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A REVIEW PAPER ON MODELING AND ANALYSIS OF TWO STROKE PISTON OF ALLOY USING FEA

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ABSTRACT

The relentless pursuit of enhanced performance and efficiency in internal combustion engines has propelled research into the intricate dynamics of engine components, with a particular focus on the piston a critical element in the combustion process. This review paper delves into the modeling and analysis of two-stroke pistons crafted from alloy materials, employing Finite Element Analysis (FEA) as a powerful tool to scrutinize their structural integrity, thermal behavior, and overall performance. The paper commences by offering an overview of the historical evolution and significance of two-stroke engines, emphasizing the pivotal role of pistons in optimizing combustion efficiency. Subsequently, it conducts a comprehensive survey of the diverse alloys employed in modern piston design, considering their material properties and their implications on strength, weight, and thermal conductivity.

Keywords: Piston, Alloy, FEA, Performance, Modelling and Analysis.

1. INTRODUCTION

Internal combustion engines, particularly those employing two-stroke cycles, have long been at the forefront of the automotive and small-scale power generation industries. The relentless pursuit of enhanced performance, fuel efficiency, and environmental sustainability has driven extensive research into the intricate dynamics of engine components. Among these, the piston stands out as a critical component influencing combustion efficiency, thermal management, and overall engine performance. This review paper aims to provide a comprehensive analysis of the modeling and analysis of two-stroke pistons crafted from alloy materials, with a specific focus on the application of Finite Element Analysis (FEA) as a powerful tool for understanding and optimizing their performance. Historically, two-stroke engines have been favored for their simplicity, lightweight design, and higher power-to-weight ratios compared to their four-stroke counterparts. However, achieving optimal performance in these engines necessitates a thorough understanding of the structural and thermal behaviors of their constituent parts, with the piston playing a central role. Alloy materials, known for their superior strength-to-weight ratios and thermal properties, have become integral in modern piston design, presenting an exciting avenue for research and innovation. The integration of Finite Element Analysis into the study of two-stroke pistons has revolutionized the ability to model and simulate their behavior under varying operational conditions. FEA allows researchers and engineers to explore complex interactions within the piston, providing insights into stress distribution, deformation, thermal gradients, and vibrational modes. Through advanced simulations, the impact of alloy selection, geometric intricacies, and manufacturing processes on the overall performance of two-stroke pistons can be systematically investigated.as shown in figure 1.

Figure 1 Two Stroke Piston

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2. LITERATURE REVIEW

Literature reviews are integral components of academic research papers, theses, dissertations, and scholarly articles. They serve to situate the research within the existing body of knowledge, demonstrate the researcher's familiarity with prior work, and justify the need for new investigations.

Antoni Jankowski (2023) The latest intensive researches are directed on advanced low-temperature combustion (LTC), homogeneous charge compression ignition (HCCI), pre-mixed charge compression ignition (PCCI), reactivity-controlled compression ignition (RCCI) and lean-burn petrol are presented in the paper. Engines with the direct injection of petrol (GDI) and Common Rail are subject of the paper. Engines the Scuderi and Holubowicz are described. The schema of Scuderi of engine is introduced. The original model of the combustion process is presented. Combustion rate at occurring of convection, velocity components of gases of liquid fuels changes combustion processes of these fuels.[1]

A.K. Azad et. al. (2023) The combustion phenomena of biodiesel and its blends are not the same as fossil diesel combustion in compression ignition (CI) engines due to their different physio-chemical fuel properties. The combustion of biodiesels is just like the combustion of fossil diesel which emits toxic gases such as nitric oxides (NOx) and particulate matter (PM), CO, HC etc. The paper has been critically reviewed the recently developed combustion strategies for biodiesel combustion in CI engine. Low temperature combustion (LTC) is one of the recently developed strategies that have three different categories, namely homogeneous charge, premixed charge and reactive controlled compression ignition which have been briefly discussed here. The study identified that LTC strategy can significantly reduce PM and NOx emission by combustion of biodiesel.[2]

Jalaj Maheshwari et. al. (2022) The study of combustion in engines has been under significant pressure for improvement. In this project we study the effects of varying geometry on the different parameters of the engine during combustion in a 4-stroke Compression Ignition (CI) engine operating on a diesel cycle, using diesel as a primary fuel. We first discuss the various types of Internal Combustion engines and briefly discuss the cycles they work on, particularly the Otto cycle and the Diesel cycle. We have further defined two distinct geometries which we use for our simulations. Here we make a crude approximation about the combustion process involving the power stroke.[3]

Pravesh Tediya and Shahnawaz Ansari (2022) In order to develop design guidelines for optimum operations of internal combustion engines fuel with alternative fuels, comprehensive understanding combustion behavior and the pollutant formation inside the cylinder are needed. The first part of this study aimed to numerically study the combustion performance in a CI engine fuel (Diesel) with Ethanol and Methanol. Advanced simulations were performed using multi-dimensional software Fluent coupled with CHEMKIN. Formation rates of nitrogen oxides (NOx) within the engine were accurately predicted using the extended chemkin mechanism.[4]

Mithilesh Kumar Sahu et. al. (2022) The exhaust gas from an internal combustion engine carries away about 30% of the heat of combustion. The energy available in the exit stream of many energy conversion devices goes to waste, if not utilized properly. The major technical constraint that prevents the successful implementation of waste heat recovery is due to its intermittent and time mismatched demand and availability of energy. In this regard, the present work focused on investigating the thermal potential available at the diesel engine exhaust and its utilization for various applications.[5]

Vishal Sapkal and Kamal Ukey (2021) Cylinder head is a critical part of an I C engines cylinder head is used to seal the working ends of the cylinder and accommodates combustion chamber in its cavity, spark plug and valves. The heat generated in combustion chamber is highly dynamic and allows very little time (few micro seconds) to transfer the heat if not distributed will lead to squeezing of piston due to overheating. Hence an effective waste heat distribution through cylinder head plays a very important role in smooth function of I C engine. Heat Transfer through cylinder head consists of conduction through walls and convective heat transfer due to surrounding air flow.[6]

Gajanan Dinkarrao More (2021) this study is carried out in view to verify and suggest design for reduction of mass & cost for connecting rod made by structural steel for 970 CC four-cylinder four stroke engine. Every stroke in the engine is need to have to its nearby components to cyclic loading that push and pulls the crankshaft and connecting rod. The design of the connecting rod can be done in a specified manner, if study carried out to identify the effects of the operating loads on the component in the form of the type of stress induced with its higher value and the identification of areas where stresses over the component.[7]

N L Narasimha Reddy (2021) Co-Axial jets have applications in areas where the mixing of two fluid jets is necessary, the two fluid jets can be effectively mixed by producing the turbulence flow. Turbulence is a chaotic behavior of the fluid particles that comes in to picture when the inertia force of the flow dominates the viscous force and it is characterized by the Reynolds Number. Co-axial jets are effective in producing the turbulence. In the present study the free compressible turbulent coaxial jet problem will be computed using CFD, and compare with different non circular coaxial jets based on constant hydraulic diameter and mass flow rate.[8]

Pagadala Siddiraju and Koppula Venkateswarareddy (2021) In the present work describes the stress distribution and thermal stresses of Five different materials for piston by using finite element method (FEM), testing of mechanical properties. The parameters used for the simulation are operating gas pressure, temperature and material properties of piston. The specifications used for this study of these pistons belong to four stroke single cylinder engine of Pulsar 220cc motorcycle.[9]

Novi Shobi Hendr et. al. (2020) Frigate Class Vessel is one of the flagships of the Indonesian Navy. The average air temperature after repowering in the engine room is ranged from 60°C-65°C, while the maximum air temperature recommended based on the Lloyds Register is below 45°C. This condition affects the performance of equipment and machine operators in it. The in and out air circulation of the engine room is not sufficient for the air required. The and out Duct design is designed to keep the room temperature following standard requirements specified. This can be known by simulation using Ansys Computational Fluid Dynamics (CFD).[10]

P. ViswabharathyIn et. al. (2019) this paper, the wok is carried out to measure the stress and temperature distribution on the top surface of the piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Pistons fail mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition and uneven temperature distribution from piston head to skirt. The analysis predicts that due to temperature whether the top surface of the piston may be damaged or broken during the operating conditions.[11]

3. RESEARCH GAP

While significant strides have been made in the modeling and analysis of two-stroke pistons, particularly those crafted from alloy materials using Finite Element Analysis (FEA), there remains a discernible research gap that warrants attention and further investigation.

The existing literature reveals several key areas where gaps persist, limiting our comprehensive understanding and impeding the development of optimal designs for these critical engine components.

4. OBJECTIVE OF PROPOSED WORK:

Conduct an extensive review of the existing literature on the modeling and analysis of two-stroke pistons crafted from alloy materials using Finite Element Analysis (FEA). Summarize the historical context, evolution, and key findings in the field, providing a foundation for the subsequent objectives.

- Investigate Dynamic Analysis under real world
- Examine Finite Element Analysis
- Evaluate Alloy Materials for Two-Stroke Piston

5. METHODOLOGY

Conduct an extensive review of existing literature related to the modeling and analysis of two-stroke pistons made of alloy using Finite Element Analysis (FEA).

This will involve a comprehensive search of scientific databases, journals, conference proceedings, and relevant books to gather insights into the historical evolution, methodologies employed, and key findings in the field. Evaluate the mechanical, thermal, and other pertinent material properties of alloy materials commonly used in two-stroke piston manufacturing. This will involve a systematic analysis of peer-reviewed articles, technical reports, and material databases to compile a comprehensive dataset for each alloy under consideration. Explore and analyze various Finite Element Analysis (FEA) techniques utilized in the modeling and simulation of two-stroke pistons. This involves reviewing literature on structural analysis methods for stress distribution, thermal analysis for heat dissipation, and modal analysis for vibrational modes. Critically assess the strengths and limitations of different FEA approaches in predicting the behavior of alloy pistons.

6. CONCLUSION

The review paper on the modeling and analysis of two-stroke pistons made of alloy using Finite Element Analysis (FEA) has provided a comprehensive overview of the current state of research in this dynamic field.

The synthesis of findings and insights from the literature, coupled with the methodologies employed in this review, offers valuable contributions to the understanding and advancement of internal combustion engine technology. The exploration of alloy materials commonly used in two-stroke piston manufacturing revealed a nuanced understanding of their mechanical, thermal, and other relevant properties. By assessing the strengths and limitations of each alloy, this review lays the groundwork for informed material selection, an essential aspect in optimizing the design of two-stroke pistons.

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