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Non Linear Heat Transfer Analysis of IC Engine Cylinder Block Using Finite Element Method

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ABSTRACT In internal combustion engines cylinder part is the heart of the engine and this cylinder block forms the walls of a combustion chamber where air fuel mixture burns. Due to this continues combustion process the cylinder walls subjected combustion zone and heat transfer takes place through the cylinder material. If the heat is not dissipated properly then it causes to development of detonation and it finally decreases the working efficiency of the engine, hence the heat removal rate from the cylinder is one of the important and interesting task. Mostly the heat transfer rate through the material is depends on the thermal conductivity of the material. Hence in this paper an attempt has been made to find out the thermal analysis of cylinder block with fins for different materials by using ANSYS, and the results has been analysed to find out the best material that gives the better heat transfer rate and consists of light weight and a possible replacement for the present one

KEYWORDS: cylinder block, aluminium alloy , Heat transfer rates,

I. INTRODUCTION

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 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%. Future internal combustion engines for light duty applications will have to cope with a very complex set of customer, legal and business requirements. Customers are expecting further improvements in durability, reliability, drivability, fuel economy, and cost of ownership. Legal requirements are focused on significant emission and fuel consumption reductions. Additional manufacturing cost reductions will be essential to maintain, or better grow the business in a very competitive environment. The challenge for the diesel engine will be to meet the future emission standards at affordable cost, while maintaining its fuel economy advantages. Regarding the emissions, advanced diesel technologies will have to focus mainly on NOx reduction. New combustion system concepts in combination with advanced air handling/boosting and control systems offer a promising potential. The focus for future gasoline engine development will be on fuel economy improvements through improved combustion systems and reduced throttle losses at part load operation. This can be achieved through e.g. direct fuel injection with Stratified lean part load operation. Downsizing in combination with boosting offers an additional potential. Internal combustion engines still

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have a huge potential to deal with the challenges of the future. Despite the green hype, internal-combustion engines will keep powering vehicles for the foreseeable future. Aim of this project is to make a comparative study of internal combustion engine having made of different metal composition under steady state condition and forced condition and to check the heat transfer rate of the internal combustion engine and to find out the material having maximum heat transfer rate. For this experiment 3 different internal combustion engine is modeled using a CATIA V5 software, part modeling and surface modeling workbenches are used for the modeling of internal combustion engine. Analysis of internal combustion is done using Ansys 15 Workbench under different condition and graphs are plotted in order to determine faster heat removal. Transient thermal workbench is used for the analysis. By this project it is trying to prove that the possible replacement of traditional materials such as cast iron with aluminium alloys.

The main objective of this project is to find out a internal combustion engine with maximum heat transfer rate. internal combustion engines are a part of our daily life an attempt to improve the material used in its construction to enhance the heat transfer rate to avoid detonation and increase its working efficiency three models of internal combustion engines are modeled and are analysed under steady state and forced condition to determine the best one For this experiment of internal combustion engine with different geometry, the 3D model of the internal combustion engine is to be made with the software Catia V5 and the thermal analysis of the same model is done in Ansys 15 Transient thermal workbench.

II. RELATED WORK

Presently cast iron is used in engine block construction. the heat removal rate from the cylinder is one of the important and interesting task. Mostly the heat transfer rate through the material is depends on the thermal conductivity of the material. Hence in this paper an attempt has been made to find out the thermal analysis of cylinder block with fins for different materials by using ANSYS, and the results has been analyzed to find out the best material that gives the better heat transfer rate and consists of light weight and a possible replacement for the present one. This work can be extended to areas where there is a need for high efficient internal combustion engine with higher heat transfer rate. Many future works are also possible in this work such as by making changes in the material composition, making changes in fins attached over the tubes to check the heat transfer rate. Few desirable properties of engine block material;

- It possesses tremendously elevated temperature stability.
- High thermal conductivity
- Low cost of material compared to traditional metallic materials
- It has excellent corrosion resistance.
- easily machined

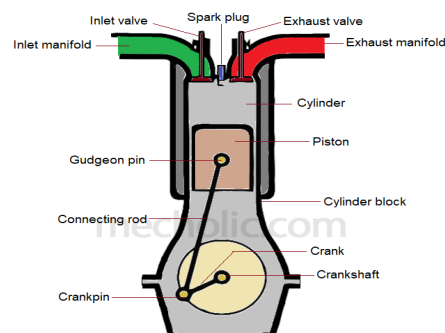


Fig 1: Schematic diagram of ic engine

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III. MODELLING AND MATERIAL SELECTION

The internal combustion is formed by taking a dimensions from official site. The whole model is created in CATIA V5. five different materials (Aluminum alloy (A356,A360,A380,ALMMC,GCI) are also chosen to enhance the material properties

Material	Composition	Tensile strength (Mpa)	density (kg/m ³)	specific heat (j/kg.k)	thermal conductivity (W/m.k)
A356	Si-6.5-7.5, Fe 0.2 Max, Cu 0.2 Max, Mn 0.2 Max, Mg 0.25-0.45, Balance Al	234	2670	963	151
A360	Si-9.0-10.0, Cu-0.6, Mg-0.4-0.6, Fe-2.0	303	2630	963	113
A380	Si 7.5-9.5, Fe 1.3 Max, Cu 3.0-4.0, Mn 0.50 Max, Mg 0.10 Max, Balance Al	324	2760	963	109
Al metal matrix composition alloys (Al-MMC)	Si-9.5-10.50, Cu-0.30-0.50, Mg-0.3-0.5, Fe-0.8-1.2	345	2760	842	124
Grey cast iron class 250	C 2.8 – 3.1, Si 1.2-1.5, Mn 1.0-1.2,	255	7200	45	46

Table 1 : Properties of materials used in analysis

IV. GEOMETRICAL MODELLING

The existed supra 110, greaves 1520, greaves 3250 cylinder block was considered for the study of thermal analysis. This model was generated with the help of GAMBIT modeling and meshing package as shown below Fig.1, tetrahedral mesh with very fine size element (1.356e-3 m) has been considered for the better convergence of solution.

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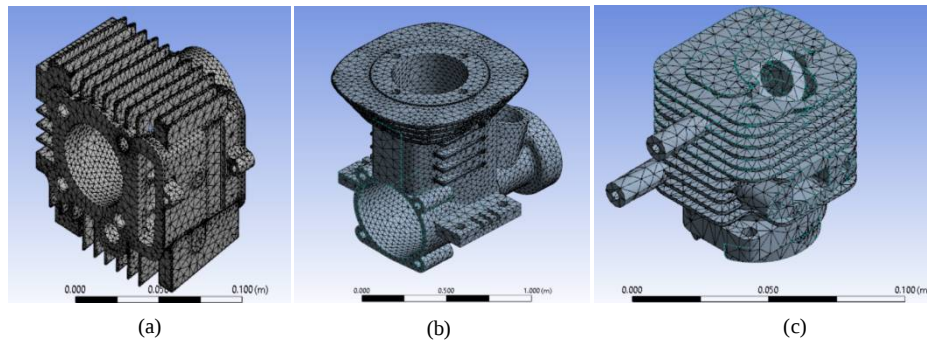


Fig. 2. Meshed model (a) supra 110 (b) greeves 1520 (c) greeves 3250

V. EXPERIMENTAL RESULTS

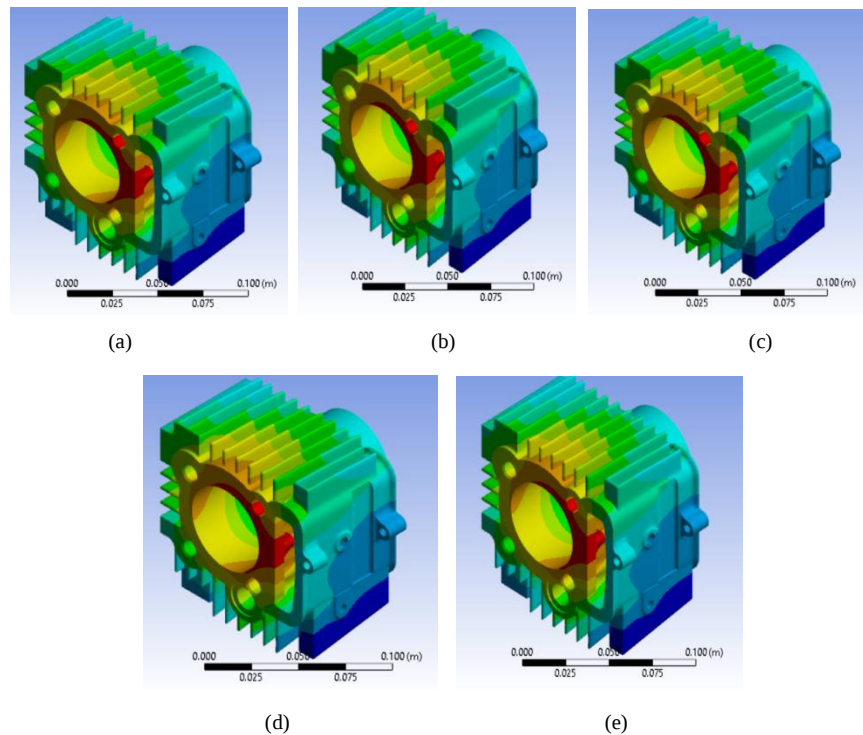


Fig. 3 temperature analysis supra110 (a) A319 (b) A356 (c) A360 (d) A380 (e)ALMMC

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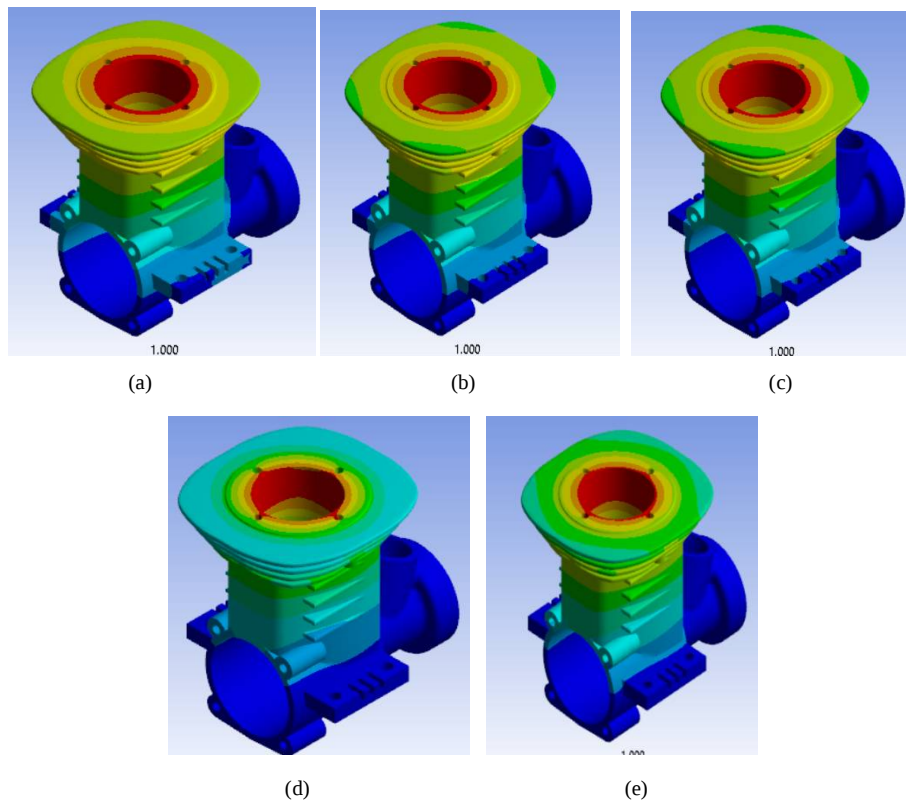
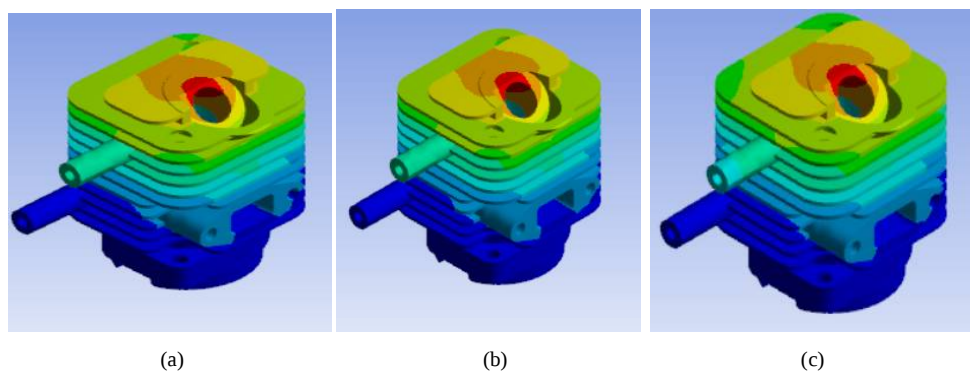


Fig. 4 temperature analysis Greeves 1520 (a) A319 (b) A356 (c) A360 (d) A380 (e)ALMMC



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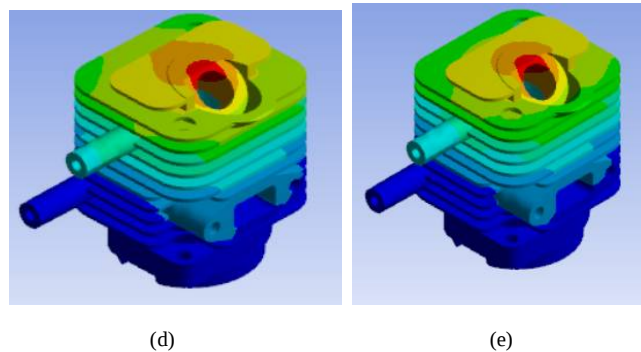


Fig. 4 temperature analysis Greeves 3520 (a) A319 (b) A356 (c) A360 (d) A380 (e)ALMMC

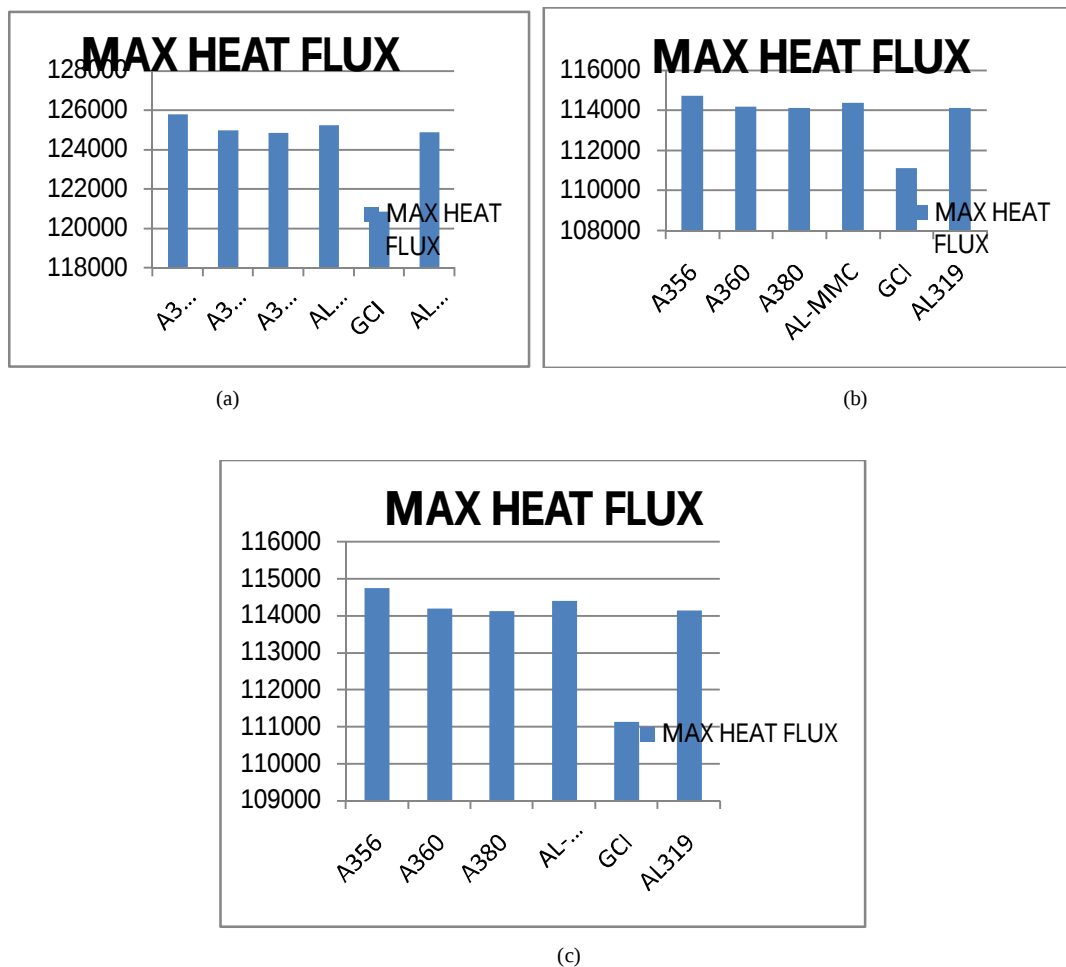


Fig. 5 heat flux graph under steady condition (a) supra 110 (b) Greeves 1520 (c) Greeves 3520

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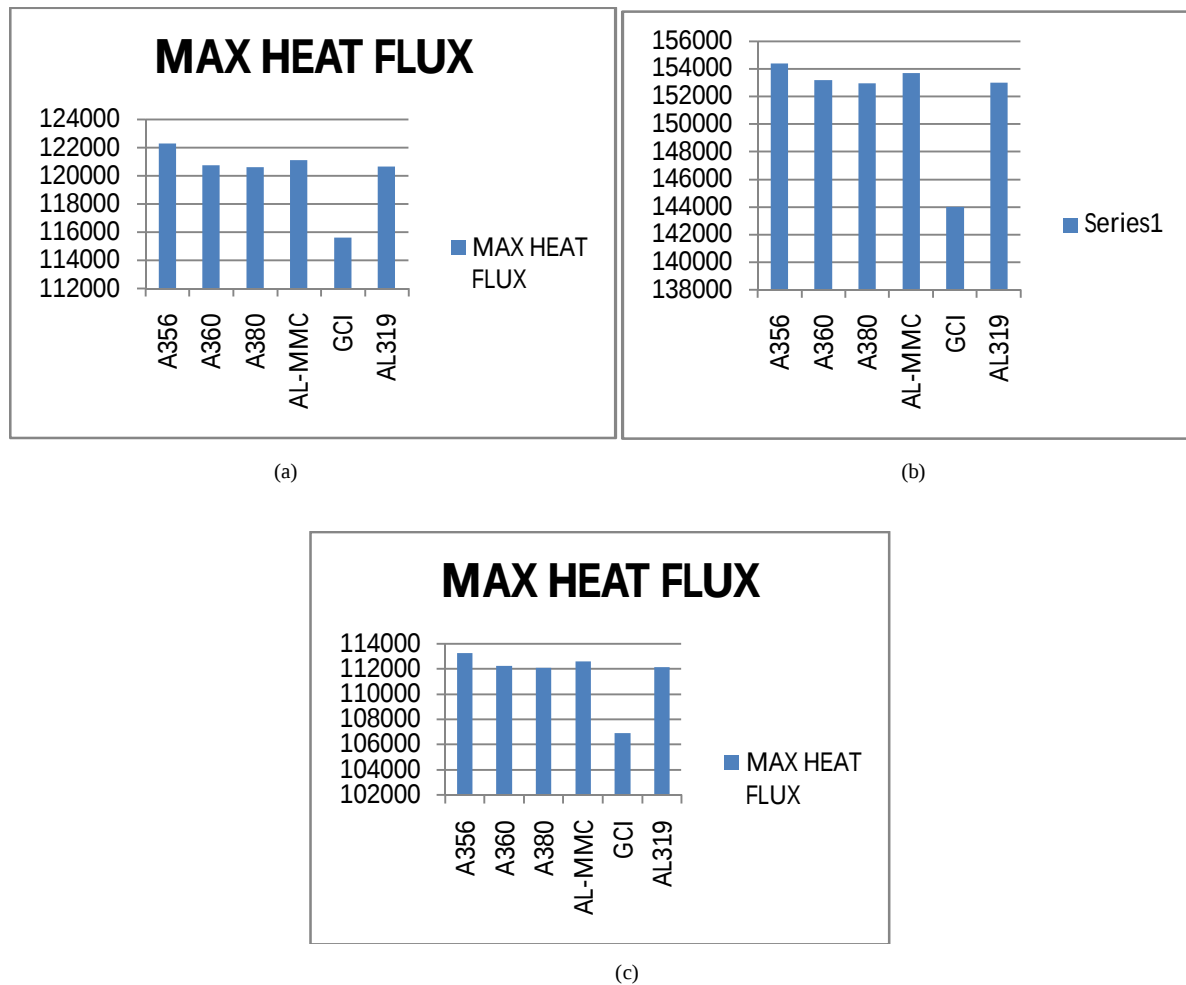


Fig. 5 heat flux graph under forced condition (a) supra 110 (b) Greeves 1520 (c) Greeves 3520

First the internal combustion engine is analysed using different aluminium alloy, grey cast iron under different condition. The below graphical representations and tables show the variation in heat transfer rates and heat flux. The heat flux transfer rates are analyzed and from graphical representation $\text{W/m}^2\text{K}$. graphs are plotted for heat flux and temperature maximum for the two condition one is steady state and air is forced over the surface body $\text{W/m}^2\text{K}$. under forced condition additional convective heat transfer occur over the fins as the as air is moving at speed of 45km/hr (most economical speed cited by automobile makers) the graphs clearly shows that aluminium alloys has greater advantage over the cast iron variant in terms of heat removal from the internal combustion engines . in the graphs plotted A356 has slight advantage over other alloys in terms of heat transfer rate

VI. CONCLUSION

The performance of the internal combustion engine made A356 has a slight improvement in the performance of the internal combustion engine over other aluminium alloy . internal combustion engine made by aluminium alloys are a clear winner over internal combustion engines made out of cast iron The above results give a clear idea of the heat

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transfer of the three internal combustion engine. The thermal analysis results give the idea about the heat transfer rate through the solid material when different materials are used. All the materials used for the analysis shows a promising alternative for the selected engines in thermal point of view. Thermal analysis results proved that A356 is better replacement for conventional materials used in IC engine cylinder block. After conducting the first analysis engine 1 shows low heat flux value comparing with other two engines. Transient analysis output shows a more realistic values for heat flux and temperature distribution from the analysis following points are obtained

- A356 is a better replacement for A319
- TRANSIENT HEAT Conduction analysis shows more accurate than steady state analysis

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