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THERMAL & STATIC ANALYSIS ON IC ENGINE PISTON USING FEA

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ABSTRACT

In this study, the static and thermal analysis on piston made of aluminium silicon alloy, zirconium and aluminium MgSi material is performed and the effects of zirconium material are observed. The analysis is performed on piston by using a CAE tool namely ANSYS. The main purpose is to find the real behaviour during combustion process i.e.; static structural and thermal stresses are found. The higher stresses and critical point of a region is found by technique of optimizing the mesh size in finite element analysis. In this work, the main emphasis is placed on the study of thermal behaviour of functionally graded coatings obtained by means of using a commercial code, ANSYS on aluminium and zirconium alloyed aluminium piston surfaces.

The upper end of the piston i.e. piston head/crown is analysed to reduce the stress concentration. The structural model of a piston is designed in CATIA V5 software and then imported into ANSYS 14.5 software for finite element analysis.

I. INTRODUCTION

Engine pistons are one of the most complicated elements among all automotive and different trade field elements. We knew an engine was known as the heart of a motor vehicle as like the piston may be viewed as the most vital part of an engine. There are many exploration works suggesting, for engine pistons, new geometries, materials and manufacturing methods, and this development has experienced with a non-stop change in the course of the most recent decades and required exhaustive examination of the littlest subtle elements. Despite every one of these studies, there are a countless of damaged pistons. Damage components have distinctive starting points and are mostly wearing, temperature, and weakness related. The exhaustion related piston damages assume an overriding part for the most part in light of thermal and mechanical fatigue, either at room or at high temperature.

Automobile parts are in incredible interest nowadays due to expanded utilization of automobiles. The expanded interest is because of enhanced execution and decreased expense of these parts. Research and development and testing engineers ought to create critical parts in most limited conceivable time to minimize dispatch time for new products. This requires comprehension of new advances and quick absorption in the improvement of new products**.** A piston is a part of responding IC-engines.

The IC engine main components are

1. Piston
2. Piston rings
3. Gudgeon pin

4. Connecting rod

1.1 Piston

A **piston** is a part of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other comparable mechanisms. It is the moving segmentwhich is contained by a chamber and is made gas-tight by piston rings. In an engine, its motivation is to exchange power from expanding gas in the cylinder to the crankshaft by means of a cylinder bar/or connecting rod. In a pump, the role is turned around and power is transformed from the crankshaft to the piston cylinder for the purpose of compressing or ejecting the fluid in the chamber. In a few engines, the cylinder also performances as a valve by covering and revealing ports in the cylinder wall.

Piston cylinders are four sorts there are:

1. Trunk pistons
2. Cross head pistons
3. Slipper pistons
4. Deflector pistons

II. PISTON DESIGN

The cylinder is designed according to the procedure and determination which are given in machine configuration and information hand books. The measurements are ascertained regarding SI Units. The pressure applied on cylinder head, temperatures of different ranges of the cylinder, heat stream, stresses, strains, length, diameter of cylinder and hole, thicknesses, and so on, parameters are taken into considerations.

2.1 Piston Design Considerations

In design planning a piston for an engine, the accompanying points ought to be taken into consideration:

I. The cylinder must have the strength to oppose the drive and inactivity forces.
II. Capacity to scatter the warmth of ignition and keep away from thermal bending.
III. Closing the gas and oil
IV. Adequate bearing zone to work for huge number of responding cycles
V. Weight required will be minimum
VI. Smooth silent operation
VII. Give sufficient backing to cylinder pin

2.2 Piston Design Parameters Procedure

The method for cylinder designs comprises of the accompanying steps:

I. Thickness of cylinder head
II. Heat courses through the cylinder head
III. Radial thickness of the ring
IV. Axial thickness of the ring
V. Width of the top area
VI. Size of other ring lands

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Thus, the measurements for the piston are calculated and these are used for exhibiting the piston in CATIA V5 R18. In the above method the ribs in the piston are not completed, so as make the piston model straight forward in its design. In demonstrating a piston considering all elements will get to monotonous procedure. In this manner, a symmetric model is produced utilizing the above measurements.

2.3 Model of the Piston Before Optimization

The accompanying are the sequence of steps in which the piston is demonstrated.

- Drawing a half part of piston
- Exiting the sketcher
- Developing the model
- Making a hole

2.4 Design Specifications

Sl. No.	Measurements	In metric units
1	Piston length	65.128
2	Piston outer diameter	90
3	Thickness of the piston head	21.629
4	Ring radial thickness(t_1)	3
5	Ring axial thickness (t_2)	2
6	Top land thickness(b_1)	10
7	Other ring lands width(t_1)	2

2.5 Material Properties

PROPERTIES	Al	Al-Zr	Al-Mg Si
Young's modulus (E)	70000MPa	2.2E5MPa	0.7E5MPa
Poisson's ratio (µ)	0.31	0.35	0.33
Density	2770Kg/M^3	2937 Kg/M^3	2700 Kg/M^3
Thermal conductivity (K)	234W/M^0C	7W/M^0C	200W/M^0C
Specific heat	875 J/Kg^0C	894 J/Kg^0C	898 J/Kg^0C

III. FINITE ELEMENT ANALYSIS (FEA)

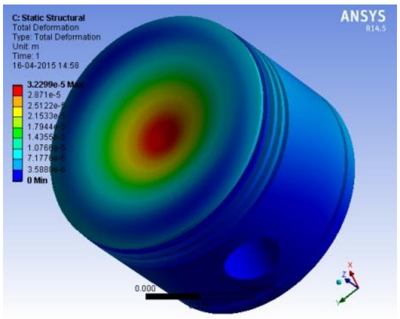
FEA is the functional utilization of the finite element method (FEM), which is utilized by architects, and scientists to scientifically model and numerically understand extremely complex structural, liquid, and multiphase issues. FEA programming can be used in extensive variety of businesses, yet is most generally utilized as a part of the aeronautical, biomechanical and locomotive industries.

A finite element (FE) model contains an arrangement of points, called "hubs", which frame the state of the outline. Joined with these hubs are the finite elements themselves which frame the finite element mesh and contain the material and basic properties of the model, characterizing response of it in specific conditions. The density of the finite element mesh may differ all through the material, contingent upon the foreseen change in stress levels of a specific part. Areas that experience high changes in stress for the most part require a higher mesh density than those that experience little or no stress variation. Purposes of interest may incorporate crack purposes of beforehand tried material, fillets, corners, complex point of intersect, and high-stress regions.

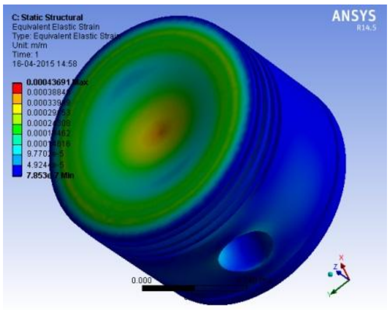
IV. STATIC AND THERMAL ANALYSIS OF PISTON

4.1 Aluminium Alloy with Zirconium

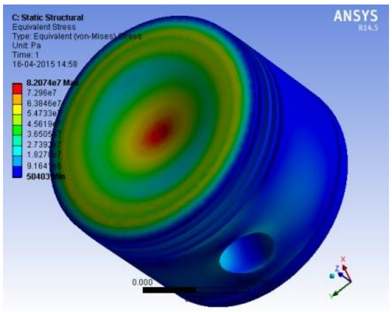
Total Deformation



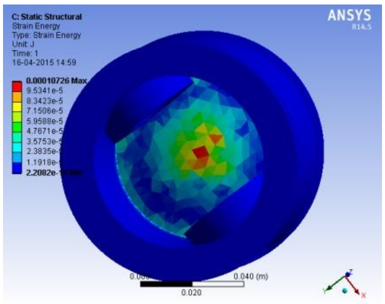
Equivalent Elastic Strain



Equivalent Stress



Strain Energy



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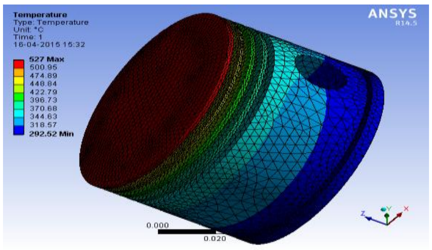
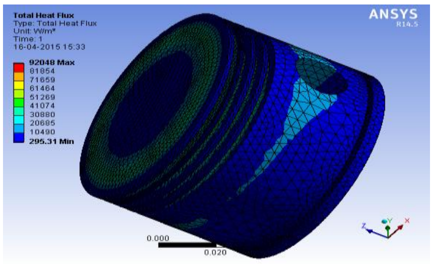
Thermal Analysis

Temperature



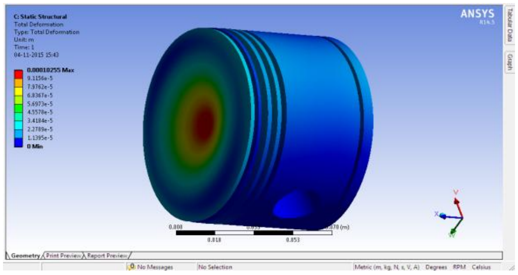
Total Heat Flux



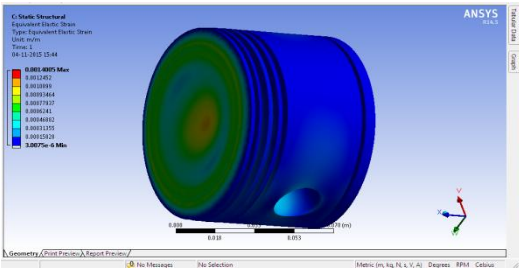
4.2 Aluminium Alloy with MgSi

Static Analysis

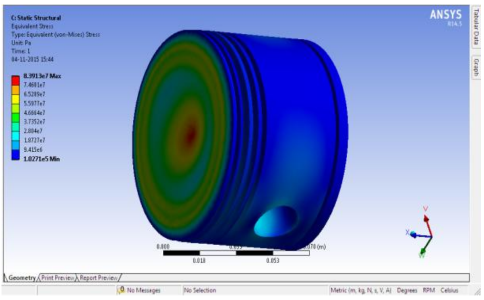
Total Deformation



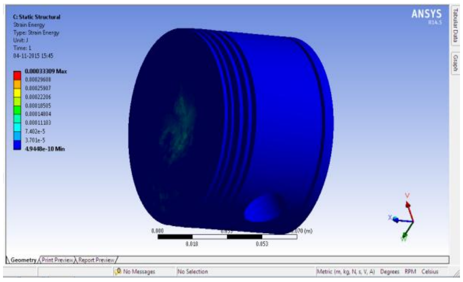
Equivalent Elastic Strain



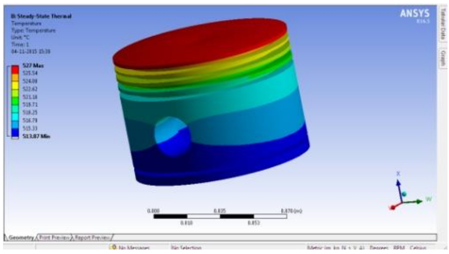
Equivalent Stress



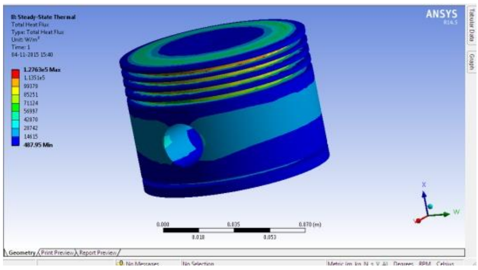
Strain Energy



Thermal analysis: Temperature



Total Heat Flux



V.VALUES OBSERVED DURING ANALYSIS

MATERIAL NAME	**ALUMINIUM**	**WITH ZIRCONIUM**	**WITH Mg Si**
TOTAL DEFORMATION,(M)	3.2299e-5	0.00010111	0.00010255
EQUIVALENT ELASTIC STRAIN,(M/M)	0.00043691	0.0013807	0.0014005
EQUIVALENT STRESS,(PA)	8.2074e7	8.3913e7	8.391e7
STRAIN ENERGY,(J)	0.00010726	0.0003284	0.00033309

Comparison Table for Steady State Thermal Analysis

	ALUMINIUM	WITH ZIRCONIUM	WITH MgSi
CONDUCTION TEMPERATURE,(C)	292.52	479.41	430
TOTAL HEAT FLUX,(W/M^2)	92048	1.2227e5	1.276e5

VI. CONCLUSION

Our project is to design and analysis of both static and steady state thermal on piston head. As engine is known as heart of automobile where piston plays a vital role where durability and thermal conduction plays an important role**.** We have designed piston using CAD software namely CATIA V5 and analysis is done using ANSYS 14.5 and the thermal and static analysis is drawn under required boundary conditions. We analysed piston with aluminium alloy material immersed with material namely zirconium and MgSi in place of silicon for better thermal conditions and deformation factors.

We have observed that alloy material after adding zirconium and MgSi shows good results when compared to regular alloy material. In static analysis aluminium alloy with zirconium shows lower deformation and less affected to stress and strain factors when compared same alloy without zirconium. The results also effected for thermal analysis where we can see a better results when zirconium and MgSi are added.

By this project we want to conclude that by adding zirconium to aluminium alloy we can extend performance of IC engine. And as a replacement for aluminium with zirconium we can use aluminium with MgSi coating.

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