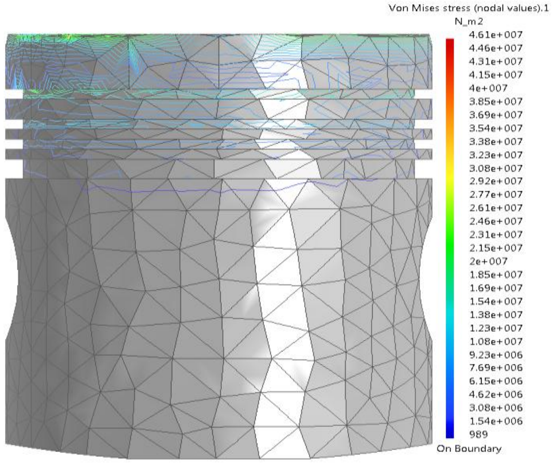


Figure19. Model II Von Mises Stress

Model IV: (At 75 bar pressure) below picture shows stress values for model 1 with elliptical cavity. Here stress ranges from 76 MPa.

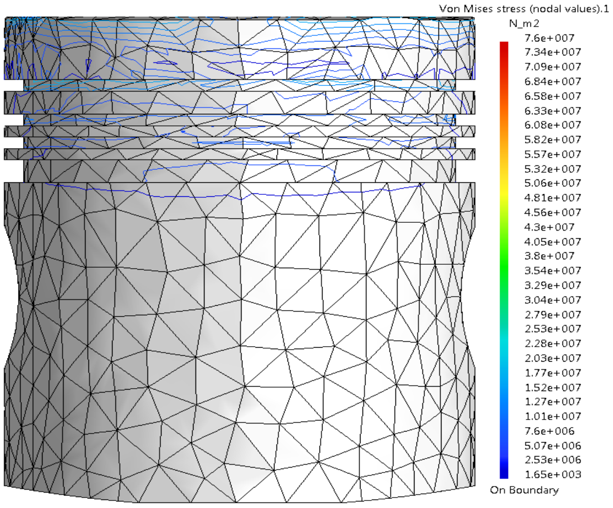


Figure20. Model IV Von Mises Stress

Model V: (At 75 bar pressure) below picture shows stress values for model 1 with square cavity. Here stress ranges from 59.6 MPa.

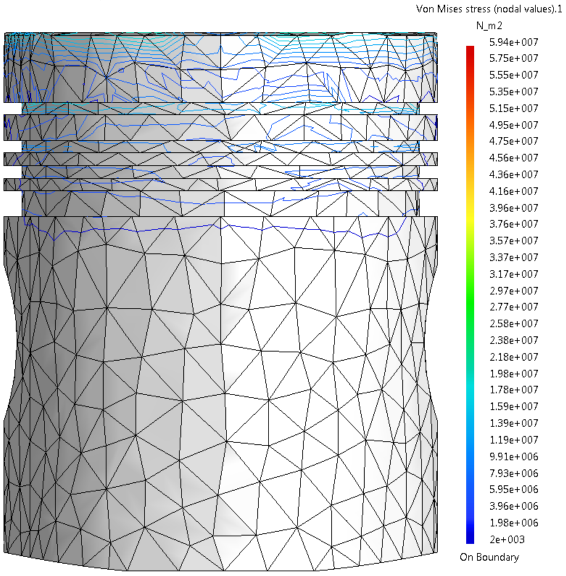


Figure21. Model V Von Mises Stress

DISPLACEMENT VALUES:

Base Model: (At 75 bar pressure) the picture shown below displays displacement values of base model these range from .00456 mm at the maximum.

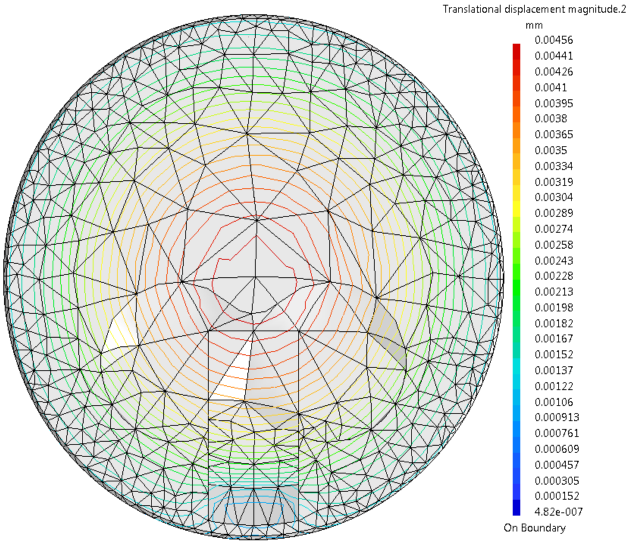


Figure22. Base model Displacement Values

Model I: (At 75 bar pressure) the picture shown below displays displacement values of base model these range from .009 mm at the maximum.

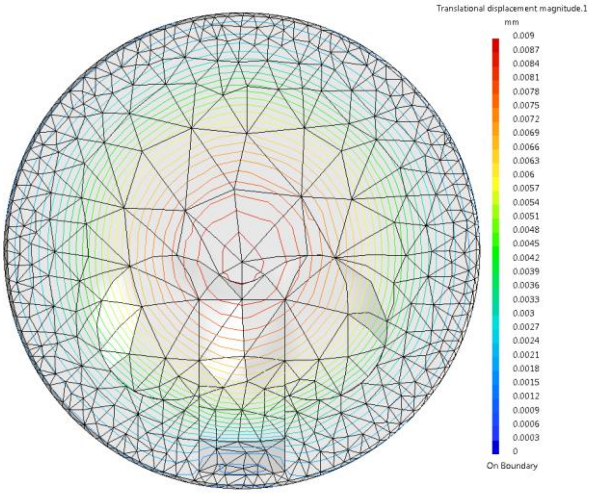


Figure23. Model I Displacement Values

Model II: (At 75 bar pressure) the picture shown below displays displacement values of base model these range from .009 mm at the maximum.

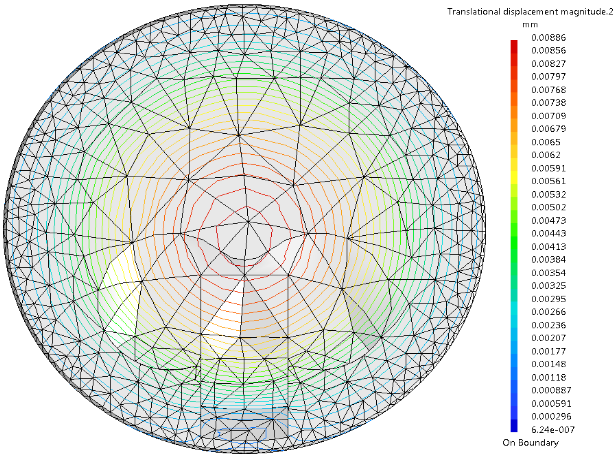


Figure24. Model II Displacement Values

Model III: (At 75 bar pressure) the picture shown below displays displacement values of base model these range from .009 mm at the maximum.

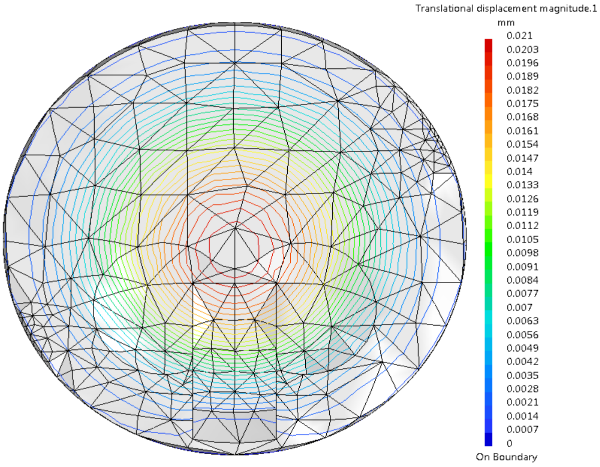


Figure25. Model III Displacement Values

Model IV: (At 75 bar pressure) the picture shown below displays displacement values of base model these range from .009 mm at the maximum.

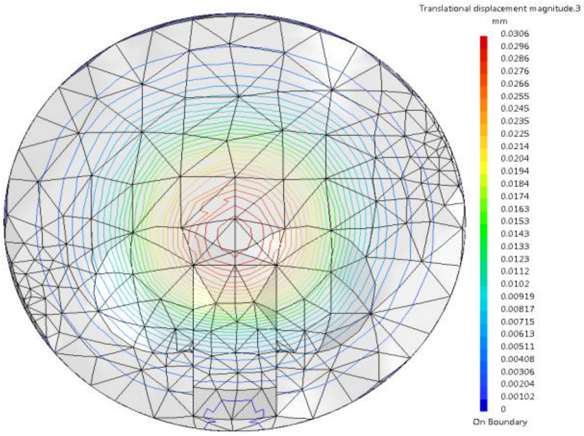


Figure26. Model IV Displacement Values

Model V: (At 75 bar pressure) the picture shown below displays displacement values of base model these range from .009 mm at the maximum.

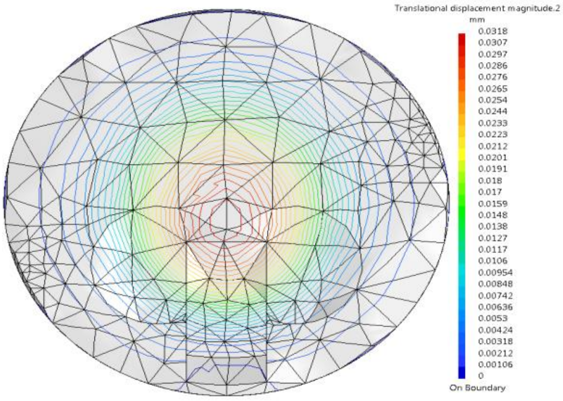


Figure27. Model V Displacement Values

V. RESULTS

Plot for Von Mises Stress in Models: Pressure load of 75 bar is applied on the model and the computed stress values are pictured in form of graph below.

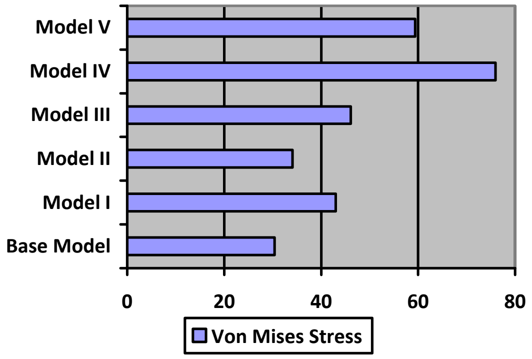


Figure28. Graphical Plot for Von Mises Stress

Graphical Plot for Displacement in Models: Pressure load of 75 bar is applied on the models and the computed displacement values are pictured in form of graph below.

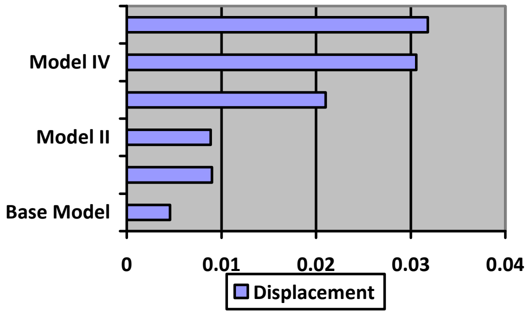


Figure29. Graphical Plot for Displacement Values

VI. CONCLUSION

The results arrived clearly indicates that honeycomb structure has good strength when compared with other structures. As the weight of piston is reduced the inertial force in piston is also reduced. For obtained weight reduction the inertial force is reduced by 21% in piston. As inertial force has indirect impact on mechanical efficiency of the engine by reducing it efficiency can be improved and hence better break power can be obtained

References

Journal Papers:

[1] Gudimetal. P and Gopinath C.V, *"Finite Element Analysis of Reverse Engineered Internal Combustion Engine Piston*" AIJSTPME *(2009) 2(4): 85-92.*

[2] R. Bhagat and Y. M. Jibhakate, "*Thermal Analysis and Optimization of I.C. Engine Piston using finite Element Method" ISSN: 2249-6645.*

[3] Piotr Szurgott and Tadeusz Niezgoda, *"CI engine as a case study of thermo mechanical FE analysis of the piston – piston rings – cylinder system*" journal of kones power train and transport, *vol. 19, no. 1 2012.*

Books:

[4] R.S.Khurmi and J.K.Guptha, *a text book of thermal engineering, 15thedition*, S.CHAND'S Publication.

[5] R.S.Khurmi and J.K.Guptha, *a text book of machine design*, 14thEdition, S.CHAND'S Publication.

Theses:

[6] Radoslav Plamenov Georgiev and Dr. Pedro Villanueva Roldan Dk, *"Design a four-cylinder Internal Combustion Engine"* Final Project Thesis, *Universidad Pública de Navarra, Pamplona*, 27.06.2011.

[7] Ilke Aydincak *"Investigation of Design and Analyses Principles of Honeycomb Structures"* Master of Science Project Thesis, *Middle East Technical University*, November 2007

Proceedings Papers:

[8] Shuoguo Zhao, *Design the Piston of Internal Combustion Engine by Pro\ENGEER*, 2nd *International Conference on Electronic & Mechanical Engineering and Information Technology (EMEIT-2012).*