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DESIGN AND STATIC ANALYSIS OF A HIGH PRESSURE DIE CATING CYLINDER WITH BORE FINS

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ABSTRACT: The Engine cylinder is one of the major automobile components, which is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the cylinder to increase the rate of heat transfer. By doing thermal analysis on the engine cylinder fins, it is helpful to know the heat dissipation inside the cylinder. The principle implemented in this project is to increase the heat dissipation rate by using the invisible working fluid, nothing but air. We know that, by increasing the surface area we can increase the heat dissipation rate, so designing such a large complex engine is very difficult. The main purpose of using these cooling fins is to cool the engine cylinder by any air. A parametric model of piston bore fins has been developed to predict the transient thermal behavior. The parametric model is created in 3D modeling software Pro/Engineer. Thermal analysis is done on the fins to determine variation temperature distribution over time. The thickness of the fin is 3mm, analysis is also done by changing the thickness to 2.5mm. The analysis is done using ANSYS. Analysis is conducted by varying material. Presently Material used for manufacturing fin body is Cast Iron. In this thesis, it is replaced by aluminum alloy 204, aluminum alloy 6082 and Copper. Thermal analysis is done for above four materials to validate the better material for piston bore fins. The die is prepared by first modeling the part, extracting core & cavity and generating CNC program. Die is designed in this thesis according to HASCO Standards. Total die components and its complete detailed drawings, material selection for each component, manufacturing processes for each component are also included. The modeling, core – cavity extraction and generating CATIA is the standard in 3D product design, featuring industry-leading

1. INTRODUCTION:

Most internal combustion engines are fluid cooled usingeither air (a gaseous fluid) or a liquid coolant runthrough a heat exchanger (radiator) cooled by air. In aircooling system, heat is carried away by the air flowingover and around the cylinder. Here fins are cast on thecylinder head and cylinder barrel which provideadditional

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conductive and radiating surface. In watercoolingsystem of cooling engines, the cylinder wallsand heads are provided with jacket Cooling fins helpkeep Chevrolet volt battery at ideal temperature Weknow that in case of Internal Combustion engines,combustion of air and fuel takes place inside the enginecylinder and hot gases are generated. The temperature ofgases will be around 2300-2500°C. This is a very highTemperature and may result into burning of oil filmbetween the moving parts and may result into seizing orwelding of the same. So, this temperature must bereduced to about 150-200°C at which the engine willwork most efficiently.

1.1 INTRODUCTION TO DIE CASTING: Die casting is a versatile process for producing engineered metal parts by forcing molten metal under high pressure into reusable steel molds. These molds, called dies, can be designed to produce complex shapes with a high degree of accuracy and repeatability. Parts can be sharply defined, with smooth or textured surfaces, and are suitable for a wide variety of attractive and serviceable finishes. Die castings are among the highest volume, massproduced items manufactured by the metalworking industry, and they can be found in thousands of consumer, commercial and industrial products. Die cast parts are important components of products ranging from automobiles to toys. Parts can be as simple as a sink faucet or as complex as a connector housing. Die casting is a method of producing alloy castings by injecting molten metal into metallic mold under pressure.

Die casting process can be classified intoThe basic die casting process consists of injecting molten metal under high pressure into a steel mold called a die.Die casting is an efficient, economical process offering abroader range of shapes and components than any othermanufacturing technique. Parts have a longer service lifewhen compared to plastic, and may be designed tocomplement the visual appeal of the surrounding part.

1.2 ADVANTAGES OF DIE CASTING PARTS: One of the main advantages of die casting is the ability to produce parts and products with a wide range of shape and sizes. Unlike other manufacturing processes such as extrusion, the die casting process does not limit the shape of parts and in most cases will be the net shape of the parts.

1.3 ENGINE CHARACTERISTICS: The diesel engines become a dominant in the transportation, power generation, irrigation field, because of its outstanding fuel economy and its lower running cost. The engine selected for the project analysis is of diesel engine type which works on diesel cycle.

1.4 IMPORTANCE OF THE ENGINE ENERGY TRANSFER: The extreme level of the combusted gas temperature in the internal combustion engine's cylinder is being the order of 1500 Kelvin. Ultimate metal temperature of the inner side of the combustion chamber, space that has been limiting to much lower values by a number of considerations of the parameters, and cylinder head cooling range, cylinder, and piston must be given. For giving mass of fuel which is within the engine's cylinder, high level of energy transfer to the walls of combustion chamber will be lowering the mean burning gas temperatures and pressure, and can be reduced the work per cycle transferring to the piston. Thus specific power and efficiency which has been affected by the amount of the internal combustion engine's heat transfers. The value of heat transfer coefficient between metal and air is appreciably low. As a result of this the cylinder wall temperature of the air-cooled cylinders are considerably higher than those of water-cooled type. In order to lower the cylinder, wall temperature the area of the outer surface which directly dissipates heat to the atmosphere must be sufficiently high.

Fins: The fins are either cast as an integral part of the cylinder or separate finned barrels inserted over cylinder barrel. Sometimes, fins are machined from the forged cylinder blanks. The amount of heat trans -firthrough the extended surfaces are by conduction and the distribution of temperature in the fin is depending upon the both properties of fin material and engine outside fluid. The extended surface configuration is generally classified as a straight fin, an annular fin, or spine. The term straight fin is applied to the extended surfaces attached to wall which is otherwise plane. Whereas an annular fin is one attached circumferentially, to the cylinder surface.

ANNULAR FINS:

Concentric annular or radial fins were provided to improve the heat transfer rates from the external wall areas of a circular cylinder. Rectangular profile, Triangular profile and Trapezoidal profile are three well known angular fins

AIR COOLED SYSTEM Air cooled system is generally used in small engines sayup to 15-20 kW and in aero plane engines. In this systemfins or extended surfaces are provided on the cylinderwalls, cylinder head, etc. The amount of heat dissipatedto air depends upon

- Amount of air flowing through the fins.
- Fin surface area.

Figure 1.1 Air Cooling System Problem Defination

In the present paper investigation on thermal issues on automobile fins were carried out. Investigation yields the temperature behavior and heat flux of the fins due to high temperature in the combustion chamber. Also the material is changed so that better heat transfer rate can be obtained. We have taken rectangular fin with 3mm thickness. The heat transfer surface of the engineis modeled in 3D modeling software CATIA V5 R20. Thermal analysis is done on the fins to determine variation temperature distribution over time. The analysis is done using ANSYS. Analysis is conducted by varying material of fins and a comparison is thus established between them.

2. LITERATURE REVIEW

Choosing the right cutting parameters is a vital step in machining because the cutting parameters influence on the output characteristics of the machined products like surface finish, the tooling cost by influencing the tool wear and finally the safety of the machine tool by influencing the cutting force. Optimizing the cutting parameters is difficult in conventional machines. However, it is easy to control the parameters precisely in case of CNC machines. In using CNC machines the advantage is that the part program can be modified even before it is loaded on to the machine i.e. the parameters can be optimized offline. Though there are facilities to have online optimization techniques like adaptive control they work out to be costly solutions. Though there are many parameters that influence the output characteristics it is found from literature that cutting speed, feed rate and depth of cut are the major parameters that have to be optimized.

[1] AmanAggarwal et al (2005) and Indrajit Mukherjee et al (2006) reported a review of literature on optimization of machining techniques. This review shows that techniques like fuzzy logic, genetic algorithm, scatter search, Taguchi technique and response surface methodology are the latest optimization techniques that are being applied successfully in industrial applications for optimal selection of process variables in the area of machining. A review of literature on optimization techniques has revealed that there are, in particular, successful industrial applications of design of experiment-based approaches for optimal settings of process variables

[2] Palanikumar (2008) studied the use of Taguchi and response surface methodologies for minimizing the surface roughness in machining Glass Fiber Reinforced Plastics (GFRP) with a Polycrystalline Diamond (PCD) tool. The experiments were conducted using Taguchi's experimental design technique. The cutting parameters used were cutting speed, feed and depth of cut. The effect of cutting parameters on surface roughness is evaluated and the optimum cutting condition for minimizing the surface roughness is determined. The experimental results revealed that the most significant machining parameter for surface roughness is feed followed by cutting speed.

[3] GulTosun (2011) reported a statistical analysis of process parameters for surface roughness in drilling of Al/SiCp metal matrix composite. The experimental studies were conducted under varying spindle speed, feed rate, drill type, point angle of drill, and heat treatment. The settings of drilling parameters were determined by using Taguchi experimental design method. The level of importance of the drilling parameters was determined by using analysis of variance. The optimum drilling parameters were obtained by using the analysis of signal-to-noise ratio. Confirmation tests verified that the selected optimal combination of process parameters through Taguchi design was able to achieve the desired surface roughness.

3. METHODOLOGY

- Collecting information and data related to cooling fins of IC engines.
- A fully parametric model of the Engine block with fin is created in CATIA software.
- Model obtained in Step 2 is analyzed using ANSYS 14.0 Or 15.0 (APDL), to obtain the heat rate thermal gradient and nodal temperatures.
- Manual calculations are done.

Finally, we compare the results obtained from ANSYS and manual calculations for different material, shapes and thickness

3.1 MODELING:

Piston Design The piston is designed according to the procedure and specification which are given in machine design and data hand books. The dimensions are calculated in terms of SI Units. The pressure applied on piston head, temperatures of various areas of the piston, heat flow, stresses, strains, length, diameter of piston and hole, thicknesses, etc., parameters are taken into consideration Design Considerations for a Piston. In designing a piston for an engine, the following points should be taken into consideration: It should have enormous strength to withstand the high pressure.

- It should have minimum weight to withstand the inertia forces.
- It should form effective oil sealing in the cylinder.
- It should provide sufficient bearing area to prevent undue wear.
- It should have high speed reciprocation without noise.
- It should be of sufficient rigid construction to
- withstand thermal and mechanical distortions.
- It should have sufficient support for the piston pin.

FIN EQUATION:

Consider a volume element of a fin at location x having a length of x, cross-sectional area of Ac, and a perimeter of p, as shown in Fig. Under steady conditions, the energy balance on this volume element can be expressed as Rate of heat conduction into the element x

=Rate of heat conduction from the element x + Δx+ Rate of heat convection in to the element where

Q convection = h(pΔx)(T -Ta)

d2θ /dx 2 = m2θ ,

where, m2 = hp /KAc

θ(x) = C1emx + C2e-mx

fin with finite length and tip un-insulated.

Qfin = hpKAc (TS – Ta)

tan h ml + h Km1+h Km

tan h(ml)θ θ0

=T−Ta /Ts−Ta

= cos h m l−x + h Km

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[sin h m l−x] cos h ml +h Km [sin h ml]

Efficiency of fin (ηfin) = Actual heat transfer by the fin maximum heat that would be transferred if whole surface of the fin is maintained at the base temperature .

FIN MATERIALS:

CAST IRON: Cast iron is basically an alloy of carbon and silicon with iron. It is containing 2.4 – 3.7 % C, 1.1 – 2.8% Si, 0.3 – 1.1% Mn, 0.16% P and 0.11% S. Cast iron possess high fluidity and hence it cast into any complex shapes and thin sections. It has an excellent wear resistance of grey iron under lubricating sliding conditions has been attributed to the presence of graphite in the micro structure.

ALUMINUM ALLOY: Aluminum is a silvery white metal and it possess following characteristics:Light metal, good conductivity, higher resistance to corrosion and very ductile. The melting point of aluminum alloy varies from 520 – 650oC. The total weight of fin is proportional to the ratio of material density to the thermal conductivity. It is common to see aluminum fins on engine cylinder and heat exchangers. The reason for choice becomes obvious when one compares the weight requirements of aluminum and another material such as cast iron.

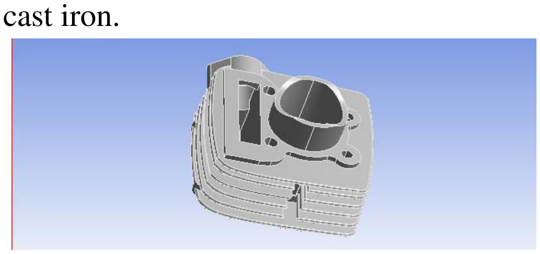

FIGURE 3.1 GEOMETRIC MODELS OF PISTON BORE FINS

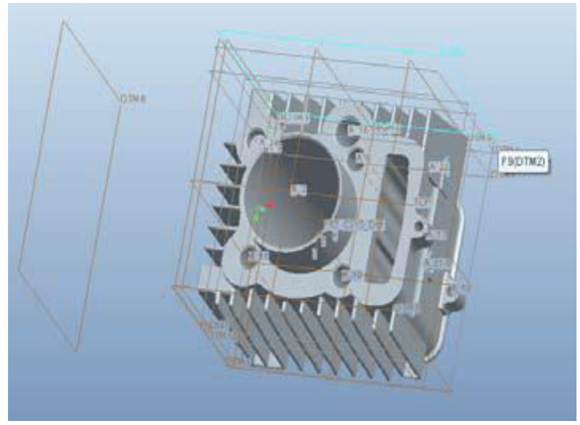

Fig. 3.2 3mm Thickness Fin Body

MESHING:

- The Figure shown is the meshed model of rigid flange coupling in the ANSYS analysis for the static structural process. To analyses, the FEM triangular type of mesh is used for the rigid flange coupling in the ANSYS environment.
- The number of elements used in this meshing is 71441and the number of nodes is 122228.In this process regular type of meshing is done to analyses the process.
- Using the working condition of the coupling a relative rotational movement between the shafts comes into picture consequently.

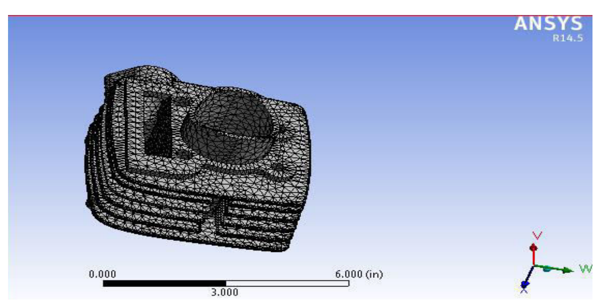

Figure 3.3 Meshed Models Of Piston Bore Fins

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4. RESULTS:

4.1 CAST IRON ANALYSIS PISTON BORE FINS

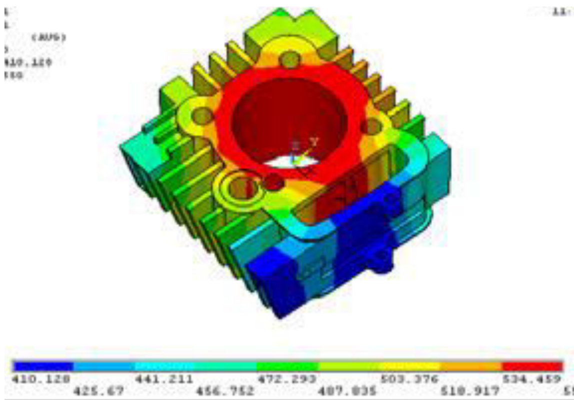

FIGURE 4.1 TOTAL DEFORMATION

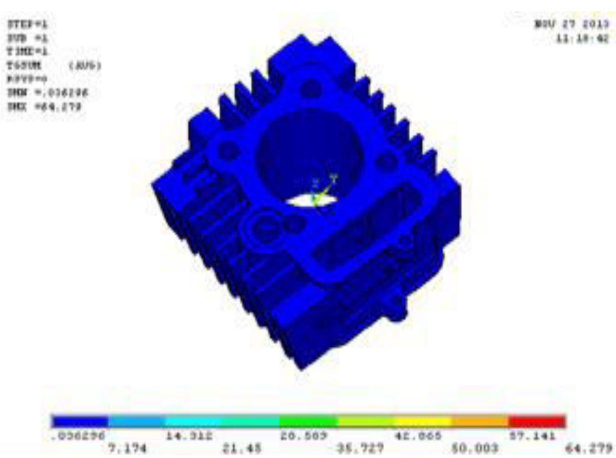

Figure 4.2 Equivalent Stresses

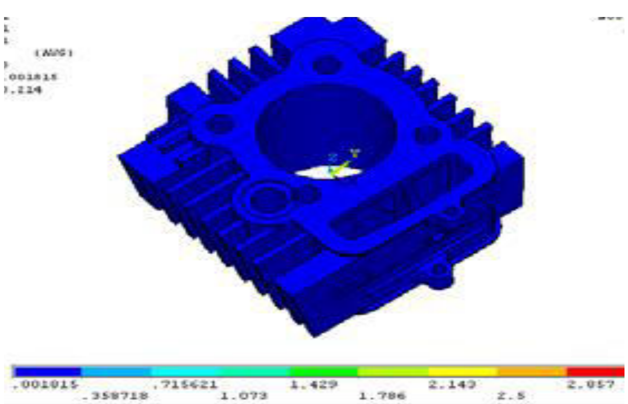

Figure 4.3 Equivalent Stresses

4.2 ALUMINUM ANALYSIS:

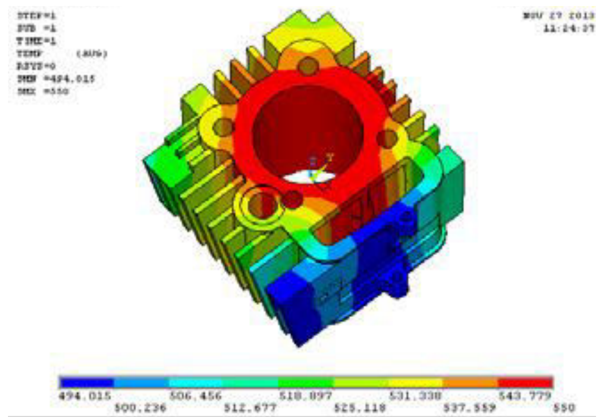

FIGURE 4.4 TOTAL DEFORMATION

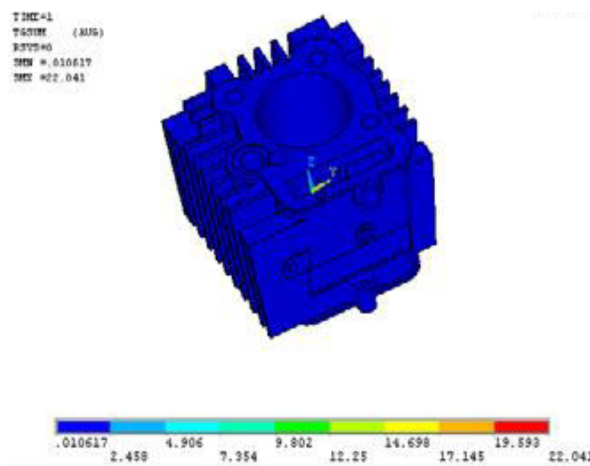

Figure 4.5 Equivalent Stresses

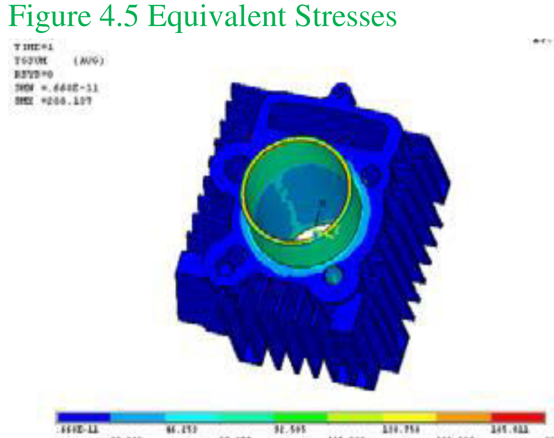

Figure 4.6 Equivalent Elastic Strain

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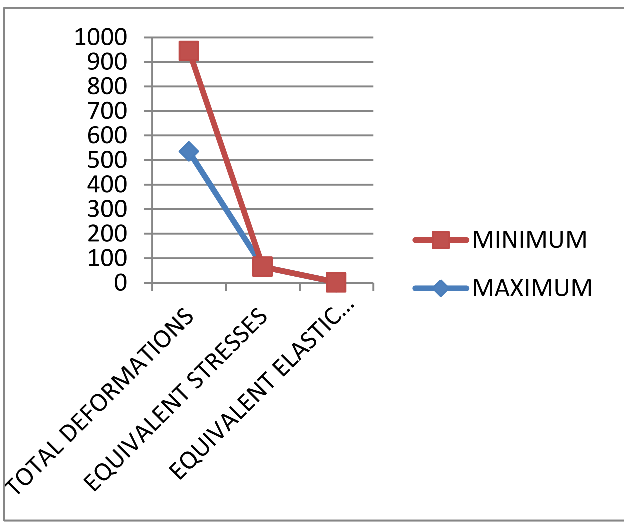
TABLE 4.1 CAST IRON MINIMUM AND MAXIMUM VALUES

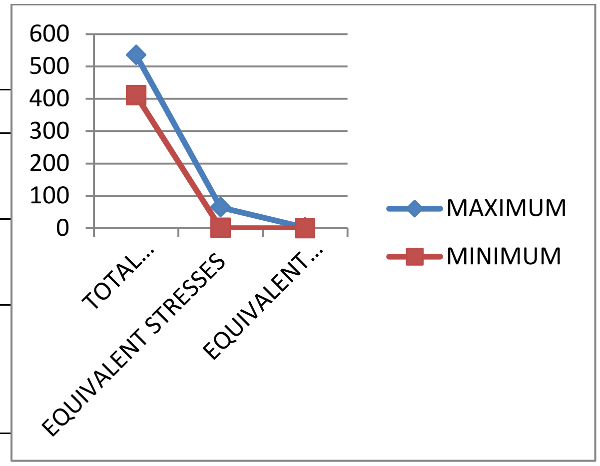
PARAMTERS	MAXIMUM	MINIMUM
TOTAL DEFORMATIONS	534.459	410.120
EQUIVALENT STRESSES	64.279	0.56279
EQUIVALENT ELASTIC STRAIN	2.057	0.001016



Graph 4.1 Cast Iron Minimum And Maximum Values Variations

Table 4.2 Aluminium Minimum And Maximum Values

PARAMTERS	MAXIMUM	MINIMUM
TOTAL DEFORMATIONS	534.779	479.015
EQUIVALENT STRESSES	22.041	0.01617
EQUIVALENT ELASTIC STRAIN	0.66E-11	0.001016



Graph 4.2 Aluminium Minimum And Maximum Values Variations

5. CONCLUSIONS:

In this project a piston bore fins for 150cc engine is modeled in 3D modeling software CATIA analysis is done on the piston bore fins using materials Cast iron and Aluminum Alloy to By observing the analysis, Aluminum alloys and Cast Iron. So heat transfer rate is more for cooper but density is also more so it is preferable to use Aluminum alloys. Also the weight of the piston bore fins is decreased when Aluminum alloy is used since the density of aluminum alloy is less than that of Cast iron.,. Die calculations are done for the casting tool for Aluminum. Plunger diameter is 98mm.Aluminum and We have designed total die for the fin body. We have done manufacturing processes for the two cavities and side insert and generated CNC Program.

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