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THERMAL AND STRESS DISTRIBUTION OF DIFFERENT I.C. ENGINE PISTON COMBUSTION CHAMBERS USING 3-D FINITE ELEMENT ANALYSIS METHOD

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ABSTRACT In this study, Work is carried out to find out the thermal and stress distribution on different Piston combustion chambers. In IC engine, Piston is one of the most important and complex part, Hence, it is important to maintain Piston in good condition in order to maintain the proper functioning of the engine.Piston mainly fails due to thermal as well as Mechanical stress. In order to find out proper thermal distribution as well as Mechanical stress four different Combustion Chambers are considered . In this study analysis is carried out on four different Piston head by using ANSYS (APDL11.0) Software and modeling is done with the heip of 3-D Proe Wild fire5.0 software. The different combustion chambers namely Shallow Depth Chamber, Hemispherical Chamber, Cylindrical Chamber and Toroidal Chamber of the four different vehicles Tata Indica CS, Tata 407 Truck, Mahindra Maximo and Tata Sumo Grande2.2L DICOR, are investigates. It is found that Toroidal Combustion Chamber- Piston showed better temperature as well as stress distribution.

KEYWORDS: DICOR, Combustion Chamber , Thermal Distribution, Stress Distribution.

I. INTRODUCTION

The piston head is one of the most complex parts in the engine and it endures high thermal and mechanical stress during its working cycles.The good combustion may be influenced by proper designing of the combustion chambers(**Ref;[7] Shuoguo Zhao**"Design the Piston ofInternal Combustion Engine by Pro\ENGINEER"; [5] **Shixiong Li , Jinlong Mao , Shumao Wang**, Cylinder Head FEM Analysis And ItsImprovement.).Piston may damage often mainly due to Temperature, Wear, Fatigue etc. It is necessary to analyse the structure , strength and reliability of this zone .In this work, a three dimensional (3D) model of the Piston head is built up by using Pro/Engineer Wildfire 5.0 and the 3D FEM analysis ANSYS (APDL) 11.0 of the SSR is carried out. The temperature distribution and stress distribution of the different piston head are carried out and to find out the best piston with optimum Thermal as well as Stress distribution.
In this Paper, describes the stress and Thermal distributions on different Piston heads of I.C engine combustion chambers using FEA software .The main objective of this Project work is to analyze the Thermal stress condition of the Piston at real engine working condition at combustion process. The paper describes about Thermal stress on the different regions on the Piston head from Top chamber portion to the bottom Skirt and how the Temperature and stress distributed in the various piston parts and also explains how the shape and structure in the piston design influenced in the combustion process in I.C engine. The FEA technique ANSYS (APDL11.0) is used to assaign different load condition to the Combustion chambers in accordance with real time engine working conditions. Piston 3-D model is modeled by using PROE-WILDFIRE 5.0 software with real time I.C engine piston dimensions especially from TATA commercial vehicles .Pre-Processing, Meshing and Post-Processing on the Piston Heads is done with the help of ANYS APDL11.0 software. Finally it comes to evident that Tata Sumo Grande 2.2L DICOR (Direct common Rail Engine Type) having Proper Temperature and Stress distribution,it having the proper piston head design.

II. PISTON STRUCTURE MODELING.

For Designing Piston model 3-D Modelling software PROE-WILDFIRE5.0 is used,it is the most commercially used 3-D modelling software available.It is more user friendly in Part Modelling as well as Engine Components designing.
Model Parameter Setting.ALUMINIUM ALLOY,with a Density of 2740 (kg/m^3) choosen as piston material

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Chemical Composition of Aluminium Alloy.

Material	Al	Si	Cu	Mg	Mn	Zn	Fe
AL Alloy	Balanced	11	4-5	0.4	0.5	1.5	1.3

Table:1; Chemical Properties of Aluminium Alloy

(**Ref: Vivek Solekar , Dr.L.N.Wankade**, Finite Element Analysis and Optimization of I.C. Engine Piston Using RADIOSS and Opti Struct)

Structural Properties of Alumnium Alloy.

Element Type	**Young's Modulus(E) (N/mm^2)**	**Poisson's Ratio,(μ)**	**Density(ρ) (Kg/m^3)**	**Thermal Conductivity(K)**	**Pressure (MPa)**	**Temperature (K)**
Axis Symmetric 4Node 75	**2E5**	**0.33**	**2740**	**134**	**1.5**	**850**

Table:2 ;Structural Properties of Aluminium Alloy

Modeling Parameters: The main factors considered for Piston Modelling are Vehicle Type ,Piston Length, Combustion Chamber Length, Dia, Chamber Depth, Material etc.

Piston Length : It is the total distance between Top Combustion Chamber (Piston Head) to Bottom Piston Surface.

Combustion Chamber Depth: By using a Digital Depth Gauge,Exact Combustion Chamber (CC) Depth can be measured.Here (CC) the Combustion Process happens.

Fig No:	**Vehicle**	**Piston Material**	**Piston Length (mm)**	**Combustion Chamber Dia (mm)**	**Combustion Chamber Depth (mm)**
1	**Tata Sumo Grande 2.2 L DICOR**	**Aluminium Alloy(Al Ai)**	**75**	**40**	**14**
2	**Tata Indica CS**	**Aluminium Alloy(Al Ai)**	**80**	**40**	**10**
3	**Tata 407 Truck**	**Aluminium Alloy(Al Ai)**	**84**	**46**	**12**
4	**Mahindra Maximo**	**(Al Ai)**	**76**	**36**	**10**

Table:3; Modelling Parameters of Combustion Chambers (CC)

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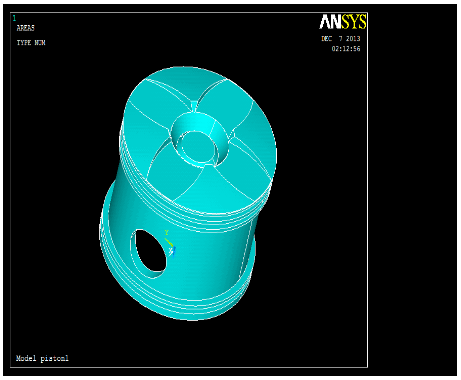

Fig:1.Toroidal Type Combustion Chamber.

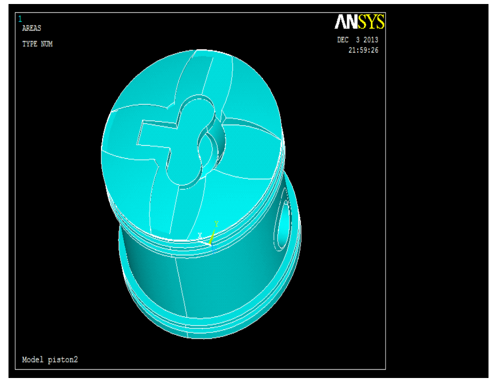

Fig: 2 , Shallow Depth Combustion Chamber.

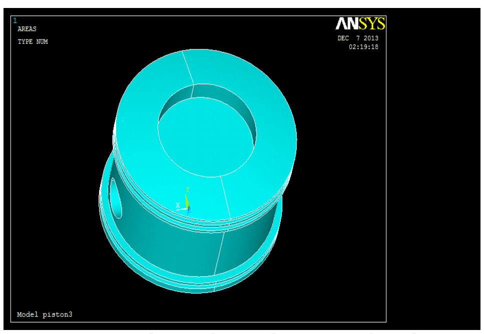

Fig: 3. Hemispherical Combustion Chamber

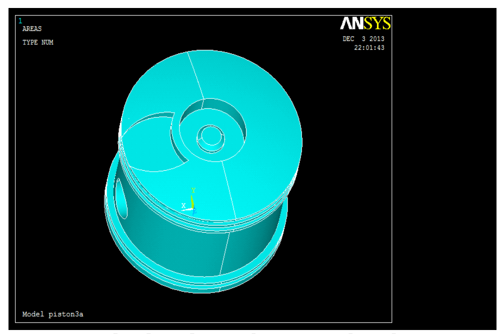

Fig: 4 ,Cylindrical Combustion Chamber

III.ANALYSIS PHASE & ANALYSIS RESULT

Material Element Type – Axis Symmetric 4Node 75. - PLANE75 is used as an axis -symmetric ring element with a 3-D thermal conduction capability. The element has four nodes with a single degree of freedom, temperature, at each node.Both Temperature and Stress problems can be determined by using this element type (Plane75),It is used to solve mainly Axis Symmetric Problems. PLANE75 Assumptions- The element must not have a negative or a zero area. .A triangular element may be formed by defining duplicate K and L node numbers as described in Triangle, Prism and Tetrahedral Elements. Thermal transients having a fine integration time step and a severe thermal gradient at the surface will also require a fine mesh at the surface.Temperature dependent material properties (including film coefficient) are assumed to be axis symmetric even if the temperature varies harmonically.Loading Condition (Temperature & Stress) – Temp applied on the Piston head is 850K (550 °C), ".Thermalconductivity was 134K ,Stress 1.5 Mpa . (**Ref:P. M. Pierz**. **"**Thermal barrier coating development for diesel engine aluminium pistons); As the Combustion process develops max temp will be on the piston Bowl and it will distributed from the top to Bottom surface depending on the piston design & its structure, and the convection coefficient has to be considered.

Temperature Distribution Diagram (fi8:5,fig:6,fig:7,fig:8) of different Pistons.

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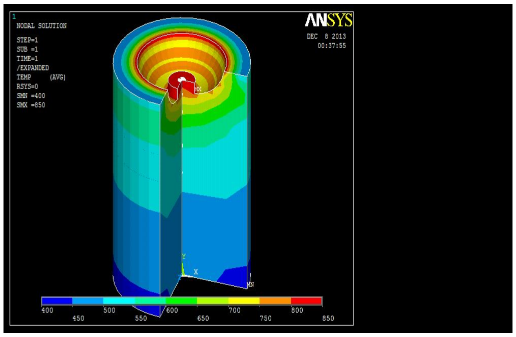
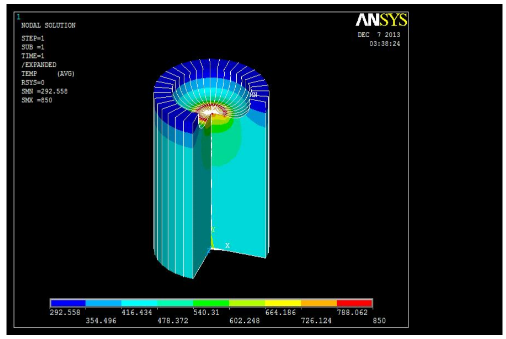


Fig,**5:**Toroidal Type Combustion Chamber



Fig,**6**: ShallowDepthType Combustion Chamber

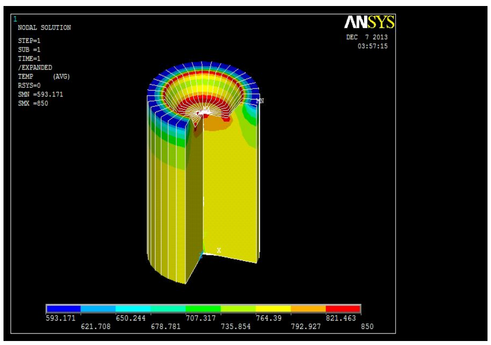


Fig:7 Hemispherical Combustion Chamber

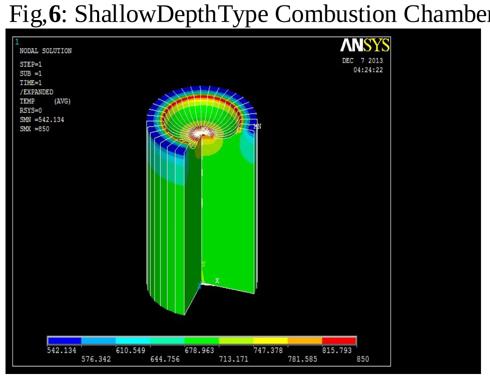
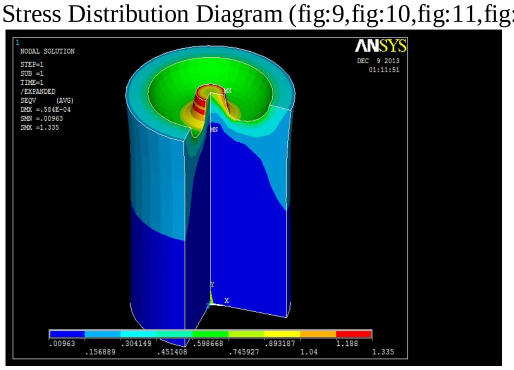
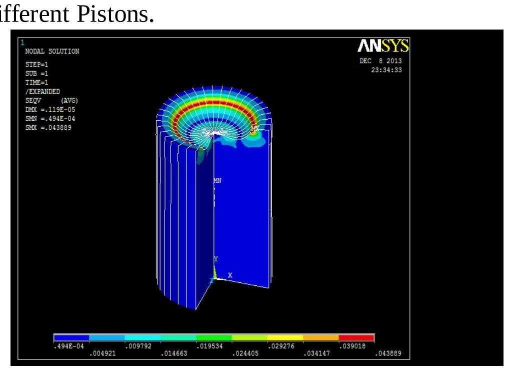


Fig: 8 Cylindrical Type Combustion Chamber

Stress Distribution Diagram (fig:9,fig:10,fig:11,fig:12).of different Pistons.



Fig,**9:**Toroidal Type Combustion Chamber



Fig,**10**:ShallowDepthType Combustion Chamber

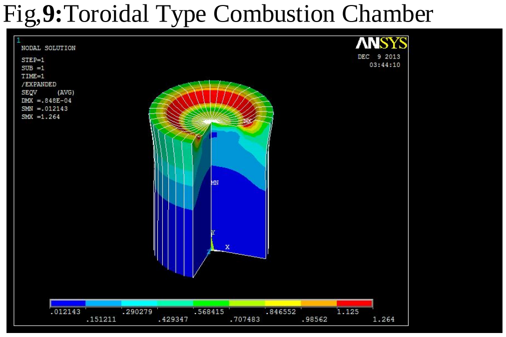


Fig:11, Hemispherical Combustion Chamber

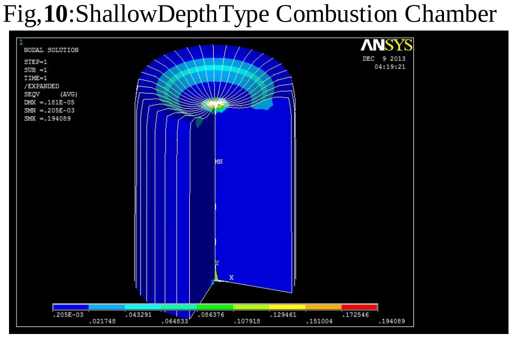


Fig:12, Cylindrical Type Combustion Chamber

Above diagrams shows the Temperature and Stress Distribution of different pistons and from the Temperature and Stress diagrams it clears that how the Temperature and Stress is distributed through the various piston heads and which Piston having the Proper Temperature & Stress Distribution.

IV ANALYSIS SUMMARY

Figures (5,6,7,8,) show the combustion process on the four different piston heads ,In fig 5;Toroidal combustion chamber which has max temperature upto 850k at the combustion chamber bowl expecially at the lip of the piston bowl which indicates at a maximum temperature of 850K at maximum Red colour,then the temp further distributed along the piston parts,650 k at the middle portion and finally reaches at 500K at the bottom surfaces. Stress distribution also proper in this shape as it having a maximum stress at about 1.5Mpa in the piston bowl lip and finally reaches about 0.009Mpa at its bottom surface. So out of four Piston heads fig 5, Toroidal type combustion chamber having proper temperature and stress distribution.From fig 8 ,cylindrical type combustion chamber it having a maximum temperature of about 850 K, at the piston bowl and it reduces eventually and finally reaches to 450K at the bottom surface, it having a maximum pressure of about 1.26Mpa at Piston head and reduces to its minimum level of about .012Mpa at its bottom surface. So its not having a proper temperature and stress distribution as Toroidal type combustion Chamber. From fig 7,Hemispherical Combustion Chamber it having a Max Temperature of about 850K and reaches to the minimum level of about 520 K ,at its bottom surface,its stress distribution varies about 1.143Mpa at the piston head surface and reaches to a minimum limit of about 0.041 at its bottom surface,so its temperature & stress distribution is not as proper as that of other two piston types.From Fig 6, shallow depth type combustion chamber it has the temperature distribution of about 850 to 300 k and stress distribution of about 1.140-0.051 Mpa,so it having the poor temperature and stress distribution among the other four piston Heads.. From analysis result over view it comes to clear that out of this four Piston Heads of Four different Commercial vehicles Toroidal Combustion Chamberof having the proper Temperature and Stress Distribution.Its having the proper Piston Structure Design.

V. CONCLUSION

In this work, four different Combustion Chambers are modelled by using 3D modelling software PRO-E WILDFIRE5.0 .Temperature and Stress distribution of this four different Combustion Chambers are analyzed by using Ansys APDL 11.0 FEA software. Out of this four combustion Chambers TOROIDAL-TYPE Combustion Chamber Engine Piston having proper Temperature and Stress Distribution. Future studies of this work is mainly dependent on the experimental analysis of the selected combustion chamber on diesel engine to verify the temperature and stress distribution of the combustion chamber .

REFERENCES

[1]. P. M. Pierz. "Thermal barrier coating development for diesel engine aluminum pistons"

[2] Vivek Solekar , Dr.L.N.Wankade, Finite Element Analysis and Optimization of I.C. Engine Piston Using RADIOSS and Opti Struct

[3] Ekrem Buyukkaya , Muhammet Cerit , Thermal analysis of a ceramic coating diesel engine piston using 3-D finite element method.

[4] Ch.Venkata Rajam, P.V.K.Murthy, M.V.S.Murali Krishna, G.M.PrasadaRao, Design Analysis and Optimization of Piston using CATIA and ANSYS.

[5] Shixiong Li , Jinlong Mao , Shumao Wang, Cylinder Head FEM Analysis And Its Improvement.

[6] . A.R. Bhakta, Y.K. Jibhakate, "Thermal analysis and optimization of I.C. Engine piston using FEA method", International Journal of Modern Engineering Research (IJMER) Vol.2, ISSN: 2249-6645.

[7] Shuoguo Zhao"Design the Piston ofInternal Combustion Engine by Pro\ENGINEER"

[8] T. Hejwowski, A. Wero!nski; The effect of thermal barrier coatings on diesel
engine performance.

[9] H. Samadi, T.W.Coyle, Alternative Thermal Barrier Coatings for Diesel Engines, Centre for Advanced Coating Technologies, University of Toronto, Toronto,Ontario, Canada. aloo,G. H. Farrahi, S. M. Mirsalim ; A review of thermal barrier coating effects on diesel engine performance and components lifetime

[11] Lei Jilin, ShenLizhong, Bi Yuhua, ShenYinggang, Yan Wensheng, Zhang Wei. Application of Finite Element Analytic Method in Internal Combustion Engine Piston Research. Tractor & Farm Transporter. 2005, 4:10-13..