ISSN NO: 9726-001X
Volume 10 Issue 01 2022

JOURNAL OF CURRENT SCIENCE

ANALYSIS ON PISTON RINGS USING DIFFERENT MATERIALS

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Abstract

In internal combustion engines, the piston and cylinder wall are sealed by piston rings. Keeping the engine's combustion gases contained and maximising its performance. Finding the best materials in terms of mechanical characteristics, thermal conductivity, and corrosion and wear resistance is the main goal of the project. The purpose of this study is to compare and contrast the performance of various materials with that of cast iron, a material that is often used to make piston rings. A well-known simulation tool for engineering analysis, ANSYS, was employed to perform the research. Improving engine efficiency and decreasing maintenance costs are two areas where this study's results might have a major impact on engine design and manufacturing.

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

Introduction

Internal combustion engines are so commonplace that we hardly notice when they're not working. Buying cars and then driving around is all we do. But you should be aware that there is a progression in development. Your vehicle's engine, which is currently small, well-toned, strong, and shockingly silent, wasn't always that subdued. It used to roar, be fairly large, and be very loud. really, the engine we are familiar with today was really based on one of the first concepts that had been considered. In contrast to external combustion engines, which require a separate combustor to convert chemical energy from fuel into mechanical effort, internal combustion engines do it all within the engine. to ignite the gasoline. Late in the nineteenth century, the idea of an internal combustion engine began to take shape. As one of the most groundbreaking innovations of the twentieth century, it changed the way people live and work. The development of several commercial innovations may be traced back to the internal combustion engine. Take the development and improvement of vehicles, trucks, aircraft, and trains as an example of how this engine type has revolutionised the transportation sector. Power output from internal combustion engines may vary from 0.01 kW all the way up to 20x103 kW, with the exact value dependent on the engine's displacement. Competitors in the market use steam engines, gas turbines, and electric motors.

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Major markets include transportation (cars and trucks), transportation (railroads and ships), aviation, residential, and other fixed settings. Most internal combustion engines have a power output of about 102 kW and are designed for use in vehicles. In addition, internal combustion engines have surpassed all other technologies as the standard for prime mover applications in a number of sectors. The majority of vehicles in use today use petrol engines, in contrast to their steam or electrical predecessors in the early 20th century. Roughly 200 million cars, trucks, and SUVs in the US alone use internal combustion engines as of the year 2000. Two- and four-stroke diesel engines are utilised nowadays to power ships and railway trains, but before 1900, steam engines were employed.There hasn't been much modification to the block, piston, valves, crankshaft, and connecting rod that make up an internal combustion engine that reciprocates since the late 1800s. When comparing engines from the past and the present, thermal efficiency and the

level of emissions. Improving thermal efficiency and decreasing noise and vibration were long-term goals of research into internal combustion engines. The result is a thermal efficiency that may reach 50%, up from 10% before. Much effort has gone into lowering engine emissions since 1970, when the significance of air quality was first acknowledged. One of the most important considerations in the development and maintenance of internal combustion engines nowadays is the need to manage emissions.

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Statement of the Problem

Internal combustion engines couldn't function without piston rings, which perform a the engine's efficiency depends on it. Their principal role is to seal the piston to the cylinder wall, which stops combustion gases from escaping and keeps the engine running smoothly. Cast iron has long served as the standard for piston rings because of its durability and reliability. On the other hand, cast iron does have some restrictions that could affect how efficient an engine is. The combustion exhaust gas molecules, for example, might settle on the piston rings due to its fluidity, damaging the cylinder walls.Also, the engine may overheat due to cast iron's limited thermal conductivity, which lowers its efficiency. Corrosion, which the material is prone to, might cause more harm over time. As a result of these restrictions, contemporary engines must explore other materials for piston rings.

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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

According to Rajam, Ch et al. [1], low-grade LHR engines have ceramic coatings on the cylinder head, piston, and liner, while medium-grade LHR engines have an air gap between the piston and other parts. To ensure the coated piston can endure the strains and stresses, testing it is essential. The authors of the study are CH. Venkatamrajam and colleagues. [2] Because the engine's performance is affected by the piston's design and weight. Zhang Hongyuan et al.
A three-dimensional definite-element analysis was applied to the petrol engine piston using the definite-element analysis program. Taking into account the thermal boundary condition, we have computed the piston's stress and deformation distribution conditions under the coupling impact of the thermal load and explosion pressure. This provides a reference for improving the design. Munyao Elijah Masango Ph.D. The temperature field, thermal stress, mechanical stress, and combined thermal-mechanical stress of a 2-stroke 6S35ME marine diesel engine piston are simulated in this work [4]. Design, failure analysis, and engine piston optimisation may all benefit from knowing the distribution and magnitudes of the strength characteristics described earlier. For preprocessing, loading, and postprocessing, the piston model was brought into ANSYS from Solid-works. The 10-node tetrahedral thermal solid 87 was selected as the material model. This paper's modelling parameters included temperature, inertial effects, combustion pressure, piston material, and piston material. Chitiwada Vinayak and Chougule Swati This study details the piston's stress distribution [5].

where the finite element technique (FEM) is used. Computer assisted engineering (CAE) programs are used to conduct FEM. One of the primary goals of this research is to study the distribution of piston stress under real engine conditions while combustion is taking place. Operating gas pressure and piston material qualities are the parameters used in the simulation. Dr. Radoslav Plamenov Georgiev In this thesis, I will define an internal combustion engine and provide an introduction to the fascinating field of such engines. Give me the rundown of its structure and primary parts. The actual functioning of the engine. Additionally, to plan a functioning engine while taking into consideration all essential computations pertaining to fundamental features of kinematics, dynamics, and strength. Another purpose of the project is to define the

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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.

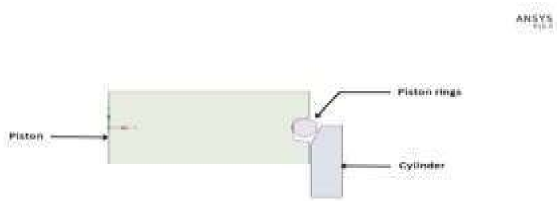

Fig1.Geometryof the piston rings

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.

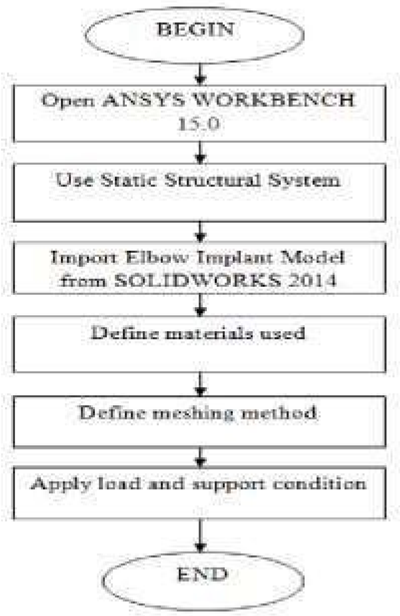

Fig 2 Workflow optimization using ANSYS

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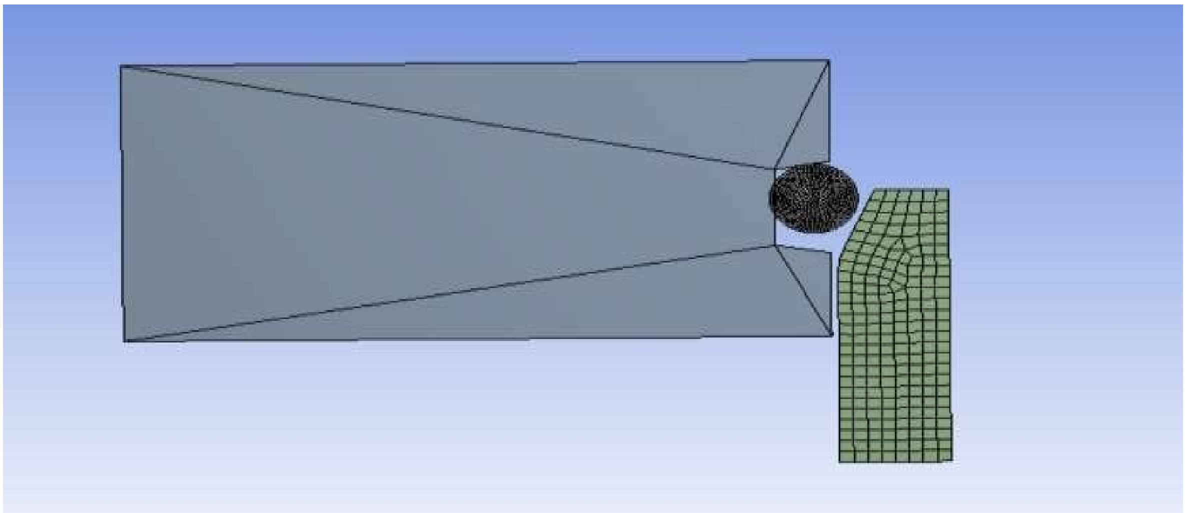


Fig 3. Domain mesh of Piston rings

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

Results &Discussion:

Figures 4–11 show the results of the static structural study conducted using the ANSYS program. All of the cylinder deformations, equivalent stress, and total deformation experienced by the piston rings are shown in these figures. To conduct the study, three distinct materials—elastomer, cast iron, and titanium alloy—were substituted for the original piston rings.

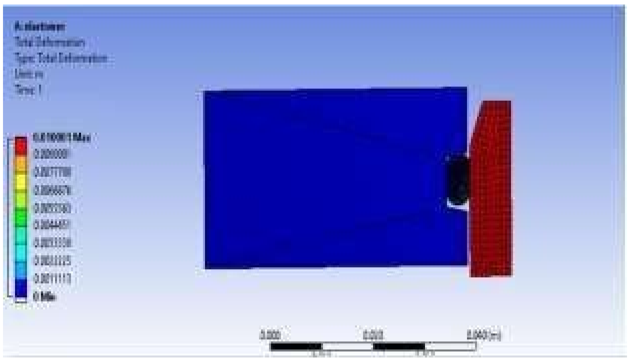


Fig4 Total Deformation of the elastomer

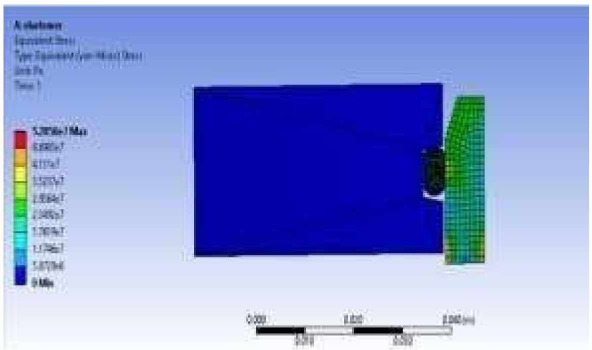
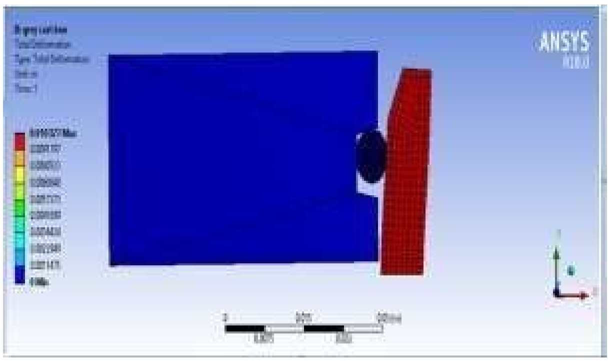


Fig 5 Equivalent Stress of the elastomer



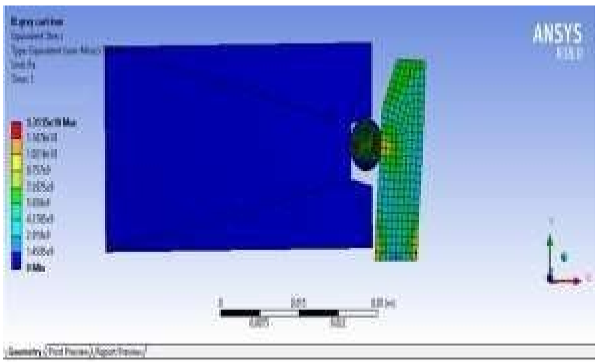


Fig 6 Total Deformation of the Grey cast iron

Fig 7 Equivalent Stress of the Grey cast iron

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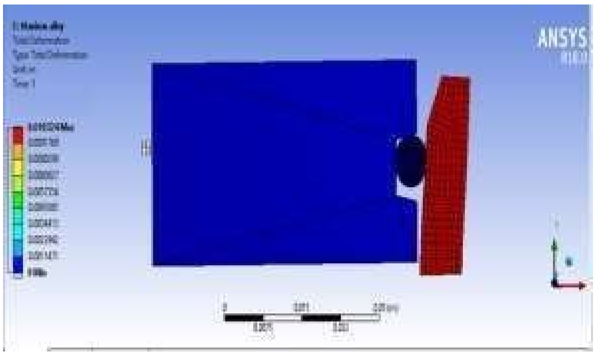


Fig 8 Total Deformation of the Titanium alloy

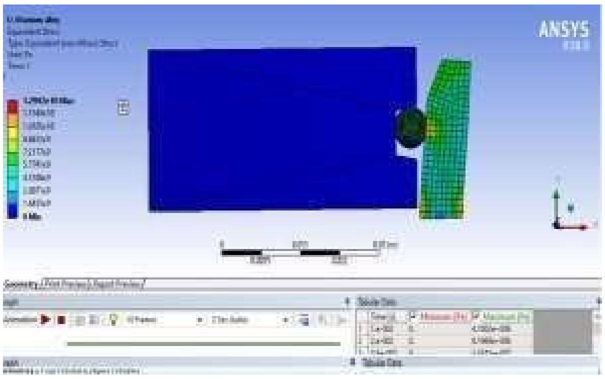


Fig 9 Equivalent Stress of the Titanium alloy

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

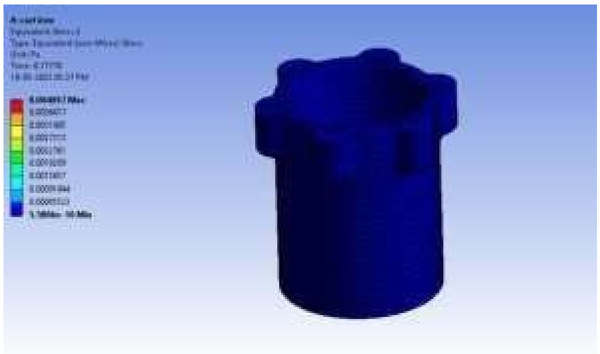
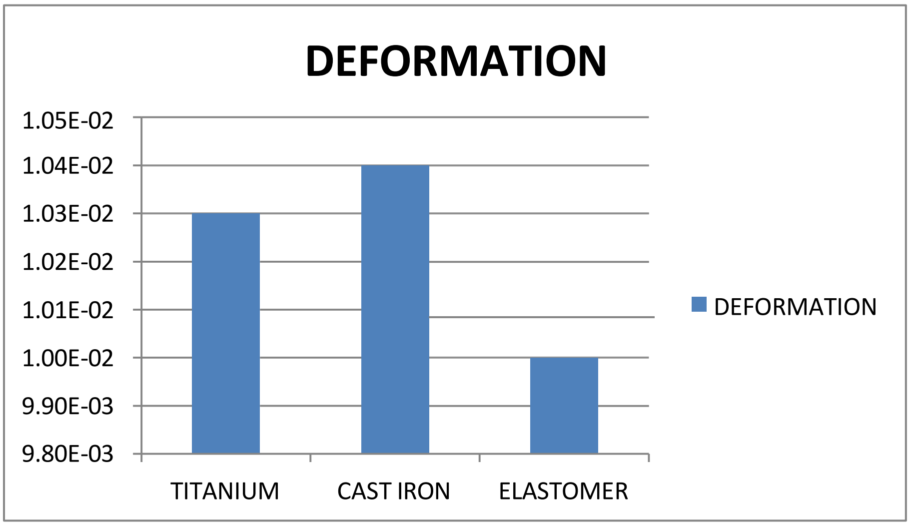


Fig 11Equivalent Stress of Cylinder with the cast iron as the piston rings

Results:



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

In order to determine the optimal material for the piston rings, we conduct an analysis using the ANSYS software in a static structural condition using cast iron, titanium, and elastomer materials.The results of the study, which are shown in graph 1 and table 1, reveal the deformation and stress.

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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:

This work presents the results of a finite element analysis (FEA) study of engine piston rings made of various materials under static structural circumstances. Investigating how elastomer, titanium alloy, and grey cast iron react to the load was the primary goal of this research. The findings show that the elastomer piston has less defects than the titanium alloy and grey cast iron pistons at the same load, however the latter exhibit larger deflections. In addition, we can see that the stress levels of all the materials are well within their respective tolerances. Because complicated geometries may lead to bigger mistakes in the analytical technique, the stress analysis software is suggested for usage in this project with complicated designs.

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