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COMPUTER AIDED THERMAL ANALYSIS OF CYLINDER HEAD FINS: REVIEW

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Abstract

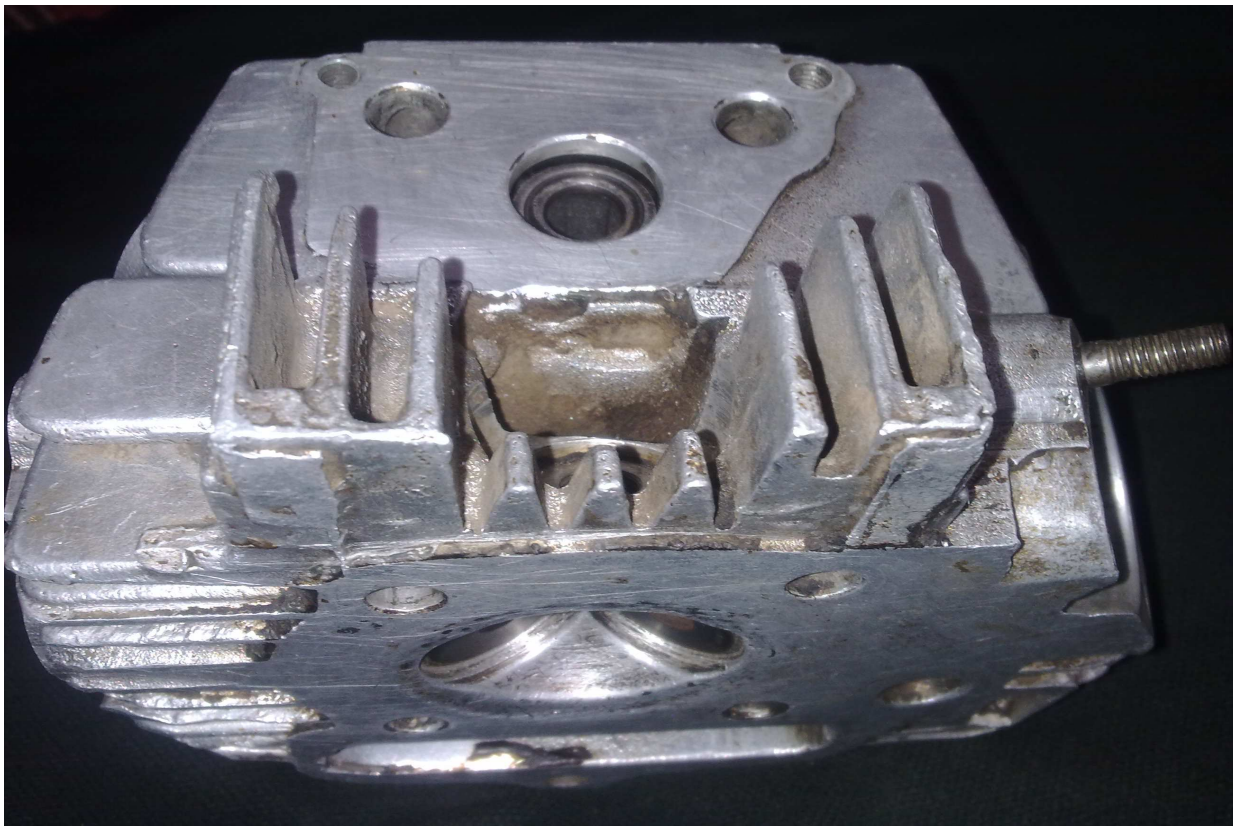
Fin is an extended surface used to increase the heat transfer rate. The heat transfer rate depends on conductivity of material and convective heat transfer coefficient and surface area to volume ratio. The selection of fin for a particular job depends upon the factors which will give maximum efficiency, minimum material for cost, weight and space consideration, minimum resistance to the flow of ambient cooling medium, adequate strength and ease in manufacturing. Fins are used to increase the heat transfer in a wide variety of applications such as I.C. Engines, Gas Engines, Jet propulsion, Nuclear Reactors. Magneto hydrodynamic devices, compressors, Cryogenic storage equipments, refrigeration and air conditioning electronic components, computer end users segment (PCs) microprocessor etc.

INTRODUCTION

If all the work regarding analyzing and improving available cylinder head is done manually, it is very time consuming. It needs lot of paper work for the data. In manual method, all the decision is taken by trial and error basis therefore amount of rework and chances of errors increases and ultimately cost of production increases. To overcome all these problems, the technology of CAD/CAM/CAE is beneficial. In which the cost of design can be reduced & manufacturing cost also by avoiding cost of rework. Here, an attempt is made to create a realistic model of product in computer which can be used for purpose of testing i.e. analysis. The result of this analysis is valid for real condition.

Reduction of design and development cycle time can be achieved by reducing number of physical and virtual prototypes. Understanding structural behavior in initial phase of design can help to reduce the number of virtual prototypes and time taken for their evaluation.

The main objective of the project is to carry out transient thermal analysis of cylinder head. For this, cylinder head of Hero Honda (Splendor plus- 97.20 cc) engine is reverse engineered and modeled in CAD software CATIA V5R 18. It is then analyzed in FEA software FEMAP 9.31 for transient thermal analysis. Possible changes in shapes of fins are also suggested to increase the heat transfer rate across cylinder head. Actual cylinder head has ‘straight fins’ which are being replaced by ‘tapered fins’ in modeling for analysis which improves heat dissipation across the head. Another effective fin shape i.e. ‘cylindrical tapered fin’ is also effective than previous two, is suggested after analysis of it in FEMAP.



The literature review gives some background into the engine worked out in various industries.

Rosli abu bakar devarajan ramasamy chiew Chen wee had studied the importance of heat transfer in design of two stroke engines to make sure the engine will perform to expectation during actual working condition. Heat transfer was modeled with conduction as the main source of heat transfer and neglecting convection and radiation. Heat transfer is a very wide field used in analysis of internal combustion engine. Heat transfer in spark ignition engine is needed to determine thermal stress on material component. Thermal stresses must be kept below level that would cause fatigue cracking (less than about 400◦c for cast iron and 300◦c for aluminum alloy). As technical remark the engine seem to dissipate the heat generated quite efficiently as the value are constant in the 60 second time of the analysis. But hear the time can also be increased to give a more detailed view of heat transfer scenario. The thermal load

causes very less displacement to the material and value are almost in microns [1].

H.K.D.H Bhadeshia suggested that Thermal analysis comprises a group of techniques in which a physical property of substance is measured as a function of temperature, while the substance is subjected to a controlled temperature program. In differential thermal analysis, the temperature differences that develop between a sample and an inert reference material are measured, when both are subjected to identical heat treatment. The related technique of directional scanning calorimetric relies on difference in energy require to maintain the sample and reference at an identical temperature. Length or volume change that occur on subjecting material heat treatment are detected in dilatometry; x-ray or neutron diffraction can also be used to measure dimensional changes.

Both thermogravimentry and evolved gas analysis are technique which relies on samples which decompose at elevated temperature. DTA may be defined formally as a technique for recording the differences in temperature between a substances and a references and a references material against either time or temperature as the two specimens are subjected to identical to temperature regimes in an environments heated or cooled at controlled rate. [2]

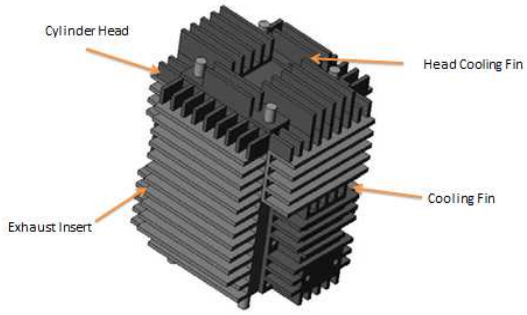
V. Esfahanian, A. Javaheri and M.G haffarpour studied Thermal analysis of an S.I. engine using different combustion boundary condition treatment and the heat transfer to an engine. Three different methods for the combustion boundary condition are used. The result of different combustion side boundary condition treatment is compared and their effect on the thermal behavior of the combustion chamber is investigation .it has been shown that using spatial and time averaged. Combustion side boundary condition is a suitable treatment method within engineering approximation. The main heat source for the piston is the hot gases in the combustion chamber for this boundary condition .this engine are modeled with KIVA-3V computational code. From the combustion chamber thermal analysis point of view the hot gases in the combustion

chamber at various stages (resulting from the KIVA-3V code) is required. There for iteration is needed to obtain the correct boundary condition. [3]

Ing. Radek Tichánek, Ing. Miroslav Španiel, CSc., Ing. Marcel Diviš The cylinder head is one of the most complicated parts of an internal combustion engine. It needs to contain a combustion chamber, intake and exhaust valve ports, valves with valve seats and guides, a fuel injector and a complex of cooling passages. In the combustion chamber there are peaks of combustion pressure and temperature on the order of 15 MPa and 2500K. The heat fluxes and temperature non uniformities lead to thermal stress, which further escalates mechanical loading from combustion pressure. The maximum temperature of the head material is much lower and the regions around the combustion chamber need to be safely cooled to prevent overheating. Placing the cooling passages closest to the most exposed regions is not always possible because of space demand, which results in limited cooling in these regions. The parts of the engine head assembly are usually made of different materials with various thermal expansions. These facts lead to many compromises in design, which can be sources of failures in operation. To avoid the risk of failure in operation is one of the targets of engine designers. The design of the engine head must be tested under operational conditions. This procedure is necessary but expensive. An FE modeling of the cylinder head assembly operational conditions is an appropriate complement to the operational testing. [4]

Azrol Bin Arof , This dissertation describes the stress distribution of the upper piston with using finite element analysis. The finite element analysis is performed by using computer aided engineering (CAE) software. The main objectives of this project are to investigate and analyze the stress distribution of upper piston at the real engine condition during combustion process. The dissertation describes the mesh optimization with using finite element analysis technique to predict the higher stress and critical region on the component. The upper piston is implemented in the six stroke engine of 110 cc Modenas motorcycle. Aluminum 356-T7 is selected as

an upper piston material. Despite all the stresses experience by the upper piston does not damage the upper piston due to high tensile strength but the upper piston may fail under fatigue loading. Thus, it is important to determine the critical area of concentrated stress for appropriate modification. With using computer aided design (CAD) which is SOLIDWORK, the structural model of an upper piston is developed. Furthermore, the finite element analysis performed with using MSC PATRAN and MSC NASTRAN. The finite element analysis is performed by using linear static stress method. The result of the analysis shows that mesh type of TET 10 give more accurate result compare to TET 4 at its each mesh convergence point. The stress analysis results are significant to improve the component design at the early developing stage. The result can also significantly reduce the cost and time to manufactured the component and the most important to satisfy customer needs.[6]



Cylinder Block

Methodology

Reverse Engineering is a growing field that continues to evolve to suit the rapid changes of the 21st century. Engineering fields are constantly improving upon current designs and methods to make life simple and easier. When referring to technology, simple and easy can be directly related to fast and accurate. Simple meaning that, you do not use up valuable time in assembly or doing a specific task. Easy meaning how many times you will have to do the process or task.

When we think of Engineering, we think of the general meaning of designing a product from a blue print or plan. Engineering is described as “the application of scientific and mathematical principles to practical ends such as the design, manufacture, and

operation of efficient and economical structures, machines, processes, and systems". This type of Engineering is more commonly known as Forward Engineering. An emerging Engineering concept is utilizing Forward Engineering in a reverse way. This method is more commonly referred to as Reverse Engineering.

Reverse Engineering is an approach that is used in many domains like Electrical Engineering, Computer Sciences and many others. The main object of RE is the analysis of an existing product (that can be a software application, a mechanical product, etc…) in order to produce a copy and/or an improved release of this one. [7]

RE can be defined in many ways like,

• The process of recreating a design by analyzing a final product.

• The process of duplicating an existing component or product without the help of drawings, documentation or computer model is known as reverse engineering.

• A systematic methodology for analyzing the design of an existing device or system either as an approach to study the design or as a prerequisite for re-designs.

DISCUSSION

The basic cylinder head has "straight rectangular fins" which are replaced by "tapered fins" in modeled head for analysis. These modified fins gives effective heat distribution than basic straight rectangular fins. Modification of fins may increase the heat transfer rate in available head if practically applied. If we modeled cylindrical tapered fins on cylinder head then it can gives more heat transfer rate than straight and tapered fins.

Scope: -

The present project is based on first few seconds' analysis when engine starts from cold condition. A detailed analysis doing considering all the aspects of engine performance like supercharging, scavenging, etc.

The study further can be extended for detailed CFD analysis with variable engine condition. Also validation doing comparing with experimental data which is not

available for the current project. Optimization of dimensions of the components can be another research topic which can be extended from this project.

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