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Static and Thermal Analysis of Aluminium Alloy Piston with Ceramic Coating

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ABSTRACT: In internal combustion engines the working fluid is the product of air –fuel mixture. In this internal combustion engines there is a direct conversion of thermal energy,obtained by combustion of fuel to mechanical power . Due to the direct combustion of fuel inside the engine cylinder the temperature produced is very high. Most of the heat energy produced in the engine cylinder is expelled from the engine cylinder through different losses .The thermal energy produced in the system is observed by the different components like valves, piston, cylinder valve, piston rings .the energy observed by the components is reduced by applying special coatings on the components, the coated materials normally termed as thermal barrier coatings. Ceramic materials are generally used as thermal barrier coatings on the components. By the application of ceramic coatings on the components thermal, mechanical, corrosive resistance properties are improved .The coatings can be applied as a whole part or on the surfaces of the components .While the ceramic coatings have some drawbacks like manufacturing difficulty, brittleness. Coating of engine components with low thermal conductivity materials keeps the temperatures within the engine cylinder. Due to high temperatures within the engine cylinder chamber the thermal efficiency of the engine increases . Ceramic materials have good temperature distribution, reduced total deformation and there by increases the life of the components

Piston is designed according to the specified dimensions using CATIA v5 .After designing, the model is exported to ANSYS. In ANSYS the geometric model is converted in finite element model on the finite element model loads and boundary conditions are applied. Finite element analysis of the piston and is done using ANSYS APDL(ANSYS Parametric Design Language) to find stresses, temperature distribution and heat flux on the piston by changing the materials aluminum alloy ALSIC (Aluminium Silicon Carbide) and NICRAL (Nickel-Chromium-Aluminium) as coating material. By adding coating we are getting good temperature distributions and lesser heat flux.

I. INTRODUCTION

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil fuel) occurs with an oxidizer (usually air) in a combustion chamber that is an integral part of the working fluid flow circuit. In an internal combustion engine (ICE) the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine blades, or a nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The first commercially successful internal combustion engine was created by Etienne Lenoir.

Four-stroke:

1. Intake
2. Compression
3. Power
4. Exhaust

The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two-stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. A second class of internal combustion engines use continuous combustion: gasturbines, jet engines and most rocket engines, each of which are internal combustion engines on the same principle as previously described.

INTERNAL COMBUSTION ENGINE

Types of internal combustion engine:

Engines can be classified in many different ways: By the engine cycle used, the layout of the engine, source of energy, the use of the engine, or by the cooling system employed.

Intake stroke: The first stroke of the internal combustion engine is also known asthe suction stroke because the piston moves to the maximum volume position (downward direction in the cylinder). The inlet valve opens as a result of the cam lobe pressing down on the valve stem, and the vaporized fuel mixture enters the combustion chamber. The inlet valve closes at the end of this stroke.

Compression stroke: In this stroke, both valves are closed and the piston starts its movement to the minimum volume position (upward direction in the cylinder) and compresses the fuel mixture. During the compression process, pressure, temperature and the density of the fuel mixture increases.

Power stroke: When the piston reaches a point just before top dead center, the spark plug ignites the fuel mixture. The point at which the fuel ignites varies by engine; typically it is about 10 degrees before top dead center. This expansion of gases caused by ignition of the fuel produces the power that is transmitted to the crank shaft mechanism.

Exhaust stroke: In the end of the power stroke, the exhaust valve opens. During this stroke, the piston starts its movement in the maximum volume position. The open exhaust valve allows the exhaust gases to escape the cylinder. At the end of this stroke, the exhaust valve closes, the inlet valve opens, and the sequence repeats in the next cycle. Four-stroke engines require two revolutions.Many engines overlap these steps in time; turbine engines do all steps simultaneously at different parts of the engines.

COMBUSTION

All internal combustion engines depend on combustion of a chemical fuel, typically with oxygen from the air (though it is possible to inject nitrous oxide to do more of the same thing and gain a power boost). The combustion process typically results in the production of a great quantity of heat, as well as the production of steam and carbon dioxide and other chemicals at very high temperature; the temperature reached is determined by the chemical makeup of the fuel and oxidizers (see stoichiometry), as well as by the compression and other factors.

IGNITION PROCESS

Gasoline Ignition Process:

Gasoline engine ignition systems generally rely on a combination of a lead–acid battery and an induction coil to provide a high-voltage electric spark to ignite the air-fuel mix in the engine's cylinders.

This battery is recharged during operation using an electricity-generating device such as an alternator or generator driven by the engine. Gasoline engines take in a mixture of air and gasoline and compress it to not more than 12.8 bar (1.28 MPa), then use a spark plug to ignite the mixture when it is compressed by the piston head in each cylinder.

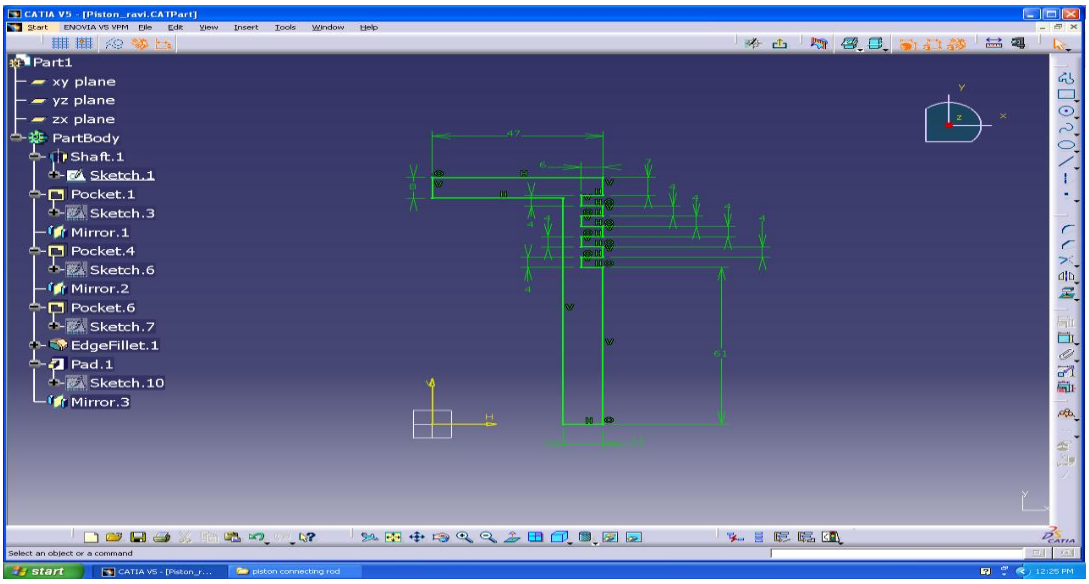
While gasoline internal combustion engines are much easier to start in cold weather than diesel engines, they can still have cold weather starting problems under extreme conditions. For years the solution was to park the car in heated areas. In some parts of the world the oil was actually drained and heated overnight and returned to the engine for cold starts.

CATIA

Introduction to CATIA:

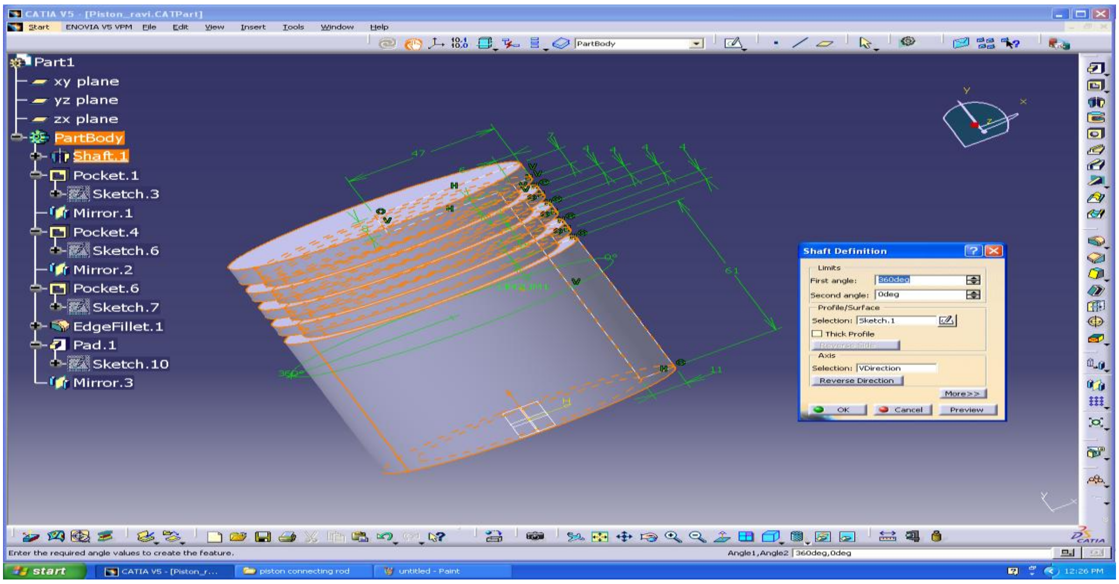
CATIA is a robust application that enables you to create rich and complex designs. The goals of the CATIA course are to teach you how to build parts and assemblies in CATIA, and how to make simple drawings of those parts and assemblies.This course focuses on the fundamental skills and concepts that enable you to create a solid foundation for your designs

PISTON MODELING



Select an object or a command

Piston model step 1

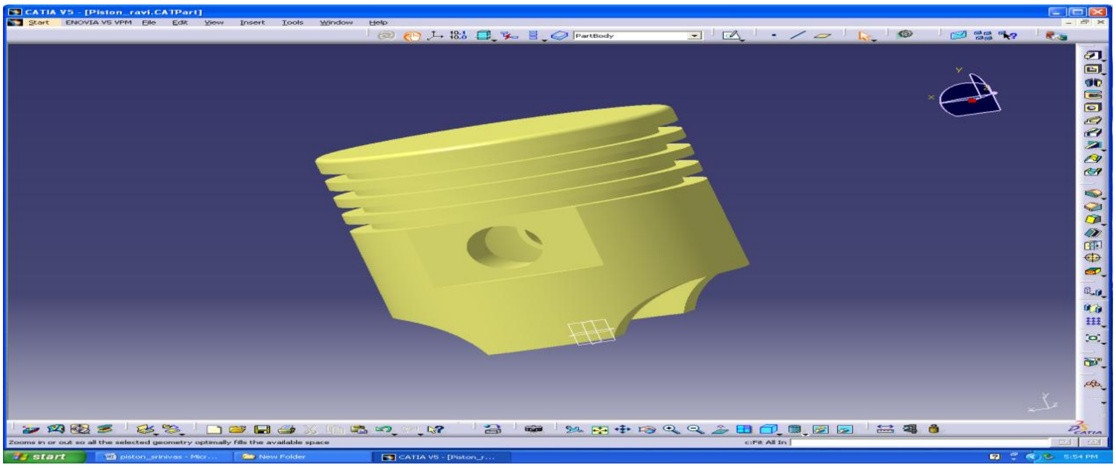


Shaft Definition
Limits
First angle: 360deg
Second angle: 0deg
Profile/Surface
Selection: Sketch.1
☐ Thick Profile
Axis
Selection: VDirection
Reverse Direction

Enter the required angle values to create the feature.

Angle1,Angle2 360deg,0deg

Piston model step 2



Zooms in or out so all the selected geometry optimally fills the available space

CATIA model of piston

ANSYS

Introduction to ANSYS:

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multi physics analyses with drag-and-drop simplicity. With bi-directional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation Driven Product Development.

Material properties:

Young's modulus	70Gpa
Poisson's ratio	0.35
Density	2700 kg/m^3
Thermal conductivity	237. W/m.°C
Specific heat	910. J/kg.°C

Alluminium Alloy Material Properties

Young's modulus	230Gpa
Poisson's ratio	0.24
Density	2937. kg/m
Thermal conductivity	197. W/m.°C
Specific heat	894. J/kg.°C

Alsic Material Properties

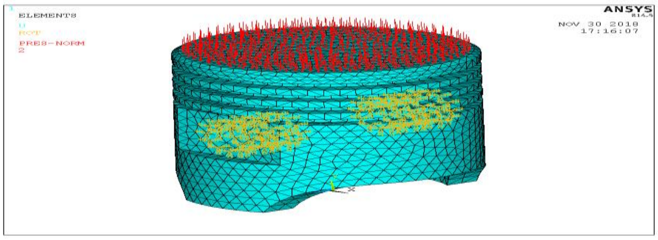
Young’s modulus	90Gpa
Poisson’s ratio	0.27
Density	7870 kg/m^3
Thermal conductivity	16.1 W/m.°C
Specific heat	764 J/kg.°C

Nicral Material Properties

Static Structural Analysis piston:

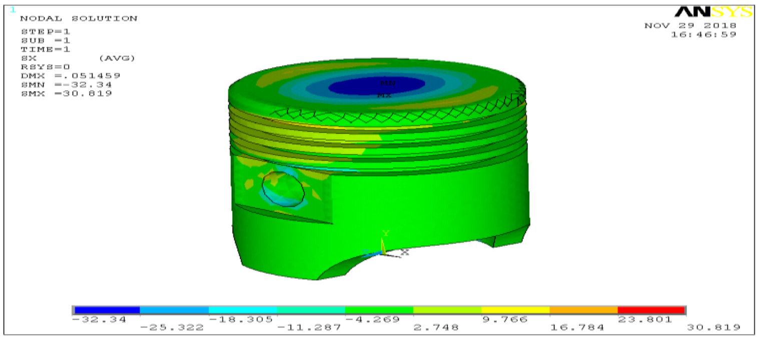
Loading and Boundary Conditions:

In this research the effect of side thrust force is negligible but in reality it have some impact on deformation and stress on piston but pressure force and inertia force are taken in record . The pressure force 2MPa is applied on the piston crown. Maximum pressure at the top surface of the piston is 2MPa. Temperature at the top surface of the piston is 400^{0}C. Temperature at the bottom of the piston is 150^{0}C

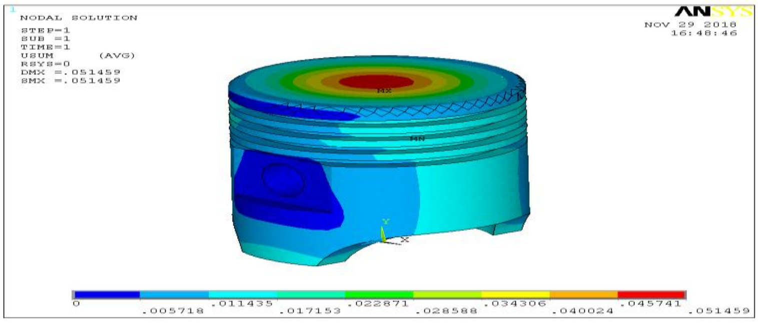


Finite element model of piston with boundary conditions

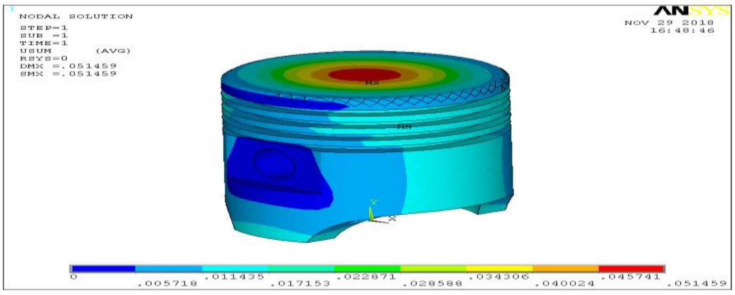
Static Structural Analysis aluminumalloy piston:



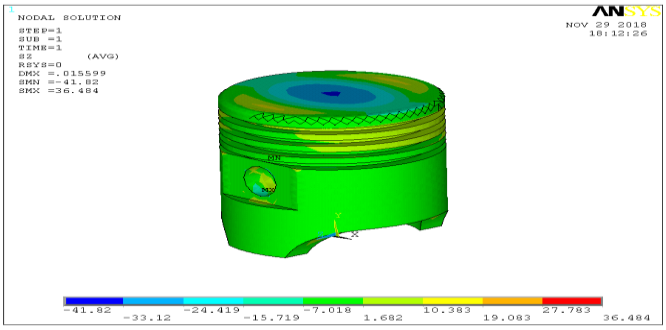
Stress in x-direction aluminum alloy piston



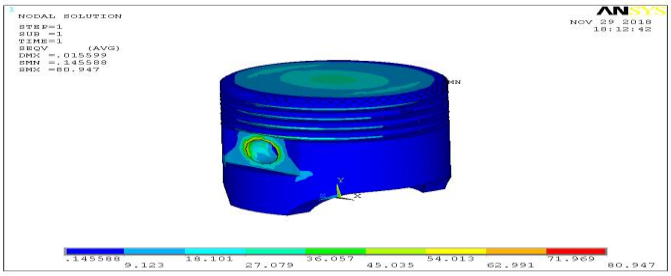
Displacement in aluminum alloy piston



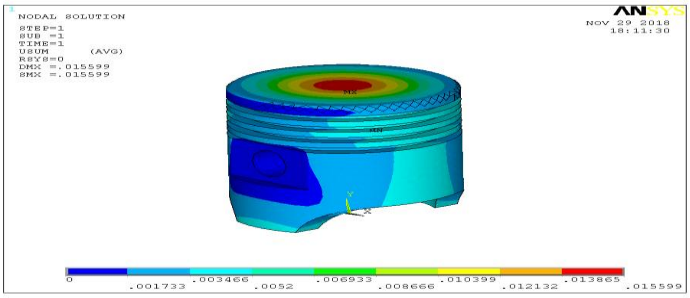
Displacement in aluminum alloy piston



Stress in Z-direction ALSIC piston

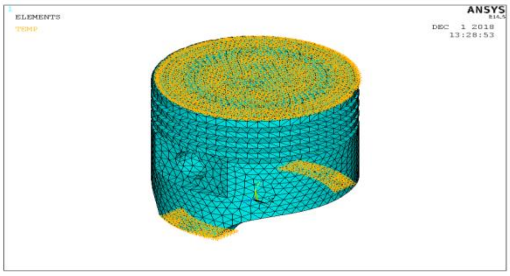


Vonmisses Stress ofALSIC piston

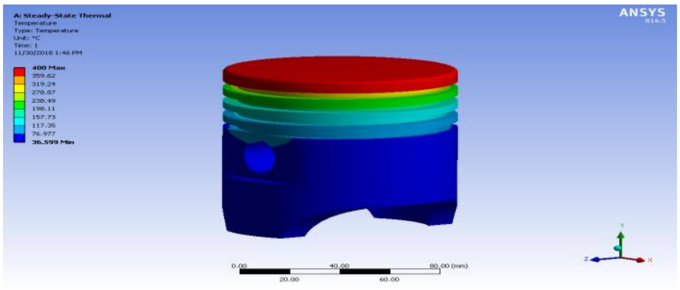


Displacement in ALSIC piston

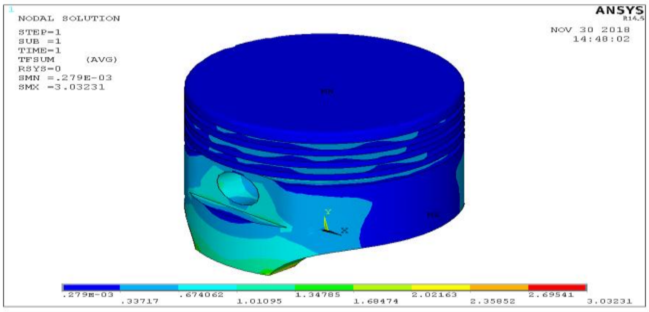
Thermal Analysis piston



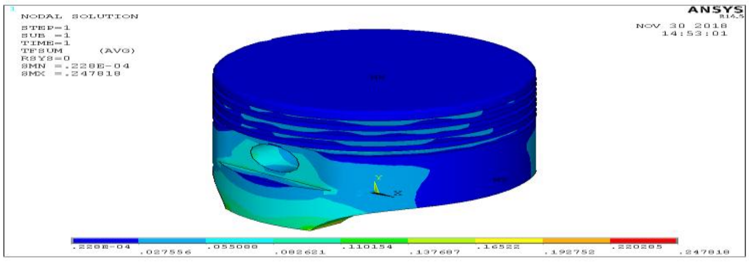
Thermal boundary conditions



Temperature distribution ALSIC piston



Heat flux ALSIC piston



Heat flux aluminum alloy and coating piston

RESULT

Table 8.1 COMPARISION OF Al AND AlSiC PISTON IN STATIC ANALYSIS

Stresses & Deformations	**Al**	**AlSiC**
S_X in MPa	30.819	27.997
S_Y in MPa	33.499	30.288
S_Z in MPa	37.764	36.484
SEQV in MPa	79.917	80.947
U_{SUM} in mm	0.0514	0.0155

Table 8.2 COMPARISION OF Al, AlSiC AND COATING PISTON IN THERMAL ANALYSIS

Material	**Temperature in ^{0}C**	**Heat flux in w/mm^2**
Al	400	3.648
AlSiC	400	3.032
Al with NiCrAl	400	0.247
AlSiC with NiCrAl	400	0.012

II. CONCLUSION AND FUTURE SCOPE

A piston made of composite material (aluminum silicon carbide) is designed and analyzed successfully. Composite piston made of metal matrix offers high strength retention on ageing even at severe environments. Compared to aluminum alloy, the aluminum silicon carbide is found to have lesser deformation and good temperature distribution. Some of the limitations faced by aluminum piston are overcome by the aluminum silicon carbide piston. In thermal analysis by adding **Ni Cr Al** ceramic coating the heat flux is very less when compared with aluminum alloys. Hence concluded that by adding coating materials we will get good temperature distribution and lesser heat flux.

REFERENCES

1. Afzal,A.andA.Fatemi,2004."AcomparativestudyoffatiguebehaviourandlifepredictionsofforgedsteelandPMconnectingrods".SAETechnicalPaper,1:1529.
2. Anonymous,2008."NissanZ24engineMaintenanceand Repayments catalogue" Mega motor Co.
3. Chen,N.,L.Han,W.ZhangandX.Hao,2006."Enhancing Mechanical Properties and Avoiding Cracks by Simulation of Quenching Connecting Rod" . Material Letters,61:3021-3024
4. El- Sayed , M.E.M . and E.H.Lund,1990. “Structural optimization with fatigue life constraints,” Engineering Fracture Mechanics,37(6):1149-1156.