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Design and Analysis of Cylinder Head of an Engine

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Abstract:
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. Heat Transfer through cylinder head consists of conduction through walls and convective heat transfer due to surrounding air flow. As the shape of cylinder head is complex and temperature within the combustion chamber is still fairly unknown. Conventional methods of evaluating heat transfer are very complex this project aims at evaluating heat transfer through cylinder head using finite element analysis as well as the structural analysis. Geometrical models of Cylinder head with and without fins are developed in Auto CAD software .Thus developed models are exported to ANSYS software, and finite element model for thermal analysis done in ANSYS. Effect of fins on heat transfer through cylinder is evaluated. The proficiency of any automobile engine is deals with the structural strength of its cylinder and cylinder head. Cylinder and cylinder head are most important parts of an engine because the piston moving inside the cylinder, so friction between cylinder wall and piston is very higher and due to this the mechanical load or fatigue load acting on the cylinder. So that structure of cylinder should be stronger. 3Dmodel of cylinder and cylinder head were created using Pro/Engineer software and ANSYS was used to analyze the thermal and structural analysis. So finally design considerations, material specifications, failure analysis, these all are reviewed successfully over here.

Keywords: Cylinder Head, I C Engines, Heat Transfer, Cylinder, cylinder head, FEM, Pro/Engineer, Fatigue Load, Thermal Load, Structural Strength

I. INTRODUCTION

The cylinder head is one of the most complicated parts of an internal combustion engine. It is directly exposed to high combustion pressures and temperatures. In addition, it needs to house intake and exhaust valve ports, the fuel injector and complex cooling passages. Compliance with all these requirements leads to many compromises in design. As a result, cylinder heads tend to fail in operation (distortions, fatigue cracking) due to overheating in regions of limited cooling. In this study, we have put emphasis on the problematic regions around the valve seats and narrow bridges between valves. These regions experience especially severe thermal loading, as they receive heat not only from in-cylinder burning gases during the combustion period but also from burned gases flowing through the exhaust valve and along the exhaust-port walls during the exhaust.

Although the temperatures of exhaust gases are significantly lower than peak in-cylinder temperatures, rapid movement of flowing gases there promotes the heat transfer to the walls. Most of the heat accumulated in the valve is rejected through the contact surface of the valve seat. Therefore, any deformations of these parts accompanied by improper contact and occurrence of leakage on the conical valve contact face dramatically increase the thermal loading of the valves and, therefore, may lead to their destruction. A detailed FE heat-transfer analysis can provide valuable information on the temperature distribution in the overall assembly of the cylinder head, especially in those regions where experimental data is almost impossible to gather. Moreover, this is the first logical stage of cylinder head strength analysis. In the next step, the temperature and mechanical stresses have to be analyzed using temperature field and pressure (and other mechanical loads, e.g., belt pre-stress). The resulting displacement/stress fields may be utilized for evaluation of operational conditions, e.g., contact pressure between valves and valve port uniformity, as well as strength and failure resistance of the assembly. Such information contributes to a detailed understanding of the thermal andmechanical processes in the cylinder-head assembly under engine operation, which is a prerequisite for further optimization of engine design.

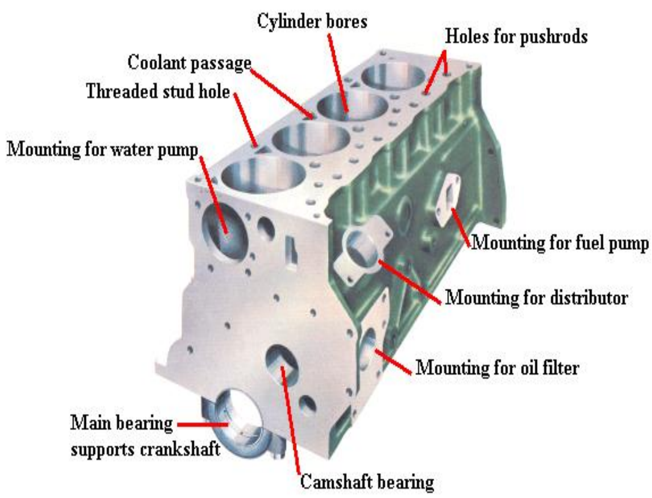


Figure.1. Cylinder Head

II. LITERATURE REVIEW

Chidiebere Okeke-Richard & Sunny Sharma [1] They analyze cylinder blocks of 4Stroke SI Engines of two wheelers from three different companies like HONDA, TVS, YAMAHA, to find out the thermal effects of combustion gases with respect to change in temperature and heat flux From the analysis they conclude that Honda Activa always have higher amount of heat dissipated throughout the time than TVS Wego and also state that the Yamaha Ray Z, dissipates the least in the winter season irrespective of the difference in thermal properties.

KM Sajesh, Neelesh Soni and Siddhartha Kosti [2] they perform CFD analysis of rectangular fins of engine. They choose two wheeler bike engine (e.g. Unicorn bike engine) and geometry is designed in Design Modeler in ANSYS 16.0.they used for is Al 6063 which was a thermal conductivity of 200 W/mK.They do modification in design of engine is made by creating holes on fin. Performed transient and steady state heat transfer analysis on the engine for a period of 400 second.

Mr. Manir Alam & Mrs. M. DurgaSushmitha[3] they worked on a cylinder fin body for motorcycle is modeled using modeling software CATIA. The original model is changed by geometry of the fin body and distance between the fins and thickness of the fins they used material for fin body is Cast Iron. Thermal analysis is done for all the three materials Cast Iron, Copper and Aluminum alloy 6082. They observed the thermal analysis result, heat flux is more for Aluminum alloy than other two materials and also by using Aluminum alloy the body weight is less so using Aluminum alloy 6082 is better.

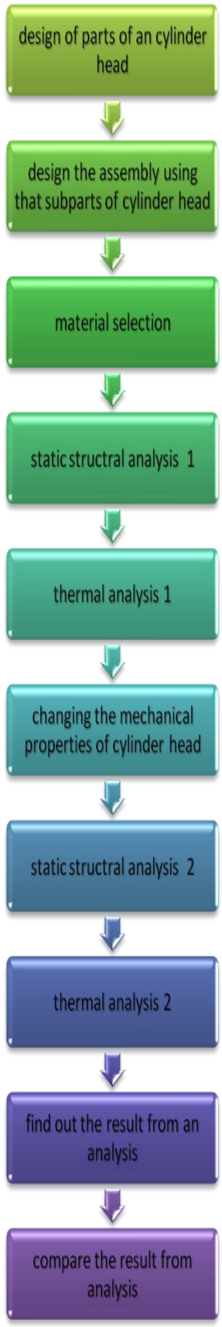
Swati Saini &Kagdi Dhruvin Nileshkumar [4] they performed CFD simulation for the results obtained by the experiments conducted by Thornhill et al and Yoshida et al. the heat transfer growth can be performed using the same cylinder with different fin profiles. The fin profile selected for heat transfer augmentation is developed using CAD software and simulation was carried out in similar way as performed for experimentally.

P.T. Nitnaware &Prachi S. Giri [5] they investigate the effect of fin geometries and coefficient of heat transfer coefficient and material they study for the heat loss for air cooling for an IC engine. heat transfer per unit weight of fin is larger for conical fin than the rectangular fins. that is why conical fins are preferred over rectangular cross section fins. The rate of heat transfer increases with increasing h. for small values of h the Aluminum is the better material for designing fins for air cooled engines due to less weight, high rate of heat transfer and lower cost.

H.Sumithra & B. Sandhya Rani [6] after doing the three different coupled (thermal & structural) analysis with three different materials they found that the maximum stresses for three materials. Before Modification Material Aluminum92, Aluminum96 and Aluminum Silican Nitrate the maximum temperatures are 671.45 oC, 665.74 oC and 505.73 oC. After Modification for Material Aluminum-92, Aluminum-96 and Aluminum Silican Nitrate the maximum temperatures are 459.68 oC, 449.91oC and 294.95 oC.

Finally they concluded that the Silican Nitrate was best material among all due to factor of Safety than other two. The Model weight is reduced after modification from 1.643kg to 1.627kg at a Density of 3000Kg/m3

III. METHODOLOGY



IV. TOOLS / PLATFORM

The tools used for the design the cylinder head of an engine are like Catia Software. On the basis of Catia software all the designing data will be covered as well as the drafting is also done on this software. The secondary part of a project is an analysis of an designed part of cylinder head in done on the Ansys software. On this software the all type of the analysis of the cylinder head is done like structural, static, thermal etc. analysis is done by using the Ansys software.

V. DESIGN / MODELLING

The location, profile, shape and volume of the intake and exhaust ports. The contour of the "short side" of the intake runners as the ports curve just above the intake valves. The height of the intake runners relative to the position of the intake valves. The shape and volume of the bowl area just above the valves.The size of the valve guides and guide supports in the intake runners. The diameter of the valve stems. The size of the intake and exhaust valves. The angles on the valve seats. The angle of the valves in the cylinder head with respect to the deck surface and each other. The relationship between the diameter of the valves, the size of the ports, and the diameter of the cylinder bores. The size and shape of the combustion chambers and how much shrouding is around the valves.The surface finish and texture inside the ports (a slightly rough finish actually flows better than mirror smooth). The length and design of the intake runners in the intake manifold.

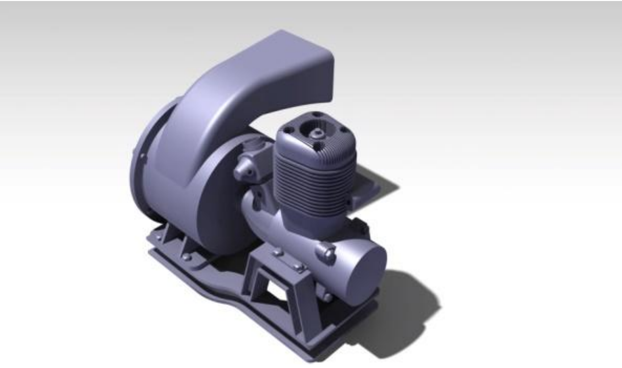


Figure.2. Assembly of Engine Blower

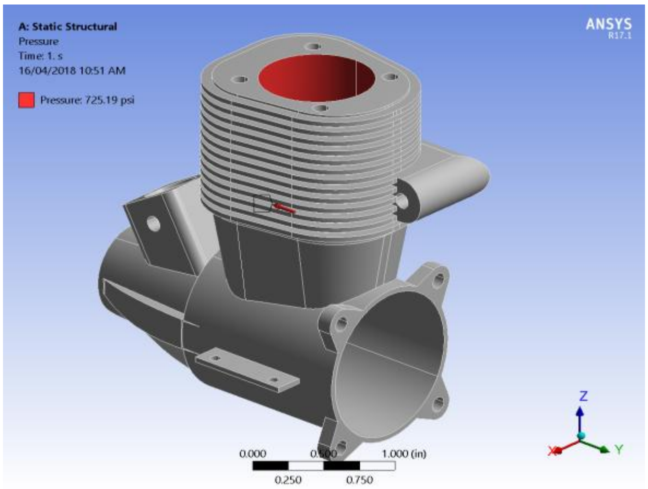


Figure.3. Pressure Applied for Engine Blower

Table.1. Meshing Properties of Engine Blower

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	8. s
MAPDL Memory Used	152. MB
MAPDL Result File Size	11.688 MB
Post Processing	
Calculate Beam Section Results	No

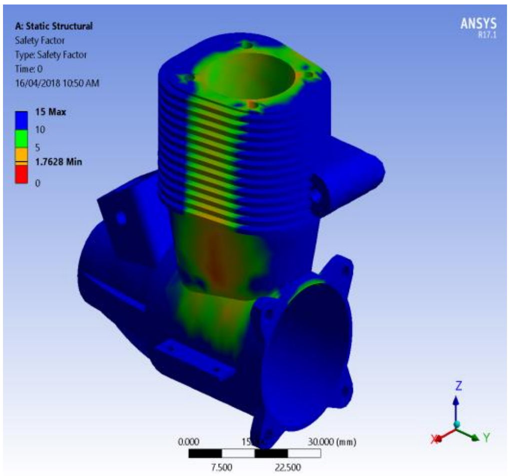


Figure.4. Safety Factor of Engine Blower

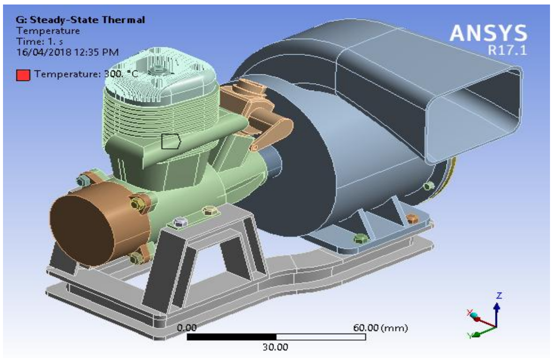


Figure.5. Temprature Applied on Engine Blower

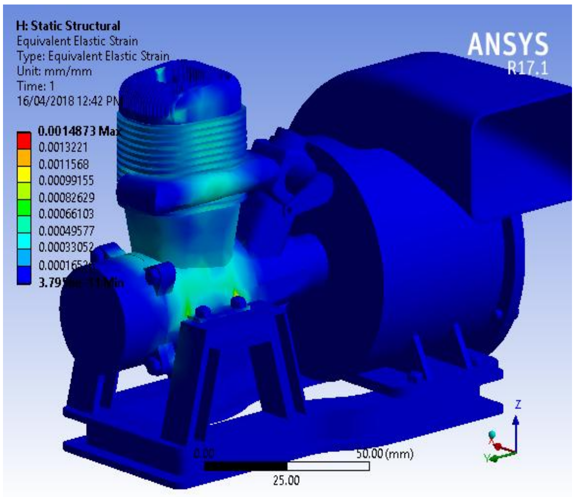


Figure.6. Equivalent Elastic Strain for Engine Blower

VI. RESULTS & CONCLUSION

After design and analysis of the engine blower the result found from the ansys software are as follows:
Pressure Applied to Engine Blower is 725 PSI

1. Static Structural

2. Thermal Stress

Table .2. Static Structural

Object Name	**Equivalent Stress**	**Equivalent Elastic Strain**	**Total Deformation**
Minimum	7.9715e-003 MPa	6.3084e-008 mm/mm	0. mm
Maximum	48.9 MPa	2.604e-004 mm/mm	4.8629e-003 mm

2. Thermal Stress

Table.3. Thermal Stress

Object Name	**Equivalent Stress**	**Equivalent Elastic Strain**	**Total Deformation**
Minimum	0. MPa	3.7956 e-011 mm/mm	1.5337E-006 mm
Maximum	6.4531 e-002 MPa	1.4873E-003 mm/mm	269.56 mm

From this paper we are conclude that the design and analysis of the engine blower is done and the static and thermal analysis also, from this analysis the material selection should be very critical part, the maximum deformation on the edge of the cylinder blower is around 269.56MPa.

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