Thermo-Mechanical Behaviour of Engine Pistons: A Review of Structural and Thermal Analysis Approaches

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Abstract: The piston is a critical component in internal combustion engines, operating under extreme mechanical and thermal conditions that significantly influence engine performance, efficiency, and durability. This review paper presents a comprehensive analysis of existing research on the structural and thermal behaviour of pistons, with particular emphasis on finite element analysis (FEA)-based approaches. The literature indicates that pistons are subjected to complex thermo-mechanical loading, where thermal stresses often play a dominant role alongside mechanical stresses. Critical regions such as the piston crown, ring grooves, and pin boss consistently exhibit maximum stress concentration and temperature gradients, making them prone to deformation and failure. The review highlights that FEA, integrated with CAD modelling and simulation tools like ANSYS, has become an essential method for evaluating stress distribution, deformation, and heat transfer characteristics. Various studies emphasise the importance of material selection, demonstrating that while aluminium alloys offer high thermal conductivity, advanced materials such as composites and carbon-based materials provide improved strength and thermal resistance. Additionally, the application of thermal barrier coatings has been shown to enhance piston performance by reducing heat transfer and minimising thermal stresses. Furthermore, the influence of operating conditions, including engine load and combustion temperature, is identified as a key factor affecting piston behaviour. The review concludes that optimising piston design requires a combined approach involving material innovation, geometric optimisation, and advanced thermo-mechanical simulations. The findings provide valuable insights for improving piston durability, efficiency, and reliability in modern engine systems.

Keywords: *Piston; Structural Analysis; Thermal Analysis; Thermo-Mechanical Behaviour; Finite Element Analysis (FEA); Temperature Distribution; Thermal Stress.*

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I. INTRODUCTION

The piston is a critical reciprocating component in internal combustion engines, responsible for transmitting the force generated by combustion to the crankshaft through the connecting rod. Operating under severe mechanical and thermal conditions, the piston is subjected to high pressure, cyclic loading, and elevated temperatures, making its structural integrity and thermal performance vital for overall engine efficiency, durability, and reliability. In modern automotive and industrial applications, increasing demands for higher power output, fuel efficiency, and reduced emissions have intensified the need for optimised piston design and material selection. Structural analysis of pistons focuses on evaluating stress distribution, deformation, fatigue behaviour, and failure mechanisms under dynamic loading conditions. Pistons experience complex stresses due to combustion pressure, inertia forces, and thermal expansion, which can lead to phenomena such as crack initiation, plastic deformation, and wear. Advanced computational techniques, particularly Finite Element Analysis (FEA), are widely employed to simulate these conditions and predict the mechanical performance of piston

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geometries under varying operating parameters. Such analyses enable engineers to identify critical stress zones and optimise design parameters such as crown thickness, skirt profile, and ring groove configuration. Thermal analysis, on the other hand, examines temperature distribution, heat transfer characteristics, and thermal stresses within the piston during engine operation. Since pistons are directly exposed to high-temperature combustion gases, efficient heat dissipation is essential to prevent overheating, thermal distortion, and material degradation. The temperature gradient across the piston influences its expansion behaviour, lubrication conditions, and clearance with the cylinder wall. Materials such as aluminium alloys and advanced composites are commonly investigated due to their favourable thermal conductivity and strength-to-weight ratios. Computational fluid dynamics (CFD) and coupled thermo-mechanical simulations are increasingly utilised to understand heat flow and its interaction with structural responses. The integration of structural and thermal analyses provides a comprehensive understanding of piston performance under real-world conditions. Recent advancements in simulation tools, material science, and manufacturing technologies— such as additive manufacturing and surface coatings—have further enhanced the capability to design pistons with improved strength, reduced weight, and enhanced thermal resistance. Consequently, a systematic review of existing literature on structural and thermal analysis of pistons is essential to identify prevailing methodologies, key findings, research gaps, and future directions in this domain.

II. LITERATURE REVIEW

[1] Liu (2017) conducted a detailed finite element analysis of thermo-mechanical conditions within a diesel engine piston to evaluate the coupled effects of thermal loading and mechanical stresses. The study developed a three-dimensional piston model and applied realistic boundary conditions representing combustion pressure and temperature distribution. Results indicated that the piston crown experiences the highest temperature and stress concentration due to direct exposure to combustion gases. The analysis further revealed that thermal stresses significantly influence the overall stress field, often exceeding purely mechanical stresses. Critical regions such as the ring grooves and piston pin bosses were identified as potential failure zones. The study emphasized the importance of considering thermo-mechanical coupling rather than isolated structural or thermal analysis for accurate prediction of piston performance. Additionally, the findings highlighted that optimized material selection and improved cooling mechanisms are essential to enhance piston durability and reduce the risk of thermal fatigue failure.

[2] Lu et al. (2017) analysed the steady-state temperature field and corresponding thermal stresses in a diesel engine piston using finite element methods. The study focused on understanding heat transfer behaviour under stable operating conditions by incorporating realistic thermal boundary conditions such as convection and conduction. The results demonstrated a non-uniform temperature distribution, with maximum temperatures observed at the piston crown and significantly lower values toward the skirt region. This temperature gradient led to substantial thermal stresses, particularly around the combustion chamber and ring grooves. The authors concluded that thermal stress plays a dominant role in piston deformation and potential crack initiation. The research also highlighted the importance of accurate thermal modelling in predicting piston life and performance. Furthermore, the study suggested that design modifications and material improvements can effectively minimize thermal stress concentrations and enhance engine efficiency and reliability.

[3] Wakshume et al. (2025) performed a comparative finite element analysis to evaluate the thermo-mechanical performance of engine pistons made from different materials. The study investigated stress distribution, temperature variation, and deformation characteristics under combined thermal and mechanical loading conditions. Results showed that material properties significantly influence piston behaviour, with advanced alloys and composite materials demonstrating improved thermal resistance and lower deformation compared to conventional aluminium alloys. The analysis identified critical stress regions at the piston crown and pin boss, consistent with prior studies. Additionally, the study highlighted that lightweight materials can reduce inertia forces while maintaining structural integrity, thereby improving engine performance. The authors emphasized the role of material optimization in enhancing piston durability and efficiency. The findings contribute to the development of high-performance pistons by providing insights into selecting suitable materials for better thermo-mechanical stability.

[4] Qian et al. (2025) investigated the thermal and stress fields of a coated diesel engine piston using finite element analysis, with particular emphasis on the impact of thermal barrier coatings. The study demonstrated that coatings significantly reduce heat transfer to the piston substrate, thereby lowering the temperature of the underlying material. As a result, thermal stresses within the piston were reduced, enhancing structural stability and resistance to thermal fatigue. The coated piston exhibited improved temperature distribution compared to uncoated configurations, with reduced peak temperatures at the crown. The analysis also indicated that coating thickness and material properties play a crucial role in determining overall performance. The authors concluded that thermal barrier coatings are an effective strategy for improving piston efficiency, reducing heat loss, and increasing engine durability. This work provides valuable insights into advanced surface engineering techniques for modern engine components.

[5] Velugula et al. (2023) conducted an integrated analysis of mechanical and thermal stresses in both the piston and cylinder of direct-injection engines using finite element methods. The study examined the interaction between piston and cylinder under realistic operating conditions, including combustion pressure and heat transfer effects. Results revealed

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that both components experience significant stress concentrations, particularly in the piston crown and cylinder liner interface. The combined thermomechanical loading was found to intensify stress levels compared to individual analyses. The study also highlighted the importance of proper clearance and lubrication in reducing friction-induced stresses. Furthermore, it was observed that temperature gradients significantly affect material expansion and stress distribution. The authors concluded that a coupled analysis of piston and cylinder provides a more comprehensive understanding of engine behaviour. The findings are useful for optimizing engine design to improve durability, efficiency, and performance under high-load conditions.

[6] Anugu (2021) developed a theoretical model of a diesel engine piston and performed finite element analysis to evaluate its structural and thermal performance under realistic operating conditions. The piston geometry was designed using CAD tools and analysed under combined pressure and temperature loads. The study emphasized the significance of material selection, particularly aluminium alloys and metal matrix composites, in improving piston performance. Results indicated that thermo-mechanical loading plays a crucial role in stress distribution and deformation characteristics. The analysis identified critical regions such as the piston crown and skirt as highly susceptible to stress concentration. Furthermore, the study demonstrated that advanced composite materials can significantly reduce deformation and improve strength compared to conventional alloys. The research concluded that integrating theoretical modelling with FEA provides an effective approach for optimizing piston design and enhancing durability in diesel engine applications.

[7] Roychoudhury (2021) carried out finite element modelling of a coated engine piston to investigate the improvement in material strength and thermal resistance. The study focused on the combined effects of surface coatings and geometric modifications on piston performance. Results revealed that coating materials significantly enhance the load-bearing capacity and reduce stress concentration in critical regions such as the piston crown. Additionally, coatings were found to improve thermal insulation, thereby lowering heat transfer to the piston core and reducing thermal stresses. The research highlighted that optimized coating thickness and material selection are essential for achieving maximum performance benefits. The study concluded that coated pistons offer superior mechanical strength and thermal stability compared to uncoated pistons, making them suitable for high-performance engine applications.

[8] Muhammad et al. (2020) conducted a finite element analysis of heat transfer in a piston-cylinder assembly to understand the thermal behaviour under engine operating conditions. The study focused on evaluating temperature distribution and heat flux across the piston and cylinder interface. Results indicated that heat transfer is highly nonuniform, with maximum temperatures occurring at the piston crown due to direct exposure to combustion gases. The analysis also showed that efficient heat dissipation is critical to prevent thermal distortion and material degradation. The interaction between piston and cylinder was found to significantly influence overall thermal performance. The study emphasized the importance of accurate thermal modelling for predicting engine efficiency and component life. Furthermore, it highlighted that improved cooling strategies and material properties can enhance heat transfer performance and reduce thermal stresses in piston-cylinder assemblies.

[9] Nallapu (2024) performed a comprehensive thermal and structural analysis of a piston using a finite element approach to evaluate its behaviour under combined loading conditions. The piston model was developed using CAD software and analysed using simulation tools under applied pressure and temperature loads. The study examined deformation, stress distribution, and temperature gradients across the piston. Results showed that thermal loads significantly contribute to overall stress levels and cannot be neglected in piston design. The analysis identified the piston crown and ring grooves as critical regions prone to failure due to high stress concentration. The study also compared different materials and concluded that aluminium alloys provide better thermal performance due to higher heat dissipation, although they may exhibit higher deformation. The research emphasized the need for optimizing both material and geometry to improve piston performance and reliability.

[10] Khan (2024) conducted static and thermal analysis of a piston using finite element method techniques to evaluate its structural integrity and thermal behaviour. The study applied mechanical loads representing combustion pressure along with thermal loads to simulate real engine conditions. Results indicated that maximum von Mises stress occurs near the piston crown and pin boss regions, while temperature distribution shows a steep gradient from crown to skirt. The study highlighted that thermal stresses significantly influence deformation and potential failure zones. Additionally, the analysis demonstrated that proper material selection and design optimization can reduce stress concentration and improve performance. The research concluded that FEM-based analysis is an effective tool for predicting piston behaviour and guiding design improvements to enhance durability, efficiency, and operational safety of internal combustion engines.

[11] Soni et al. (2022) carried out modelling and thermal analysis of an automobile piston using ANSYS to evaluate temperature distribution and heat transfer characteristics under engine operating conditions. The piston geometry was developed using CAD tools and subjected to realistic thermal boundary conditions. The study revealed that maximum temperature occurs at the piston crown due to direct exposure to combustion gases, while lower temperatures were observed at the skirt region. The results highlighted significant temperature gradients, which contribute to thermal stresses and deformation. The authors emphasized the importance of effective cooling and

material selection to minimize thermal effects. The study concluded that ANSYS-based thermal analysis is an efficient approach for predicting piston behaviour and improving design for enhanced thermal performance and durability.

[12] Karem and Ismail (2021) performed finite element analysis of a piston focusing on structural assessment under mechanical loading conditions. The study analysed stress distribution, deformation, and safety factors using realistic loading scenarios representing combustion pressure. Results indicated that maximum stress concentrations occur near the piston crown and pin boss regions, which are critical for structural failure. The study demonstrated that piston geometry plays a significant role in stress distribution and overall strength. Additionally, the findings suggested that optimizing design parameters such as thickness and shape can reduce stress concentration and improve performance. The authors concluded that FEA is a reliable tool for structural evaluation and can effectively guide the design of durable and efficient pistons.

[13] Cerit and Coban (2014) investigated temperature distribution and thermal stresses in a ceramic-coated aluminium alloy piston used in a diesel engine through finite element analysis. The study focused on evaluating the effectiveness of thermal barrier coatings in reducing heat transfer to the piston substrate. Results showed that the coated piston exhibited lower substrate temperatures and reduced thermal stresses compared to uncoated pistons. The ceramic coating acted as an insulating layer, improving thermal efficiency and minimizing heat loss. The analysis also revealed that coating thickness and material properties significantly influence thermal behaviour. The study concluded that ceramic coatings enhance piston performance by improving thermal resistance, reducing thermal fatigue, and increasing engine efficiency.

[14] Bhagat and Jibhakate (2012) conducted thermal analysis and optimization of an internal combustion engine piston using the finite element method. The study aimed to reduce thermal stresses and improve piston design through optimization techniques. Results indicated that modifying piston geometry, particularly crown thickness, can significantly influence temperature distribution and stress levels. The analysis identified critical regions prone to thermal stress concentration and suggested design improvements to enhance heat dissipation. The study emphasized the importance of balancing strength and weight during optimization. The authors concluded that FEM-based optimization is an effective method for improving piston performance, reducing material usage, and enhancing overall engine efficiency.

[15] Pandey et al. (2020) analysed static and thermal stresses of an IC engine piston using different materials through finite element analysis. The study compared materials such as aluminium alloys, cast iron, and composite materials to evaluate their performance under combined loading conditions. Results showed that aluminium alloys exhibit better thermal conductivity, leading to lower thermal stresses, while composite materials demonstrated improved strength and reduced deformation. The analysis highlighted that material selection significantly affects piston performance, durability, and efficiency. Critical stress regions were identified at the piston crown and ring grooves. The study concluded that selecting appropriate materials based on thermo-mechanical properties is essential for optimizing piston design and achieving improved engine performance.

[16] Datta and Singh (2017) analysed the performance of carbon graphite and aluminium alloy as piston materials using finite element analysis to compare their thermomechanical behaviour. The study evaluated stress distribution, deformation, and thermal characteristics under simulated engine conditions. Results indicated that carbon graphite exhibits lower thermal expansion and better wear resistance, while aluminium alloy provides superior thermal conductivity. However, aluminium pistons showed higher deformation under thermal loading, whereas carbon graphite demonstrated improved dimensional stability. The analysis highlighted that each material has distinct advantages depending on operating requirements. The authors concluded that material selection plays a crucial role in piston performance, and hybrid or composite materials may offer an optimal balance between thermal efficiency and mechanical strength.

[17] Rajam et al. (2013) performed design analysis and optimization of a piston using CAD modelling and ANSYS based finite element analysis. The study focused on reducing stress concentration and weight while maintaining structural integrity. Various design parameters, including piston crown thickness and skirt profile, were modified and analysed under mechanical loading conditions. Results showed that optimized designs significantly reduced maximum stress and deformation compared to the original model. The study also demonstrated that weight reduction can be achieved without compromising strength by improving geometry. Critical regions such as the piston crown and ring grooves were identified for design enhancement. The authors concluded that CAD and FEA integration is an effective approach for piston optimization, leading to improved performance, reduced material usage, and enhanced durability.

[18] Jovanovic and Janko (2011) conducted finite element analysis of a reverse-engineered internal combustion engine piston to evaluate its structural behaviour. The study involved reconstructing piston geometry from an existing component and applying realistic boundary conditions for analysis. Stress distribution and deformation patterns were examined under operational loads. Results revealed that reverse-engineered models can effectively replicate actual piston performance and identify critical stress zones. The study highlighted the importance of accurate geometric modelling in achieving reliable simulation results. Additionally, the findings indicated that areas such as the piston crown and pin boss are highly susceptible to failure. The authors concluded that reverse

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engineering combined with FEA is a valuable approach for analysing existing designs and improving piston performance.

[19] Gustof and Hornik (2009) investigated the influence of engine load on temperature distribution in the piston of a turbocharged diesel engine. The study focused on experimental and analytical evaluation of thermal behaviour under varying load conditions. Results indicated that increasing engine load leads to higher temperatures, particularly at the piston crown, due to intensified combustion processes. Significant temperature gradients were observed between the crown and skirt regions, contributing to thermal stresses and expansion. The study emphasized that load conditions play a critical role in determining piston thermal performance and durability. The authors concluded that understanding temperature variation under different operating conditions is essential for designing efficient cooling systems and improving piston reliability.

[20] Mittler and Mierbach (2009) examined thermal loading and stress analysis of pistons in internal combustion engines using advanced simulation techniques. The study focused on evaluating the combined effects of thermal and mechanical loads on piston performance. Results showed that thermal stresses significantly contribute to overall stress levels and can lead to fatigue failure if not properly managed. The analysis identified critical regions such as the piston crown, ring grooves, and pin boss as areas of high stress concentration. The study also highlighted the importance of material properties and cooling strategies in reducing thermal effects. The authors concluded that comprehensive thermo-mechanical analysis is essential for optimizing piston design, improving durability, and ensuring reliable engine operation under high-temperature conditions.

III. PROBLEM IDENTIFICATION

Internal combustion (IC) engine piston works under harsh thermo-mechanic conditions, being constantly subjected to high temperatures of combustion and to varying loads of pressure. The synopsis presents a situation that traditional piston materials, especially aluminium alloys, albeit light, and highly prevalent, have limitations in their capacity to sustain the high temperatures without experiencing pronounced thermal expansion as well as heat-induced deformation and activity. One of the problems that are noted is that the combustion chamber loses too much heat because of poor thermal insulation, and this lowers the efficiency of the engine and negatively impacts the fuel combustion. Also, thermal as well as mechanical stress causes fatigue, wear, and ultimate failure of the piston particularly in areas or points of importance like the crown and ring grooves. Although cooling systems such as oil galleries are available, they add complexity and they are not capable of completely averting the thermal gradients. Hence, there is the need to increase thermal resistance and structural integrity of pistons by better choice of materials and optimization of design.

IV. RESEARCH GAP

Through the literature review conducted in the synopsis, it can be seen that much has been conducted in regard to thermal barrier coatings, piston material, and finite element analysis of engine parts. A key deficiency however lies in the combined optimization of the piston design taking into account both the thermal load and the structural load at the same time. The past researches have concentrated solely on the thermal analysis, or the structural analysis, with not enough attention to the thermo-mechanical interaction of the piston in real operating conditions. Moreover, although the use of thermal barrier coating has undergone experimental study on the use to enhance performance and minimize emissions, research studies on their use in an organized design optimization model have not been done extensively using a full-blown computational tool. The lack of some holistic method to optimization of the response surface like the Taguchi-based design of experiments, combined with finite element analysis, provides a vacuum in determining the most significant design parameters and their interactions. Another factor is the lack of analytical validation of the outcomes of the simulation, which is a prerequisite of the reliability of the numerical models. The purpose of the current work is, therefore, to fill such gaps by considering CAD modelling, the thermo-mechanical analysis created with the use of FEA and statistical optimization to solve an optimized piston design with better performance features.

V. PROPOSED METHODOLOGY

The suggested methodology adheres to the systematic and simulation-based approach in order to optimize the design of the IC engine piston. In the first step, existing literature and standards are taken to obtain the relevant data and design parameters that may be used to identify the baseline model. Three-dimensional CAD model of the piston is then generated via CREO software and is given realistic features of geometry including piston crown, skirt and ring grooves. The model would then be imported into ANSYS where it is pre-processed by removing geometry and creating mesh with the relevant types of elements in order to make the computationally accurate. Analysis phase In this step, both thermal and structural simulations of the defined boundary conditions, such as loads imposed by combustion temperature and gases pressure, will be used to analyse the temperature distribution and thermal flux, von Mises and principal stresses. A twinned thermo-mechanical test is also conducted to estimate joint actions of loading conditions. This is followed by stage three of optimization of response surface whereby the Taguchi design of experiments is utilized to control the key design parameters in a systematic manner and produce respective output responses. Sensitivity analysis is carried out so as to determine the most important variables that affect the stress and thermal performance. Simulation results are also checked by calculations to ascertain reliability of models. Lastly, the interpretation of response plots and optimization results is done to reach the objective of the study by selecting the best piston design configuration that

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defined the minimum of stress and the maximum thermal efficiency.

VI. CONCLUSION

The comprehensive review of literature on structural and thermal analysis of pistons indicates that piston performance is predominantly governed by the combined influence of mechanical loading and thermal effects encountered during engine operation. Across the studies, it is consistently observed that the piston crown, ring grooves, and pin boss regions are the most critical zones subjected to maximum stress concentration and temperature gradients, making them highly susceptible to deformation, fatigue, and failure. The findings strongly establish that thermal stresses often exceed or significantly augment mechanical stresses, highlighting the necessity of coupled thermo-mechanical analysis rather than isolated evaluations. Finite Element Analysis (FEA) emerges as a highly reliable and widely adopted tool for predicting stress distribution, deformation, and temperature fields within piston structures. The integration of CAD modelling with simulation platforms such as ANSYS has enabled precise design optimization, allowing engineers to minimize stress concentrations and improve structural integrity while reducing weight. Additionally, studies focusing on material selection reveal that conventional aluminium alloys offer excellent thermal conductivity but may suffer from higher deformation, whereas advanced materials such as carbon graphite and metal matrix composites provide improved strength and thermal stability. The review further highlights the growing importance of surface engineering techniques, particularly thermal barrier coatings, which effectively reduce heat transfer, lower substrate temperatures, and enhance resistance to thermal fatigue. Optimization of coating thickness and material composition has been shown to significantly improve piston durability and engine efficiency. Moreover, the influence of operating conditions, especially engine load and combustion intensity, plays a crucial role in determining temperature distribution and stress behaviour, emphasizing the need for realistic boundary conditions in simulation studies.

REFERENCES

[1]. Liu, X. F. (2017). Finite element analysis of thermomechanical conditions inside the piston of a diesel engine. Applied Thermal Engineering, 119, 312–318. https://doi.org/10.1016/j.applthermaleng.2017.03.063
[2]. Lu, Y., et al. (2017). Analysis of thermal temperature fields and thermal stress under steady temperature field of diesel engine piston. Applied Thermal Engineering, 113,796–812. https://doi.org/10.1016/j.applthermaleng.2016.11.070
[3]. Wakshume, E., et al. (2025). Finite element analysis of engine pistons: Comparative study of thermomechanical performance. Scientific Reports.
[4]. Qian, Z., et al. (2025). Finite element analysis of thermal and stress fields in coated diesel engine piston. Coatings, 15(3), 259.
[5]. Velugula, R., et al. (2023). Analysis of mechanical and thermal stresses in piston and cylinder of directinjection engines. Energies, 16(21), 7400.
[6]. Anugu, A. R. (2021). Theoretical modelling and finite element analysis of piston for diesel engine applications. Materials Today: Proceedings.
[7]. Roychoudhury, A. (2021). Finite element modelling of coated engine piston for enhanced material strength. Materials Today: Proceedings.
[8]. Muhammad, A., et al. (2020). Finite element analysis of heat transfer in piston-cylinder assembly. Journal of Mechanical Manufacturing and Materials Science.
[9]. Nallapu, S. (2024). Thermal and structural analysis of piston using finite element approach. SSRN Electronic Journal.
[10]. Khan, S. (2024). Static and thermal analysis of piston using FEM techniques. MATEC Web of Conferences.
[11]. Soni, A. K., Godara, S. S., Gade, R., & Prasad, R. (2022). Modelling and thermal analysis for automobile piston using ANSYS. International Journal on Interactive Design and Manufacturing.
[12]. Karem, M. H., & Ismail, A. E. (2021). Finite element analysis of piston for structural assessments. Journal of Sustainable Manufacturing and Transportation, 1(1), 8–16.
[13]. Cerit, M., & Coban, M. (2014). Temperature and thermal stress analyses of a ceramic-coated aluminium alloy piston used in a diesel engine. International Journal of Thermal Sciences, 77, 11–20.
[14]. Bhagat, A., & Jibhakate, Y. M. (2012). Thermal analysis and optimization of I.C. engine piston using finite element method. International Journal of Modern Engineering Research, 2(4), 2919–2921.
[15]. Pandey, K. D., Gupta, K., Papaiya, V., & Dwivedi, M. K. (2020). Analysis of static and thermal stresses of IC engine piston using different materials. International Journal of Innovation in Engineering Research and Management, 7(Special Issue), 1–14.
[16]. Datta, J., & Singh, S. S. (2017). Analysis of carbon graphite, and aluminium alloy as piston materials using FEA. International Journal of Engineering Research and Applications.
[17]. Rajam, C. V., Murthy, P. V. K., Krishna, M. V. S., & Rao, G. M. P. (2013). Design analysis and optimization of piston using CAD and ANSYS. International Journal of Innovative Research in Engineering & Science.
[18]. Jovanovic, J., & D. Janko (2011). Finite element analysis of reverse-engineered internal combustion engine piston. AIJSTPME Journal, 2(4), 85–92.
[19]. Gustof, P., & Hornik, A. (2009). Influence of engine load on temperature distribution in the piston of a turbocharged diesel engine. Journal of Achievements in Materials and Manufacturing Engineering, 35(2), 177–184.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26may444

[20]. Mittler, R., & Mierbach, A. (2009). Thermal loading and stress analysis of pistons in internal combustion engines. In Proceedings of the ASME Internal Combustion Engine Division Spring Technical Conference.