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Thermal Analysis of IC Engine Piston Using Finite Element Method

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ABSTARCT:

In this study, first, and thermal analyzes are being investigated in the traditional diesel piston (uncut) Made design silicon aluminum alloy 1 and 2 design parameters. Second, the thermal analysis Made in the piston, coated with zirconium through the use of commercial law, namely ANSYS. And I investigated the effects of coating on the thermal behavior of the pistons. Finite element analysis is Programs using computer-aided design. The main objective is to achieve and analysis Thermal stress distribution of the piston in the event of an actual engine during the combustion process. To illustrate this thesis network optimization technique using the finite element analysis to predict the sensitive region of high pressure On race. In this work, the focus is on the study of the thermal behavior of functionally Classified coatings obtained through the use of commercial laws, aluminum and zirconium ANSYS Piston coated aluminum surfaces. This analysis is to reduce the pressure of the concentration of the upper limbs Any of the piston (piston ring / piston and Ras Tanura and how much). Using NX design / computer assisted Katia The software structural model developed piston. Moreover, finite element analysis Using computer simulation software with the help of ANSYS.

INTRODUCTION:

Functionally graded materials are of great interest due to the above, for example, corrosion and erosion and oxidation resistance, high hardness, chemical and thermal properties at cryogenic temperature and high stability. These characteristics make them useful for many applications including thermal barrier coating (TBC) on metal substrates are used at high temperatures in the fields of aviation and space, especially for thermal protection of components in gas turbines and engines diesel. It has been successfully applied thermal barrier coating inside Combustion engine, in particular the combustion chamber in order to simulate adiabatic changes. It is not only to reduce the targets in the cylinder heat Rejected and the protection of the basic thermal fatigue of metal surfaces, but also A possible reduction of emissions Engine braking and fuel consumption. tuberculosis application reduces heat loss from the engine cooling jacket through Of the exposed surface of heat transfer, such as the cylinder liner, the piston The crown of the piston rings. The isolation of the combustion chamber with ceramic Coating affects the combustion process, and thus performance and characteristics of the exhaust emissions of engines improvement. On the other hand, The desire to increase the thermal efficiency or reduce fuel consumption engines Lead to the adoption of higher compression ratios, especially for diesel engines, Decreased heat removal cylinder. Increased because each of these factors materials used mechanical and thermal stresses in the combustion chamber

Tuberculosis application to the surfaces of these components improves the durability of high temperature by reducing the heat and reduce the degree of heat transfer of the base metal. Typical TBCs exfoliation of the top layer of the layer ceramic bonding failure. There are many factors that affect the overall performance of the paint, coating and cause landslides. However it is determined oxidation and thermal mismatch where the two main factors affecting the life of the paint system. Painting is impermeable to liquids and gases in the atmosphere, leading to oxidation of the bond coat and coating detachment. He has been using functionally graded coatings and to reduce impact of mismatch. Therefore, interfaces pressure and thermal expansion are an alternative approach to conventional coating thermal barrier. In this project, and are the main focus in the study of the thermal behavior functionally graded coatings obtained using commercial law put, ANSYS on aluminum and steel pistons and results with numerical and experimental work was verified.

LITERATURE REVIEW:

Thermal behavior of functionally graded coatings on AlSi and steel piston materials were investigated by means of commercial code, namely ANSYS. Thermal analysis were employed to deposit metallic, cermets and ceramic powders such as NiCrAl, NiCrAl+MgZrO3 and MgZrO3 on the substrate. The numerical results of AlSi and steel pistons were compared with each other. The maximum surface temperature of coated AlSi and coated steel piston were compared with their corresponding uncoated piston. The heat resistance of each piston was compared. The resistance of the coated piston was found more than the uncoated aluminium piston by 14.5%. The resistance of the piston was found more than uncoated steel piston by 11.3%. The coated piston yields comparatively less wear wit uncoated piston. This is one of the first few papers that deal with studies for nanostructure coatings. In this paper three different applications were discussed. Conventional air plasma spray of nano crystalline alumina-titania ware coatings for turbine applications was studied. Finally a brief mention of recent progress in spraying dense materials for use a standalone ceramics is been studied. Also the various coating thickness on the component were discussed.

INTRODUCTION TO FINITE ELEMENT ANALYSIS

Methods to solve real time engineering problems

Any engineering problem can be solved using the 3 methods mentioned below

1) Analytical Method
2) Numerical Method
3) Experimental method

Analytical methods: It is a systematic procedure or technique used to break down material into its component parts so that its organizational structure can be understood and its chemical or physical composition can be determined easily. They provide closed form exact solutions to the mathematical model of engineering problems. They can be used only if the geometry, loading and boundary conditions of the problem are simple. Integration methods and other analytical solution methods of differential equations are the examples of the analytical methods.

Numerical Methods:

A method to solve mathematical equations approximately is called the numerical method. Basically numerical method transforms the mathematical problem into such a form that it can be solved by a simple arithmetic operation. They provide discrete form or approximate solution to the mathematical model of engineering problems. They can be used to solve the problems with relatively complex geometry, loading and boundary conditions. In particular finite elements can represent structures of arbitrarily complex geometry. Examples of few numerical methods are Finite Difference Method, Finite Element Method, Boundary Element Method, etc. As the numerical method deals with a lot of calculation, the technique would be an effective tool when it is employed in combination with computer.

Experimental methods:

The experimental method is usually taken to be the most scientific of all methods, the 'method of choice'. The main problem with all the non-experimental methods is lack of control over the situation. The experimental method is a means of trying to overcome this problem. The experiment is sometimes described as the cornerstone of psychology: This is partly due to the central role experiments play in many of the physical sciences and also to psychology's historical view of itself as a science. A considerable amount of psychological research uses the experimental method.

METHODOLOGY:

PISTON

A piston is a component of reciprocating engines, pumps and gas compressors. It is located in a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall.

Main Components of diesel engine

(1) Exhaust camshaft,

(2) Crankshaft,

(3) Water jacket for coolant flow,

(4) Intake camshaft,

(5) Spark plug,

(6) Valves,

(7) Piston,

(8) Connecting rod,

(9) Crankshaft,

(10) Water jacket for coolant flow.

INTERNAL COMBUSTION ENGINES

There are two ways that an internal combustion piston engine can transform combustion into motive power: the two-stroke cycle and the four-stroke cycle. A single-cylinder two-stroke engine produces power every crankshaft revolution, while a single-cylinder four-stroke engine produces power once every two revolutions. Older designs of small two-stroke engines produced more pollution than four- stroke engines. However, modern two-stroke designs, like the Vespa ET2 Injection utilise fuel-injection and are as clean as four-strokes. Large diesel two-stroke engines, as used in ships and locomotives, have always used fuel-injection and produce low emissions

.

One of the biggest internal combustion engines in the world, the wartsila sulzer RTA96-C is a two-stroke; it is bigger than most two-storey houses, has pistons nearly 1 meter in diameter and is one of the most efficient mobile engines in existence. In theory, a four-stroke engine has to be larger than a two-stroke engine to produce an equivalent amount of power. Two-stroke engines are becoming less common in developed countries these days, mainly due to manufacturer reluctance to invest in reducing two-stroke emissions. Traditionally, two-stroke engines were reputed to need more maintenance Even though the simplest two-stroke engines have fewer moving parts, they could wear out faster than four-stroke engines. However fuel-injected two-strokes achieve better engine lubrication, also cooling and reliability should improve considerably

COMMON FEATURES IN ALL TYPES

There may be one or more pistons. Each piston is inside a cylinder, into which a gas is introduced, either already hot and under pressure (steam engine), or heated inside the cylinder either by ignition of a fuel air mixture (internal combustion engine) or by contact with a hot heat exchanger in the cylinder (Stirling engine). The hot gases expand, pushing the piston to the bottom of the cylinder. The piston is returned to the cylinder top (Top Dead Centre) either by a flywheel or the power from other pistons connected to the same shaft. In most types the expanded or "exhausted" gases are removed from the cylinder by this stroke. The exception is the Stirling engine, which repeatedly heats and cools the same sealed quantity of gas. In some designs the piston may be powered in both directions in the cylinder in which case it is said to be double acting. In all types the linear movement of the piston is converted to a rotating movement via a connecting rod and a crankshaft or by a swash plate. A flywheel is often used to ensure smooth rotation. The more cylinders a reciprocating engine has, generally, the more vibration-free (smoothly) it can operate. The power of a reciprocating engine is proportional to the volume of the combined pistons' displacement.

A seal needs to be made between the sliding piston and the walls of the cylinder so that the high pressure gas above the piston does not leak past it and reduce the efficiency of the engine. This seal is provided by one or more piston rings. These are rings made of a hard metal which are sprung into a circular groove in the piston head. The rings fit tightly in the groove and press against the cylinder wall to form a seal.

APPLICATIONS

The first successful application of the free-piston engine concept was as air compressors. In these engines, air compressor cylinders were coupled to the moving pistons, often in a multi-stage configuration. Some of these engines utilized the air remaining in the compressor cylinders to return the piston, thereby eliminating the need for a rebound device. Free-piston air compressors were in use among others by the German Navy, and had the advantages of high efficiency, compactness and low noise and vibration .

Gas generators

After the success of the free-piston air compressor, a number of industrial research groups started the development of free-piston gas generators. In these engines there is no load device coupled to the engine itself, but the power is extracted from an exhaust turbine. (The only load for the engine is the supercharging of the inlet air.)

A number of free-piston gas generators were developed, and such units were in widespread use in large-scale applications such as stationary and marine power plants. Attempts were made to use free piston gas generators for vehicle propulsion (e.g. in gas turbine locomotives) but without success.

COATINGS

Coating is a covering that is applied to an object. The aim of applying coatings is to improve surface properties of a bulk material usually referred to as a substrate. One can improve amongst others appearance, adhesion, wet ability, corrosion resistance, wear resistance, scratch resistance, etc. They may be applied as liquids, gases or solids. Coatings can be measured and tested for proper opacity and film thickness by using a Drawdown card.

NANO COATING:

Nano-coating is a recently developed technology used for coating any kind of material in hard coating and low friction coating both in which coating is done at nano scale that is of the order of 10-9 . The two major types of nano coating are

1. Physical vapour deposition (PVD)
2. Chemical vapour deposition (CVD)

PHYSICAL VAPOUR DEPOSITION (PVD)

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Thin film deposition is a process applied in the semiconductor industry to grow electronic materials and in the aerospace industry to form thermal and chemical barrier coatings to protect surfaces against corrosive environments and to modify surfaces to have the desired properties. The deposition process can be broadly classified into physical vapour deposition (PVD) and chemical vapour deposition (CVD). In CVD, the film growth takes place at high temperatures, leading to the formation of corrosive gaseous products, and it may leave impurities in the film. The PVD process can be carried out at lower deposition temperatures and without corrosive products, but deposition rates are lower and it leaves residual compressive stress in the film. Electron beam physical vapour deposition, however, yields a high deposition rate from 0.1 μm / min to 100 μm /
min at relatively low substrate temperatures, with very high material utilization efficiency.

Parameters of PVD

Deposition chamber vacuum pressure: 10-3 tor No of electron guns: 6

Accelerating voltage: 20kv-25kv

Evaporation rate: 10-2 g/cm2sec

RESULTS:

1. Define the Type of Element

Pre-processor > Element Type > Add/Edit/Delete > Solid 90

2. Define Element Material Properties

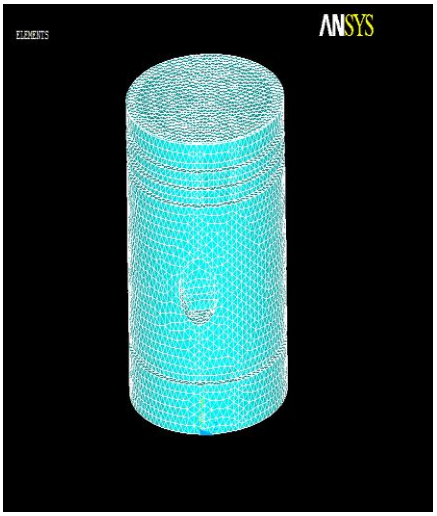
Pre-processor > Material Props > Material Models > Thermal > Conductivity > Isotropic

3. Define Mesh Size

Pre-processor > Meshing > Size Cntrls > Global >Set

4. Mesh Volumes

Pre-processor > Meshing > Mesh volume > Tet >Free Mesh >Pick all



5. Define Analysis type

Solution > Analysis Type >New Analysis > Type of Analysis > Thermal Analysis > Ok

6. Obtaining Solution

Solution >Solve >Current Ls >ok

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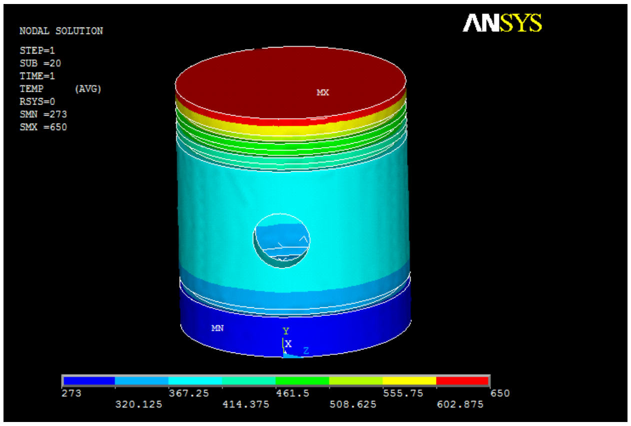
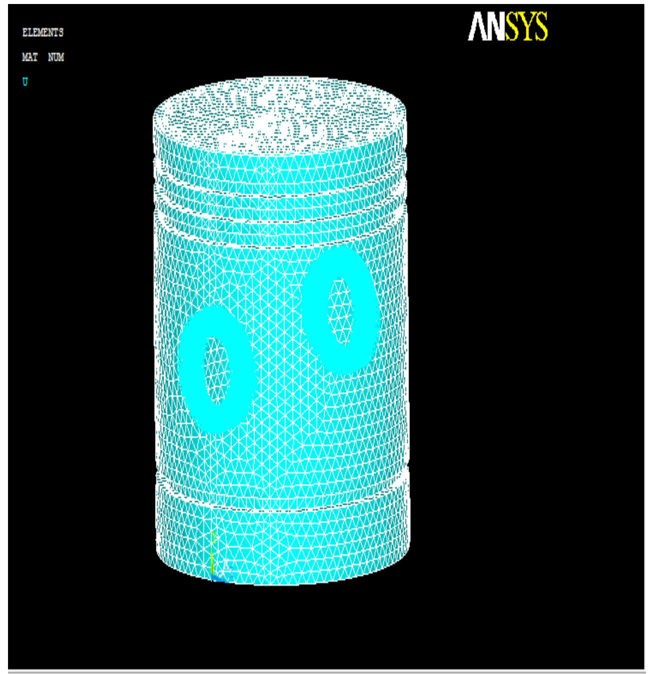


The below steps followed for the Static Analysis

1. Define the Type of Element
Pre-processor > Element Type > Add/Edit/Delete > Solid 186
2. Define Element Material Properties
Pre-processor > Material Props > Material Models > Structural >Linear >Elastic >Isotropic
Young's Modulus and Poisson's Ratio
Pre-processor > Material Props > Material Models > Structural >Thermal expansion
3. Define Mesh Size
Pre-processor > Meshing > Size Cntrls > Global >Set
4. Mesh Volumes
Pre-processor > Meshing > Mesh volume > Tet >Free Mesh >Pick all
5. Solution >Define Loads >apply >Structural >Displacement >fixed in all Dof's



6. Solution >Define Loads > Apply >Structural >Temperature >from Thermal Analysis.. Solution >Solve >current LS >ok

CONCLUSION:

A finite element model of the piston without and with coating layer is created in **ANSYS** and analyzed in the influence of thermal load on the top surface of the piston

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