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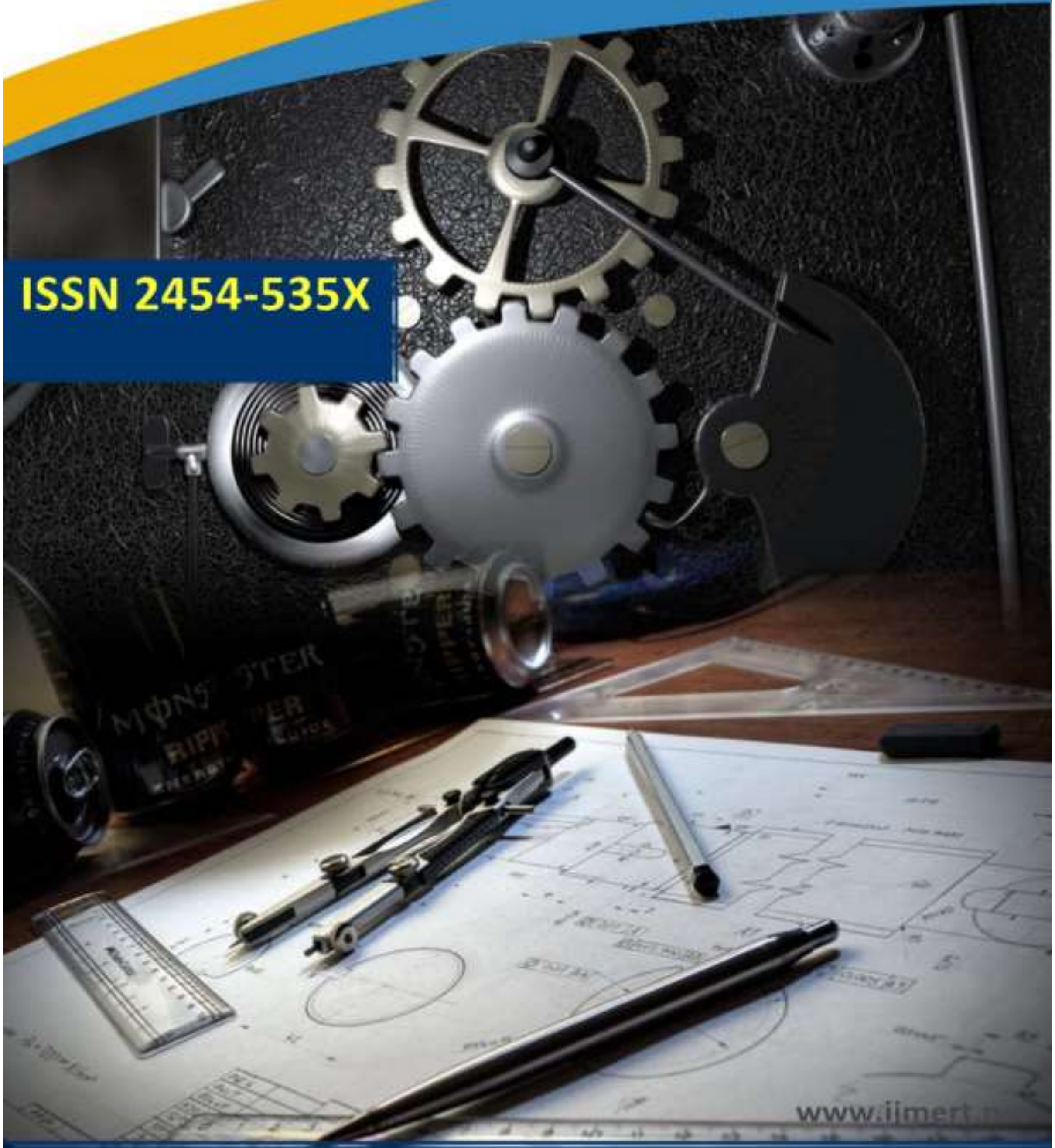

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ANALYSIS ON PISTON RINGS USING DIFFERENT MATERIALS

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Abstract

Piston rings are used in internal combustion engines to create a seal between the piston and the cylinder wall. Preventing the loss of combustion gases and ensuring efficient engine performance. The project focuses on identifying the different materials that offer superior mechanical properties, thermal conductivity, and resistance to wear and corrosion. The aim of this analysis evaluates the performance of materials that can be used in the production of piston rings and a comparison was made with the commonly used cast iron material. The study was conducted using the ANSYS software, which is a popular simulation tool used for engineering analysis. The findings of this study have significant implications for the design and manufacture of engines, particularly in terms of improving engine efficiency and reducing maintenance costs.

Keyword: static structural analysis, Titanium alloy, gray cast iron, Neo-Hookean, Piston rings.

Introduction

We almost take our Internal Combustion Engines for granted, don't we? All we do is buy our vehicles, hop in and drive around. There is, however, a history of development to know about. The compact, well-toned, powerful and surprisingly quiet engine that seems to be purr under your vehicle's hood just wasn't the tame beast it seems to be now. It was loud, it used to roar and it used to be rather bulky. In fact, one of the very first engines that had been conceived wasn't even like the engine we know so well of today. An internal combustion engine is defined as an engine in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel.

The internal combustion engine was conceived and developed in the late 1800s. It has had a significant impact on society, and is considered one of the most significant inventions of the last century. The internal combustion engine has been the foundation for the successful development of many commercial technologies. For example, consider how this type of engine has transformed the transportation industry, allowing the invention and improvement of automobiles, trucks, airplanes and trains. Internal combustion engines can deliver power in the range from 0.01 kW to 20x103 kW, depending on their displacement. The complete in the market place with electric motors, gas turbines and steam engines.

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The major applications are in the vehicle (automobile and truck), railroad, marine, aircraft, home use and stationary areas. The vast majority of internal combustion engines are produced for vehicular applications, requiring a power output on the order of 102 kW. Next to that internal combustion engines have become the dominant prime mover technology in several areas. For example, in 1900 most automobiles were steam or electrically powered, but by 1900 most automobiles were powered by gasoline engines. As of year 2000, in the United States alone there are about 200 million motor vehicles powered by internal combustion engines. In 1900, steam engine was used to power ships and railroad locomotives; today two- and four-stoke diesel engine.The components of a reciprocating internal combustion engine, block, piston, valves, crankshaft and connecting rod have remained basically unchanged since the late 1800s. The main differences between a modern-day engine and one built 100 years ago are the thermal efficiency and the

emission level. For many years, internal combustion engine research was aimed at improving thermal efficiency and reducing noise and vibration. As a consequence, the thermal efficiency has increased from about 10% to values as high as 50%. Since 1970, with recognition of the importance of air quality, there has also been a great deal of work devoted to reducing emissions from engines. Currently, emission control requirements are one of the major factors in the design and operation of internal combustion engines.

Statement of the Problem

Piston rings are essential components in internal combustion engines, playing a critical role in ensuring efficient engine performance. Their primary function is to create a seal between the piston and the cylinder wall, preventing the loss of combustion gases and facilitating the smooth functioning of the engine. Traditionally, piston rings have been made of cast iron, which was an excellent material for this purpose. However, cast iron does have some limitations that can impact engine efficiency. For instance, its fluidity can cause some of the molecules of the exhaust gases from the combustion to rest at the piston rings, leading to damage to the cylinder walls.Additionally, cast iron has relatively low thermal conductivity, which can cause the engine to heat up quickly, reducing its overall efficiency. The material is also susceptible to corrosion, which can lead to further damage over time. These limitations make it necessary to consider alternative materials for piston rings in modern engines.

Objectives of the study

- Finding out the limitations of the Cast iron material in the Piston rings.
- In order to reduce the limitations of using cast iron in piston rings, it is crucial to conduct a thorough analysis and evaluation of alternative materials that can offer better performance, durability, and reliability.
- The goal is to identify materials that can overcome the disadvantages of cast iron, such as Fluidity, and susceptibility to corrosion.

Review of Literature

Rajam, Ch et al. [1] the low grade LHR engines are using ceramic coatings on piston, liner and cylinder head, while medium grade LHR engines provide air gap in the piston and other components. It is necessary to test the coated piston for withstanding the stresses and strains.

CH. Venkatamrajam, **et al.** [2] Since the design and weight of the piston influence the engine performance. Hongyuan zhang **et al.** [3] With the definite-element analysis software, a three- dimensional definite-element analysis has been carried out to the gasoline engine piston. Considering the thermal boundary condition, the stress and the deformation distribution conditions of the piston under the coupling effect of the thermal load and explosion pressure have been calculated, thus providing reference for design improvement. Elijah Masango Munyao [4] **t**his paper involves simulation of a 2-stroke 6S35ME marine diesel engine piston to determine its temperature field, thermal, mechanical and coupled thermal-mechanical stress. The distribution and magnitudes of the aforementioned strength parameters are useful in design, failure analysis and optimization of the engine piston. The piston model was developed in solid-works and imported into ANSYS for preprocessing, loading and post processing. Material model chosen was 10-node tetrahedral thermal solid 87. The simulation parameters used in this paper were piston material, combustion pressure, inertial effects and temperature. Swati S Chougule **and** Vinayak H Khatiwada [5] **t**his work describes the stress distribution of the piston by using finite element method (FEM). FEM is performed by using computer aided engineering (CAE) software. The main objective of this project is to investigate and analyze the stress distribution of piston at the actual engine condition during combustion process. The parameter used for the simulation is operating gas pressure and material properties of piston. Radoslav Plamenov Georgiev [6] The aim of this Thesis is to introduce to the interesting world of internal combustion engines and to describe what actually Internal Combustion Engine is. What are its main components and structure. How the engine indeed operates. Also, to design a real engine, having into account all necessary calculations concerning with kinematics, dynamics and strength calculation of basic details. Another purpose of the project is to define the proper materials for each part. Next to that I will make 2D and 3D drawings on CATIA and animation of working Internal Combustion Engine. Ajay Raj Singh [7]The presented paper uses the Finite Element Method (FEM) to analyze the thermal stress and distribution of three different aluminum alloys. The simulations are carried out by evaluating the parameters like gas pressure, temperature and material properties of the Piston. The four-stroke engine of Bajaj Pulsar 220CC is used to study the analysis procedure for aluminum alloy piston.

Research Methodology

This study will use a numerical simulation approach to perform static structural analysis on piston rings with titanium and neo-Hookean material properties in ANSYS software. A 2D model of the piston ring will be created in Space claimand imported into ANSYS for analysis. The study will compare the stress distribution and deformation behavior of the piston ring made from Cast-Iron versus titanium-alloy and Neo-Hookean. The analysis will be conducted under static loading conditions. The results will be analyzed and compared to determine the advantages and disadvantages of using titanium-alloy and Neo-Hookean for piston rings in terms of their structural behavior. The below figures (1 – 3) represents the process.

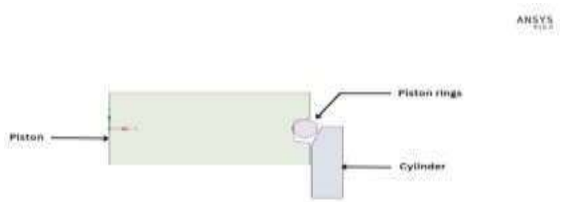
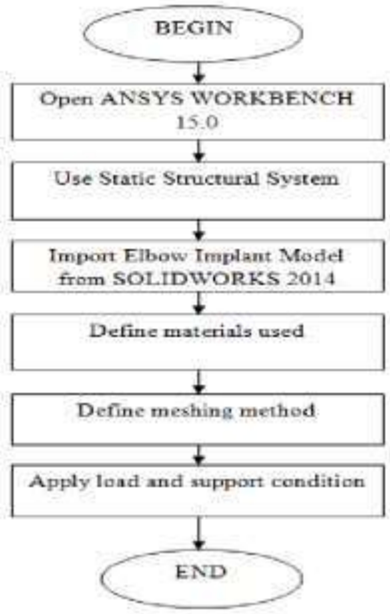


Fig1.Geometryof the piston rings

Mesh the geometry of the piston rings and setup the boundary conditions to perform the static structural analysis on the Piston rings. Assign materials for the Piston rings, to understand the stresses and deformation of that materials. Use Static Structural within the Workbench Environment to take advantages of efficient model setup afforded by Ansys Mechanical.

Fig 2 Workflow optimization using ANSYS



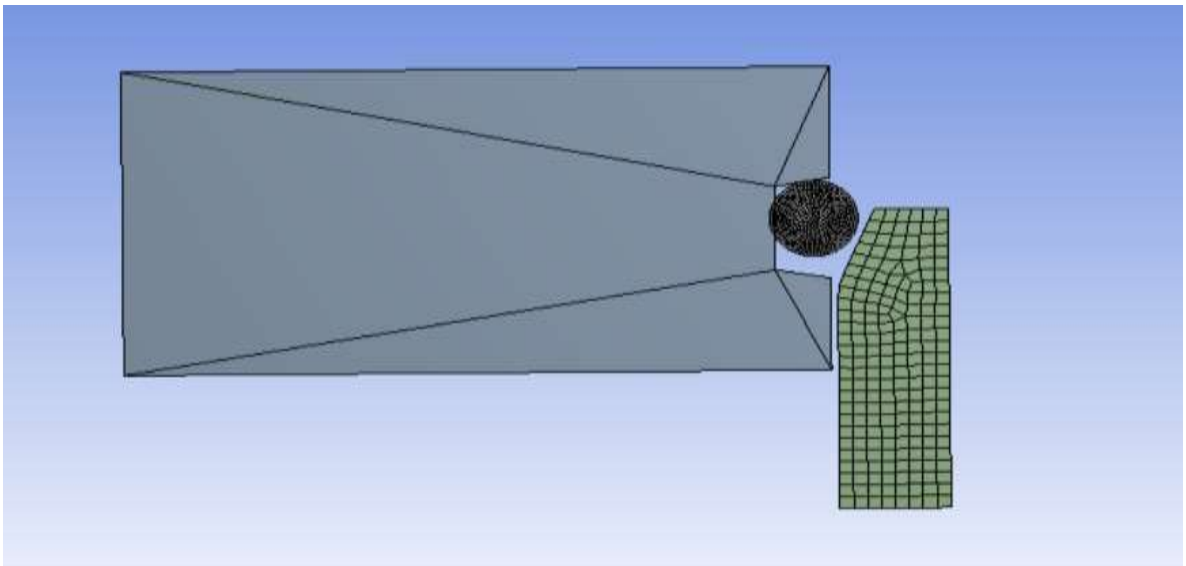


Fig 3. Domain mesh of Piston rings

Total no. of nodes: 866
Total no. of elements: 792
Shape of the element: Rectangle

Results &Discussion:

The ANSYS software static structural analysis results are shown in Figures 4 to 11. These figures depict the Total Deformation, Cylinder Deformations, and Equivalent Stress induced on the piston rings. The analysis was performed by changing the material of the piston rings to three different materials, namely elastomer, cast iron, and titanium alloy.

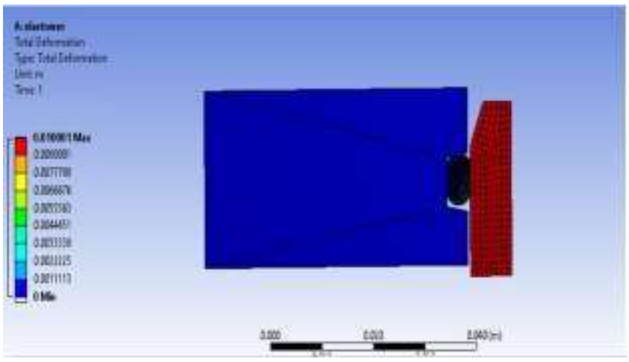


Fig4 Total Deformation of the elastomer

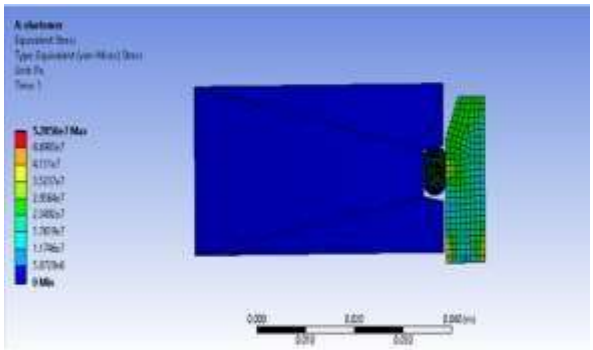


Fig 5 Equivalent Stress of the elastomer

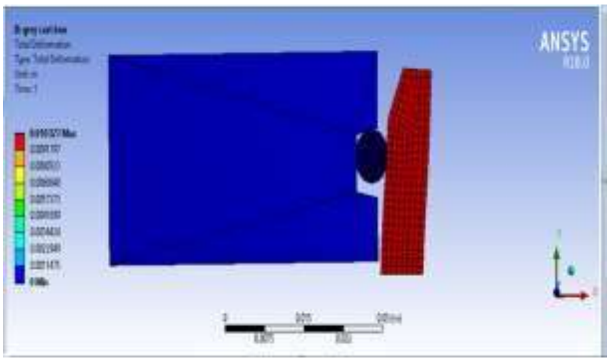


Fig 6 Total Deformation of the Grey cast iron

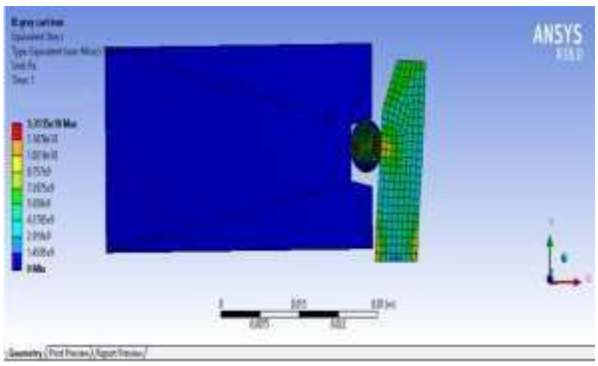


Fig 7 Equivalent Stress of the Grey cast iron

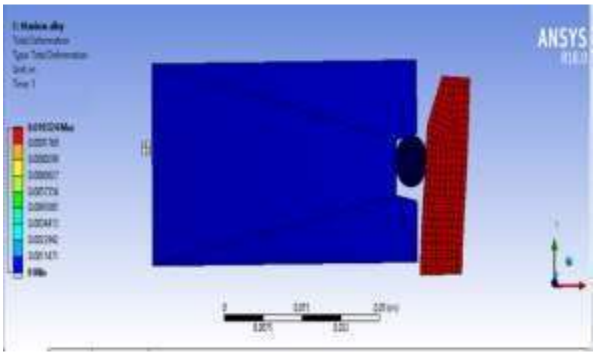


Fig 8 Total Deformation of the Titanium alloy

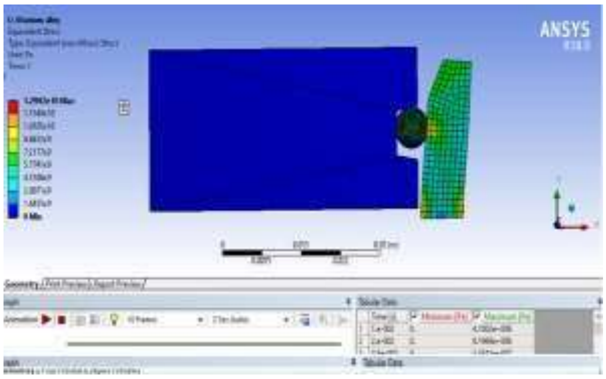


Fig 9 Equivalent Stress of the Titanium alloy

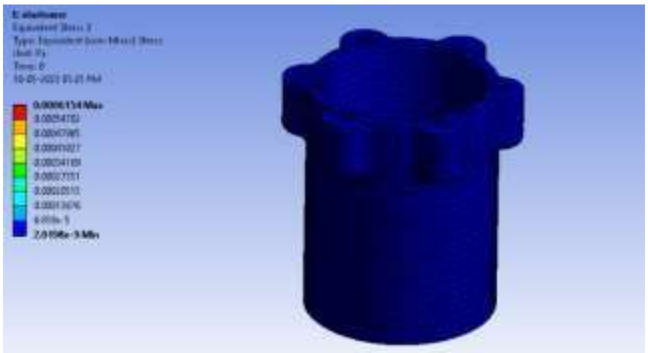


Fig 10Equivalent Stress of Cylinder with the elastomer as the piston rings

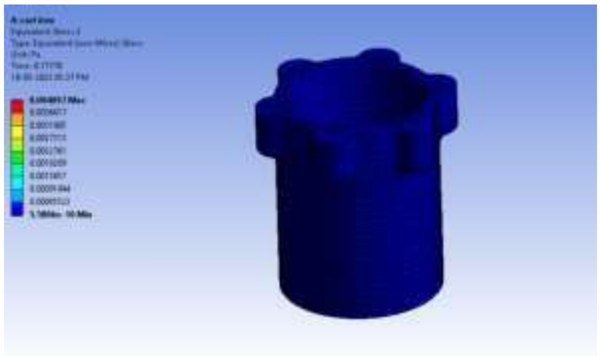
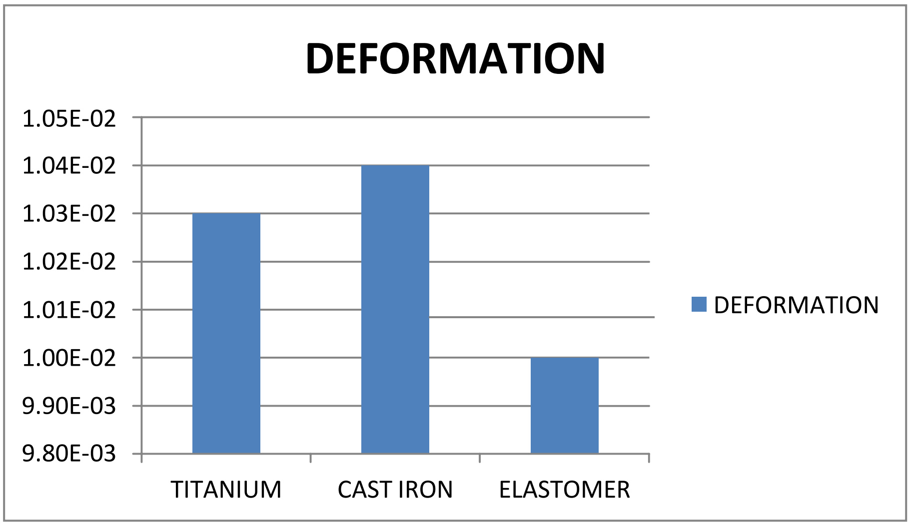


Fig 11Equivalent Stress of Cylinder with the cast iron as the piston rings

Results:



Graph :1 Deformation of the Titanium , Cast iron , Elastomer

We analyze the piston rings with the cast iron,titanuim,elastomer Materials in the static structural Condition in the ANSYS Sofware to find the best material for the piston rings.We get the Deformation and stress from the analysis there were illustrated in the graph 1 above and properties are shown in table 1.

Table: 1 Stress of the Grey cast iron, Titanium, Elastomer

MATERIAL	STRESS
GREY CAST IRON	1.3*E10
TITANIUM	1.2*E10
ELASTOMER	5.3*E7

CONCLUSION:

In this paper finite element analysis for static structural conditions of the engine piston rings with different materials was performed. The main objective of this project was to study the response of titanium alloy, grey cast iron and elastomer for the load. From the results it is concluded that the piston with elastomer material is having less defections, while the piston with titanium alloy and grey cast iron is having more deflections for the applied load. It is also observed that the stress for all the materials is within the allowable limits of the respective material. In this project for complex designs it is recommended the use of the stress analyses software because complex geometries may cause larger errors in the analytical procedure.

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