International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design Thermal and Structural Analysis of Piston with Different Materials Using Finite Element Analysis

[1]Ayush Kumar, [2]Kamlesh Gangrade

[1]PG Scholar, MED, SIRT, Sage University, Indore (M.P.), India
[2]Professor, MED, SIRT, Sage University, Indore (M.P.), India

ABSTRACT: -

The finite element technique (FEM) is used in this study to examine the stress distribution and thermal stresses of three distinct piston materials. The working gas pressure, temperature, and piston material qualities are all taken into account while running the simulation. These pistons were studied using specs from a 150cc single-cylinder four-stroke motorcycle engine. FEA simulations are used to estimate the maximum stress and critical area on various piston materials. CATIA V5 and Ansys 19.2 are used for design and analysis. Static and thermal analyses are carried out. Structural and thermal analyses of these AL 6061, AL 4032, and Gray Cast iron materials guide the selection of the best material.

Keywords: FEA, study state thermal analysis, static structural analysis, thermal stresses, deformation etc.

I. INTRODUCTION:

Introduction In contrast to an external combustion engine, which burns fuel in a separate combustor, an internal combustion engine utilises chemical energy generated inside the engine itself to do mechanical work. The late 1800s saw the conception and development of the internal combustion engine. As a result, it is regarded as one of the most important innovations of the twentieth century for all the good it has done. Many commercial innovations have benefited from the success of the internal combustion engine. As an example, have a look at how vehicles, trucks, aircraft, and trains have all been improved because to this sort of engine. Pneumatic cylinders, gas compressors, reciprocating engines, and reciprocating pumps all use pistons. Piston rings keep the moving part sealed within the cylinder and prevent leakage. A piston rod and/or connecting rod are used in an engine to transmit the force generated by the expanding gas in the cylinder to the crankshaft. Because of the rising usage of vehicles, automotive parts are in high demand. These components are in more demand owing to their better performance and lower cost. To reduce the time it takes to launch new goods, R&D and testing engineers should build crucial components in the lowest amount of time feasible. The creation of new items demands an awareness of new technology and an ability to absorb them quickly. Using piston rings, a piston may be made gas-tight and enclosed inside a cylinder.

To move expanding gas from the cylinder to the crankshaft, the piston rod and/or connecting rod are used in engines. An engine piston's cyclic gas pressure and inertia forces may cause wear damage since it is such an essential element of the engine.

An IC engine's reciprocating piston is an essential part. It is the moving part of a cylinder and is gas-tight because of the piston rings that hold it in place. A piston rod connects the expanding gas in the cylinder to the crankshaft of an engine, transferring the resulting force. During operation, the piston is subjected to cyclic gas pressure and inertial forces, which may produce fatigue damage, such as piston side wear and piston head fractures, among other things. Therefore, the design of the piston must be optimised by taking into account a variety of factors. Pressure and heat study of the piston's top surface in different strokes are the chosen parameters for this project.. Using this information, design engineers might make modifications to the piston during the design process.

Significant study has been done on engine piston designs, and these designs have evolved over the last decades with a constant development and needed a careful investigation of the tiniest aspects." One of the most complicated parts of an engine, pistons are susceptible to wear, temperature, and fatigue-related damage. Thermal and mechanical fatigue, whether at room temperature or at high temperatures, are major contributors to fatigue damage. We employed the finite element approach and piston vibration analysis for mechanical fatigue study. The latest version of ANSYS is 19.2.

PISTON FUNCTION:

As a result of the combustion process, the energy tied up in fuel is swiftly transformed into heat and pressure by the piston. The piston is tasked with transforming the released energy into mechanical work by rapidly increasing the heat and pressure in the system. It's common for the piston to have a hollow cylinder and a segment piston head with a ring belt, pin base, and skirt. The pin boss, piston pin, and connecting rod all originate from the combustion chamber's gas forces (fuel air mixture) being transferred to the crankshaft via the piston head.

II. LITERATURE SURVEY

This topic shows review on design analysis of piston on the basis of improving strength according to the material properties.

[1]. **Vibhandiket. al. (2014),** Using CAE tools, he analysed the design analysis and optimization of the piston and the deformation of its thermal stresses. He picked an I.C. engine piston from TATA motors of a diesel engine vehicle. On a standard diesel piston and an optimised piston constructed of aluminium alloy and titanium alloy material, he had undertaken thermal analysis. Structural steel piston used in traditional diesel engines. The primary goal of this investigation is to decrease the amount of stress on the piston's upper end in order to extend the piston's lifespan. According to the investigation, titanium has an excellent heat conductivity and can increase piston performance, but it is prohibitively costly for large-scale applications.

[2]. **Ch. Venkata Rajamet. al. (2013)**, focused on CATIA and ANSYS piston design analysis and optimization He'd optimised for every single one of them. It was hoped that the optimization process would result in a decrease in piston mass. With this study, a crown is coated in ceramic. Because the length has no effect on heat flow, the length and diameter of a piston are optimised together. Because the thickness of the piston is more impacted by temperature and pressure loads than the length and diameter, the volume of the piston changed. The piston's weight is lowered by removing the excess material. After optimization, Von misses stress and Deflection are both raised by decreasing the piston's capacity, barrel thickness, and the width of other ring lands. All criteria, however, are within the scope of design.

[3]. **V. V. Mukkawaret. al. (2015),** CAE techniques are used to characterise the stress distribution in two distinct aluminium alloys. Piston from Bajaj Pulsar 220 cc motorcycle's four-stroke single-cylinder engine utilised in analysis. Deformation is lower in the AL-GHY 1250 piston than in a normal piston. This alloy has the potential to reduce mass. At the same working conditions, the factor of safety improved by 27%. A comparison of the performance of Al-GHY 1250 vs standard alloy pistons made using Al-2618 and Al-2650 revealed the former to be superior.

[4]. **Manjunatha T. R. et. al.(2013),** High- and low-pressure specifications are examined, as well as analyses of suction and compression strokes that reveal areas where stress concentration is highest. cylinder and piston are made of aluminium alloy, with the former being cast iron and the latter being an aluminium alloy/aluminum alloy alloy.

III. METHODOLOGY

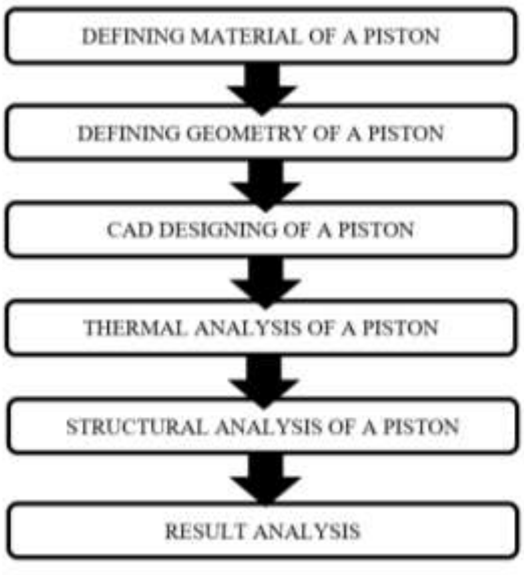

Figure 1: Methodology

IV. MODELLING

CATIA, or Computer Aided Three Dimensional Interactive Application, is a kind of CAD programme. Unique to CATIA is the ability to simulate a product in the context of its actual behaviour. Using this software's technology, its users can regularly create a new strong, parametric, feature-based model. Small and medium-sized businesses, as well as major industrial organisations, may benefit from CATIA's easy-to-use solution adapted to their specific demands in all sectors, such as consumer products, fabrications and assembly, electrical and electronic goods, automobiles, aircraft, and shipbuilding. It's easy to use. It's simple to create both solid and surface models.

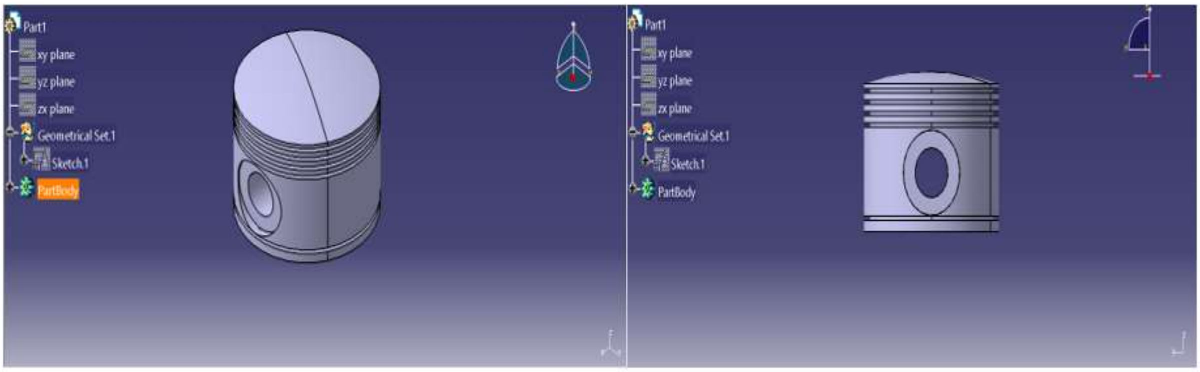

Figure 2: Isomatric and Front view of piston

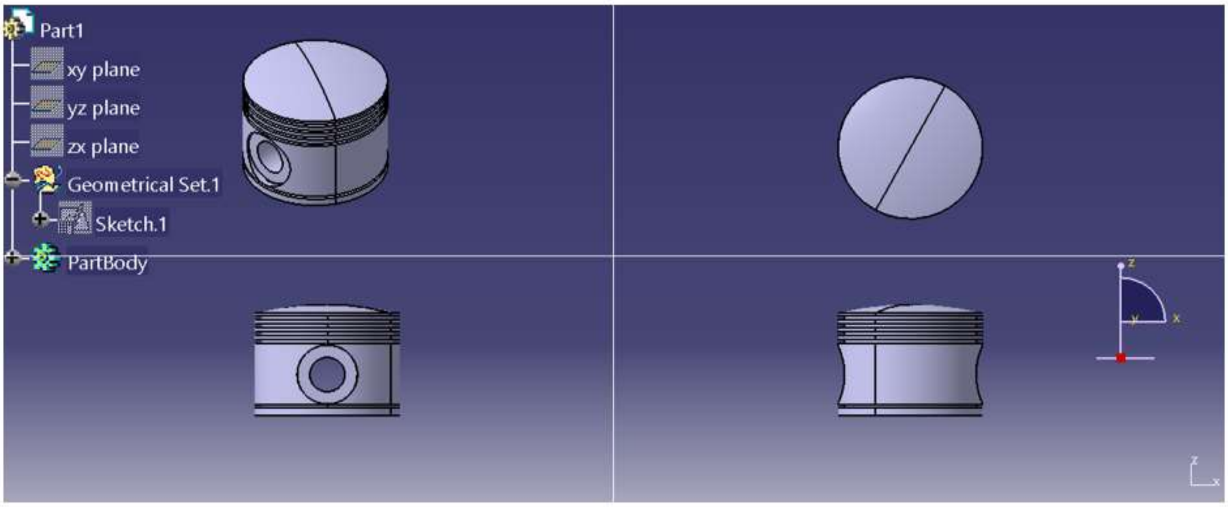

Figure 3: Multi-view of piston

V. MESHING AND BOUNDARY CONDITION

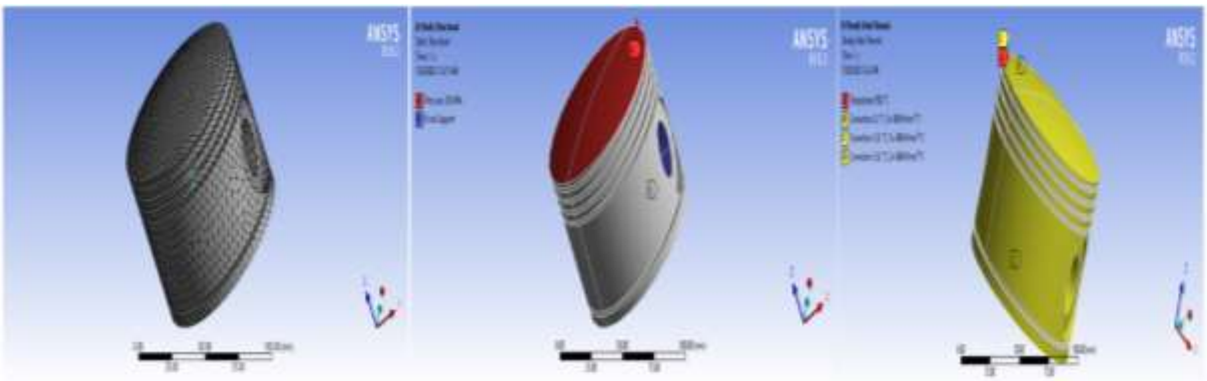

Figure 4: Meshing & Boundary Condition

VI. ANALYSIS OF PISTON

1. Thermal Analysis of Piston

Gray Cast Iron

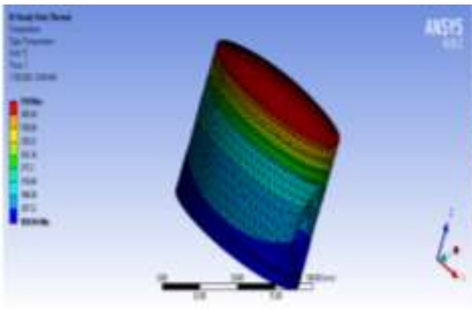

Figure 5: Temperature

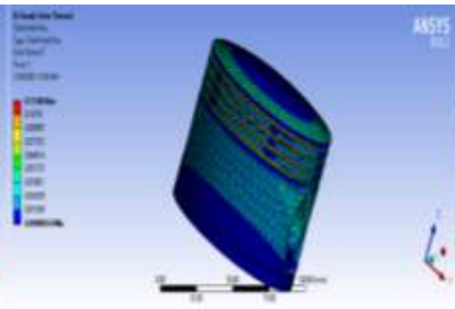

Figure 6: Total Heat Flux

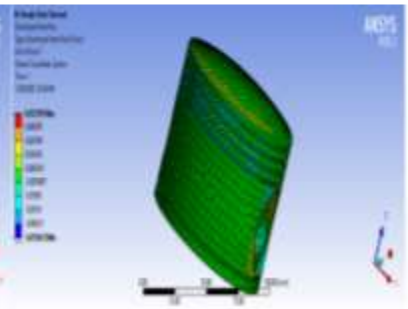

Figure 7: Directional Heat Flux

AL 4032

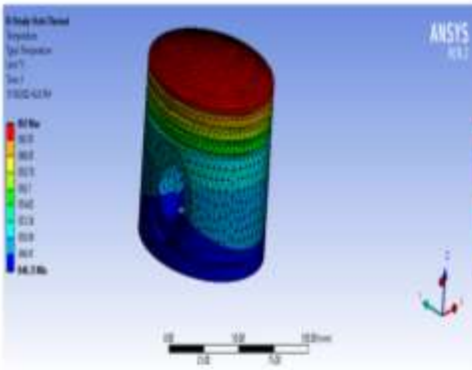

Figure 8:

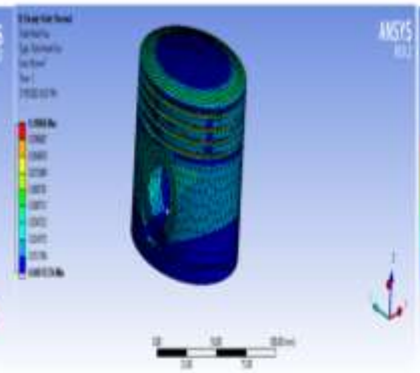

Figure 9: Total Heat Flux

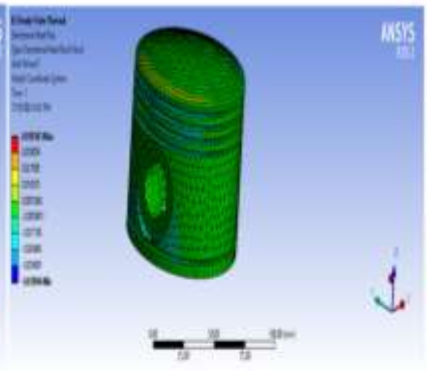

Figure 10: Directional Heat Flux

AL 6061

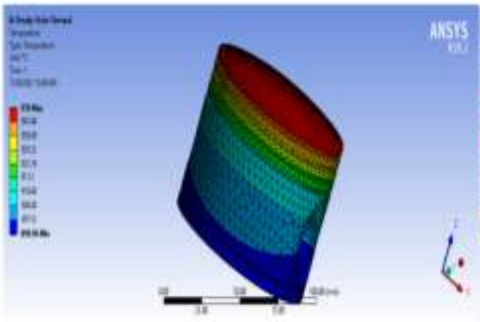

Figure 11: Temperature

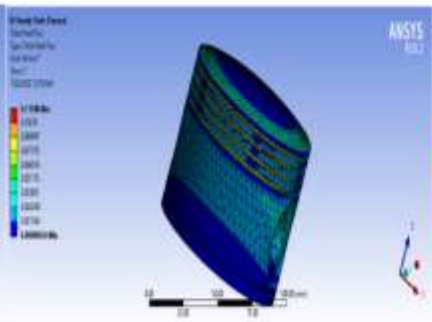

Figure 12: Total Heat Flux

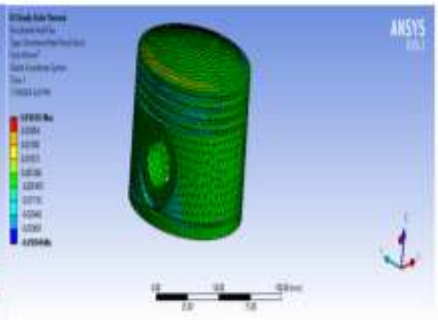

Figure 13: Directional Heat Flux

2. Structural Analysis

Gray Cast Iron

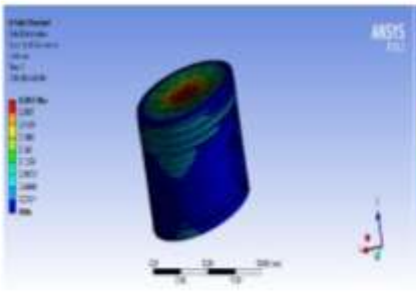

Figure 14: Deformation

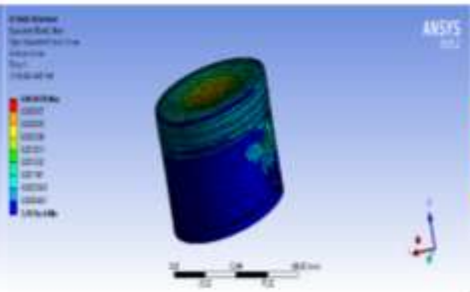

Figure 15: Equivalent Strain

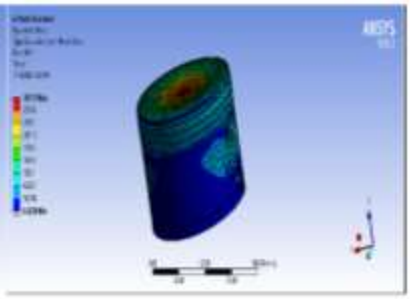

Figure 16: Von misses Stress

AL 4032

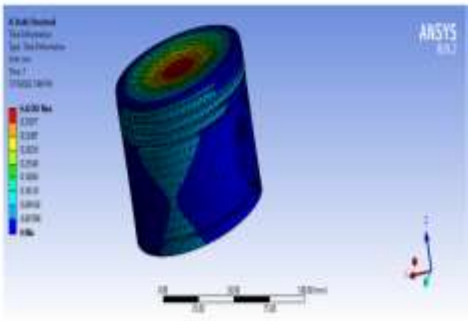

Figure 17: Deformation

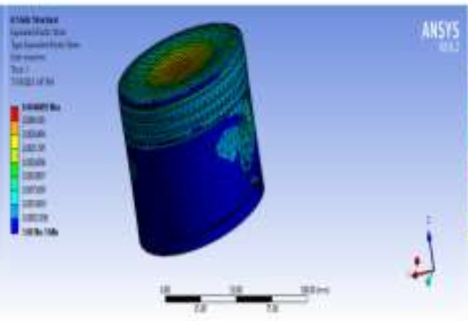

Figure 18: Equivalent Strain

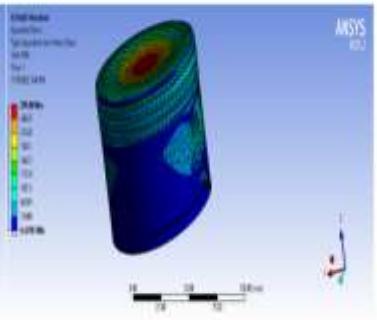

Figure 19: Von misses Stress

AL 6061

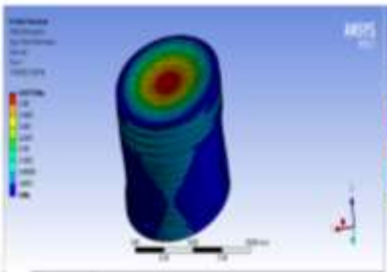

Figure 20: Deformation

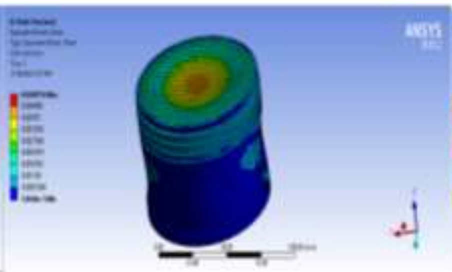

Figure 21: Equivalent Strain

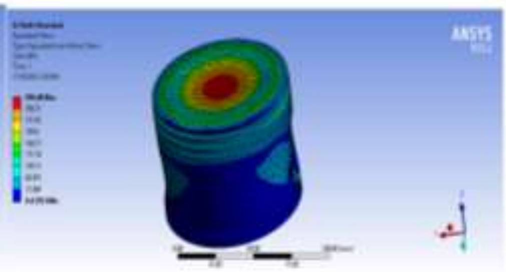

Figure 22: Von misses Stress

VII. CONCLUSION

According to the aforesaid research, the piston is constructed using CATIA V5 software and analysed using ANSYS software. To create a three-dimensional graphic, just a few simple steps are required. Analyzing the piston model in ANSYS is the next step. a piston constructed from two distinct types of material The alloys Al 4032 and AL 6061 Alloy, Gray cast iron are scrutinised in this investigation. Stress intensity is highest on all piston crown surfaces, except for the Al alloy piston, which has a stress intensity similar to its yield strength. The piston's upper surface, where the temperature rises to its highest point, is where it reaches its hottest point. This applies to all substances equally. Al alloy pistons have the highest heat transfer rate because of their high thermal conductivity. The Al alloy piston is best suited for the specified load circumstances. However, if the loading pattern changes, additional materials may be necessary. The I.C.Engine may now be built with more confidence because to advancements in material science that have made it possible to employ lightweight materials with excellent thermal and mechanical qualities. As a result, we'll save money on gasoline and help the environment.

Reference

[1]. DeovratVibhandik, Ameya Pradhan, SampadaMhaskar, Nikita Sukthankar, AtulDhale, (2014) Design Analysis and Optimization of Piston and Determination of its Thermal Stresses Using CAE Tools, 3(5), pp.273-277.

[2]. Ch. VenkataRajam, P. V. K. Murthy, M. V. S. Murali Krishna, G. M. Prasada Rao, (2013), Design analysis and optimization of piston using CATIA and ANSYS, International Journal of Innovative Research in Engineering & Science, 1(2), pp. 41-51.

[3]. Vaibhav V. Mukkawar, Abhishek D. Bangale, Nititn D. Bhusale, Ganesh M. Surve, (2015), Design analysis and optimization of piston using

CAE tools, International Conference, Pune, India.

[4]. Manjunatha.T. R, Dr. Byre Gowda. H. V, Prabhunandan. G. S, (2013), Design and Static Structural Analysis of Cylinder and Piston of Two Stage Reciprocating Compressors Using ANSYS, International Journal of Innovative Research in Science, Engineering and Technology , 2 (12), pp. 7590-7596.

[5]. Swati S. Chougule, Vinayak H. Khatawate, (2013), Piston Strength Analysis Using FEM,International Journal of Engineering Research and Applications, 3, pp.124-126

[6]. Lokesh Singh, Suneer Singh Rawat, Taufeeque Hasan, Upendra Kumar, (2015), Finite element analysis of piston in ansys, 02, pp. 239-241.

[7]. R. C. Singh, Roop. Lal, Ranganath M. S., Rajiv Chaudhary, (2014), Failure of Piston in IC Engines: A Review, IJMER, 4.

[8]. Jan Filipczyk, ZbigniewStanik, (2012), Piston damages-case studies and possibilities of early detection, Journal of KONES Powertrain and Transport, 19(4), pp. 179-184.

[9]. GantlaShashidhar Reddy and N. Amara NageswaraRao, (2013), Modeling and analysis of diesel engine piston, International journal of Mathematics and Engineering, 2, pp. 199 – 202.

[10]. VivekZolekar, Dr. L. N. Wankhade, (2013), Finite Element Analysis and Optimization of I.C. Engine Piston Using RADIOSS and Optistruct, Altair technology conference.

[11]. S. Srikanth Reddy, Dr. B. SudheerPrem Kumar, (2013), Thermal Analysis and Optimization of I.C. Engine Piston Using Finite Element Method, International Journal of Innovative Research in Science, Engineering and Technology, 2, pp. 319-323.