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Thermal Analysis of Three Cylinder Engine Head and Performance Optimisation

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Abstract: *The internal combustion engine is a rich source of examples of almost every conceivable type of heat transfer. There are a wide range of temperatures and heat fluxes in the various components of the internal combustion engine. Internal combustion engines come in many sizes, from small model airplane engines with a 0.25 " (6 mm) bore and stroke to large stationary engines with a 12" (300 mm).About 25 % of the air/fuel mixture energy is converted to work, and the remaining 75% must be transferred from the engine to the environment. The heat transfer paths are many, and include many different modes of heat transfer. In this module, we will discuss the heat transfer processes in the engine components, then consider the engine parameters and variables which affect the heat transfer processes. Maximum amount of heat is transferred through the cylinder head. In this project we have taken efforts to analyze the heat transfer through the cylinder head of three cylinder S.I. engine. CAE is extensively used for simulation. Heat transfer is analyzed for different rates of coolant flow and a optimized coolant flow rate is suggested.*

Keywords: Cylinder Head, Thermal Analysis, Heat Transfer

I. INTRODUCTION

As an appreciable amount of heat is transferred through the I. C. engine which effects the engine performance, it is therefore essential to look forward to analyze the modes of heat transfer and temperature variations in the engine components.

About 35% of the total chemical energy that enters an engine in the fuel it converted to crankshaft work, & about 30% of the fuel energy is carried array from the engine in the exhaust flow in the form of enthalpy & chemical energy. This leaves about one third of the total energy that must be dissipated to the surrounding by some mode of heat transfer. Temperatures within the combustion of an engine reach values on the order 2700 K & up. Materials in the engine cannot tolerate this kind of temperature & would quickly fail if proper heat transfer did not occur. Removing heat is highly critical in keeping an engine & engine lubricant away from thermal failure. On the other hand it is desirable to operate an engine as hot as possible to maximize thermal efficiency. - [Willard Pulkrabek Engineering Fundamtation of I. C. engine Second Edition.]

It must be remembered that the reliability of an engine depends not so much, it is true on the proportion of the total heat converted into useful work, but rather upon the proportion of the total heat which is not so converted & which is left over to make trouble. [Harry Ricardo, High speed combustion Engine 1923]

Internal combustion engines at best can transform about 25 to 35% of chemical energy in the fuel into mechanical energy. About 35% of heat generated is lost into the surrounding of combustion space. Remainder being dissipated through exhaust & radiation from the engine.

It should be remembered that abstraction of heat from the working medium by the way of cooling the engine components is a direct thermodynamic loss.

High pressure fuel injection systems such as common rail system & electronically controlled unit injector [EUI] systems have been widely applied modern heavy duty diesel engines. They are shown to be very effective for achieving high power density with high fuel efficiency & low exhaust gas emissions. However the increased peak combustion pressure gives additional structural & thermal load to engine structure. Thus proper material selection & thermal analysis of engine components are essential in order to meet the durability, requirements of heavy duty CI engines adopting high pressure injection systems.

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II. OBJECTINVE OF WORK

Temperature of burned gases in the cylinder of an internal combustion engine may reach upto ten times of surface temperature and leads to great heat fluxes emitted to the chamber walls during the combustion period. Maximum metal temperatures for the inside of combustion chamber space are limited to much lower values by a number of considerations & hence cooling for the engine becomes essential. In regions of high heat flux, thermal stresses must be kept below levels that would cause fatigue cracking (less than about 400°C for cast iron & 300°C for aluminium alloys). The gas side surface of cylinder wall must also be kept low to prevent deterioration of the lubrication oil film. Heat transfer effects the engine performance, efficiency & emissions.

III. LITERATURE SURVEY

3.1 LITERATURE REVIEWS

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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.

IV. HEAT TRANSFER THROUGH CYLINDER HEAD

4.1 HEAT TRANSFER

Heat transfer is that science which predicts the rate of energy transfer taking place between material bodies is a result of temperature difference between them. The study of heat transfer has become an increasingly intense concern in modern technology in the earth science, in organic metabolism in environmental Engineering. The study of heat transfer is carried out for the following purpose-

i) To estimate the rate of flow of energy as heat through the boundary of the system under study. (Both under steady and transient conditions)

ii) To determine the temperature field under steady and transient condition.

In almost every branch of engineering, heat transfer problems are encountered which cannot be solved by thermodynamics reasoning alone, but requires an analysis based on heat transfer principles. The areas covered under the discipline of heat transfer are-

Design of thermal and nuclear power plants.
Internal combustion engines.
Refrigeration and air conditioning units.
Design of cooling systems for electronics motors, generators and transformers.
Heating and cooling of fluids etc. in chemical operations.
Construction of dams and structures; minimization of building heat loss using improved insulation techniques.
Thermal control of space vehicles.
Heat treatment of metals.
Dispersion of atmospheric pollutants.

V. RESULT AND CONCLUSION

The CAE softwares are nowadays widely used for simulation as the result achieved are quite close and approximate to the real condition. Various software were used in the project. Modeling was done with CATIA V5. Meshing was done with the thermal analysis was done with ANSYS WORKBENCH 2014.0.

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CONCLUSION

The Three Cylinder Head S.I. engine in conventional mode is suggested to be operated at a flow rate of 63 GPM where the max. temp. 72˚ C. at the exhaust valve region. On reducing flow rate to 49 GPM the max temperature at the exhaust valve region goes to 90˚ C. where the cylinder head get overheated and for increasing the flow rate up to 80 GPM the temperature in the vicinity of exhaust valve reduces to 50˚ C. where cylinder head is overcooled