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DESIGN OPTIMISATION OF CYLINDER FINS WITH OR WITHOUT COATINGS

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Abstract — *Fins or extended surfaces have many applications in heat transfer such as air conditioning, refrigeration, automobile, chemical processing equipment and electrical chips for increasing the heat transfer rate. Recently, researchers and engineers in this field have been paying more attention to both energy conservation and equipment size reduction due to energy crisis in the world.*

So, optimizing the heat transfer is highly desired for effective energy utilization. Because the weight and material cost of the extended surfaces are very important, fin dimensions should be optimized so that the least amount of fin material be used to dissipate a given amount of heat flow, or alternatively that the highest dissipation rate be obtained from a given volume of fin material.

The analysis is carried out for various models of the engine cylinder fins. The modeling is done in Creo Parametric 2.0, thermal analysis is done in Ansys 15.0 (Workbench 15.0). The thermal analysis is performed to check for the better material which can be used to the engine cylinder fins in order to increase the performance. With different shapes and based on the results obtained the geometry that yielded the maximum beneficiary results was identified.

Keywords- *Effective energy utilization, Extended surfaces, Fin dimensions.*

I. INTRODUCTION

A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels. Multiple cylinders are commonly arranged side by side in a bank, or engine block, which is typically cast from aluminum or cast iron before receiving precision machine work. Cylinders may be sleeved (lined with a harder metal) or sleeveless (with a wear-resistant coating such as Nikasil). A sleeveless engine may also be referred to as a "parent-bore engine".

A cylinder's displacement, or swept volume, can be calculated by multiplying its cross-sectional area (the square of half the bore by pi) by the distance the piston travels within the cylinder (the stroke). The engine displacement can be calculated by multiplying the swept volume of one cylinder by the number of cylinders.

A piston is seated inside each cylinder by several metal piston rings fitted around its outside surface in machined grooves; typically two for compressional sealing and one to seal the oil. The rings make near contact with the cylinder walls (sleeved or sleeveless), riding on a thin layer of lubricating oil; essential to keep the engine from seizing and necessitating a cylinder wall's durable surface.

The cylinder liner forms the cylindrical space in which the piston reciprocates. The reasons for manufacturing the liner separately from the cylinder block (jacket) in which it is located are as follows; The liner can be manufactured using a superior material to the cylinder block. While the cylinder block is made from a grey cast iron, the liner is manufactured from a cast iron alloyed with chromium, vanadium and molybdenum. (cast iron contains graphite, a lubricant. The alloying elements help resist corrosion and improve the wear resistance at high, temperatures.)The cylinder liner will wear with use, and therefore may have to be replaced. The cylinder jacket lasts the life of the engine. At working temperature, the liner is a lot hotter than the jacket.

II. REVIEW OF LITERATURE

R. Suresh [4] in his study he examine that the temperature and stress distribution in transient analysis of hypereutectic Al-Si alloy(NASA 398) under different operating conditions of pressure and temperature. A three dimensional CAD model of the inline engine block with 4 cylinders was created using CATIA V5 R16 and was meshed using C3D6T(penta elements) and C3D8T(hexa elements) in HyperMesh 10.0. The analysis of the engine cylinder is carried out considering NASA 398(hypereutectic Al-Si) material using ABAQUS 6.10.

N. Venkateswaran [6], in his study discussed the Coupled thermo mechanical analysis of a cylinder head, cylinder block and crank case with the liner of an uprated engine. The existing engine develops 780 hp output with mechanical driven supercharger and the engine is uprated to 1000 hp by replacing the supercharger with a turbocharger and new Fuel injection equipment. For uprating any engine, the piston and cylinder head are the most vulnerable members due to increased mechanical and thermal loadings. Mechanical loading is due to the gas pressure in the gas chamber and its magnitude can be judged in terms of peak pressure.

The main aim of the project is to analyze the thermal properties by varying geometry, material and thickness of cylinder fins. Transient thermal analysis determines temperatures and other thermal quantities that vary over time. The variation of temperature distribution over time is of interest in many applications such as in cooling. The accurate thermal simulation could permit critical design parameters to be identified for improved life. Presently Material used for manufacturing cylinder fin body is Aluminium Alloy A204 which has thermal conductivity of 110-150W/mk. We are analyzing the cylinder fins using this material and also using Aluminum alloy 6061 and Magnesium alloy which have higher thermal conductivities.

III. MODELING OF A DIESEL ENGINE CYLINDER FINS

The modeling of a diesel engine cylinder is done in Creo Parametric 2.0 modeling software. Creo Parametric was designed to begin where the design engineer begins with features and design criteria. Creo Parametric's cascading menus flow in an intuitive manner, providing logical choices and pre-selecting most common options, in addition to short menu descriptions and full on-line help.

This makes it simple to learn and utilize even for the most casual user. Expert users employ Creo Parametric's "map keys" to combine frequently used commands along with customized menus to exponentially increase their speed in use. Because Creo Parametric provides the ability to sketch directly on the solid model, feature placement is simple and accurate.

The drawing specifications of a diesel engine cylinder fins are as shown in the Fig. 1.

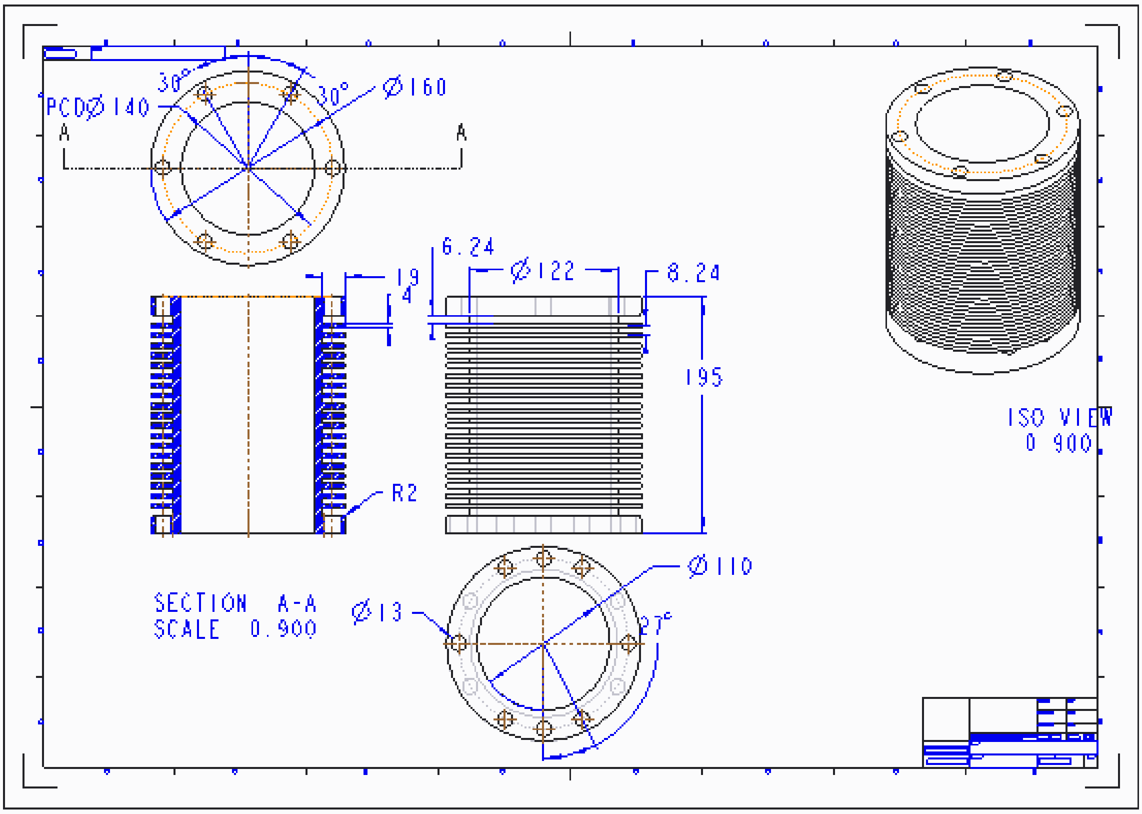


Fig. 1 Drawing Specifications of a diesel engine cylinder fins

IV. COMPUTATIONAL ANALYSIS

The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has developed simultaneously with the increasing use of the high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problem, started in terms of different equations or as an extrinum problem.

F.E.A is a way to deal with structures that are more complex than dealt with analytically using the partial differential equations. F.E.A deals with complex boundaries better than finite difference equations and gives answers to the 'real world' structural problems. It has been substantially extended scope during the roughly forty years of its use.

F.E.A makes it possible it evaluate a detail and complex structure, in a computer during the planning of the structure. The demonstration in the computer about the adequate strength of the structure and possibility of improving design during planning can justify the cost of this analysis work. F.E.A has also been known to increase the rating of the structures that were significantly over design and build many decades ago.

A numerical analysis is carried out to study efficiency and temperature distribution of annular fins of different fin profiles (constant and variable cross-sectional area) when subjected to simultaneous heat and mass transfer mechanisms. The temperature and humidity ratio differences are driving forces for heat and mass transfer, respectively. Actual psychometric relations are used in the present work instead of a linear model between humidity ratio and temperature that has been used in the literature. A non-linear model representing heat and mass transfer mechanisms was solved using a finite difference successive over-relaxation method.

Fins improve heat transfer in two ways. One way is by creating turbulent flow through fin geometry, which reduces the thermal resistance (the inverse of the heat transfer coefficient) through the nearly stagnant film that forms when a fluid flows parallel to a solid surface. A second way is by increasing the fin density, which increases the heat transfer area that comes in contact with the fluid. Fin geometries and densities that create turbulent flow and improve performance also increase pressure drop, which is a critical requirement in most high performance applications. The optimum fin geometry and fin density combination is then a compromise of performance, pressure drop, weight, and size.

FEA can be used in new product design, or to refine an existing product, to ensure that the design will be able to perform to specifications prior to manufacturing. With FEA you can:

- Predict and improve product performance and reliability
- Reduce physical prototyping and testing
- Evaluate different designs and materials
- Optimize designs and reduce material usage

Solutions are obtained for temperature distribution over the fin surface in addition to fin efficiency for both fully wet and partially wet fin surfaces. The numerical results are compared with those of previous studies. It was found that one of the linear models for the relation between the humidity ratio and temperature is a reasonable approximation.

Geometry and Domain are created in ANSYS 15.0. Blocking and Meshing is done. Checking the mesh quality and saving the file to solver.

The deformation model for the diesel engine cylinder fins is as shown in the Fig. 2.

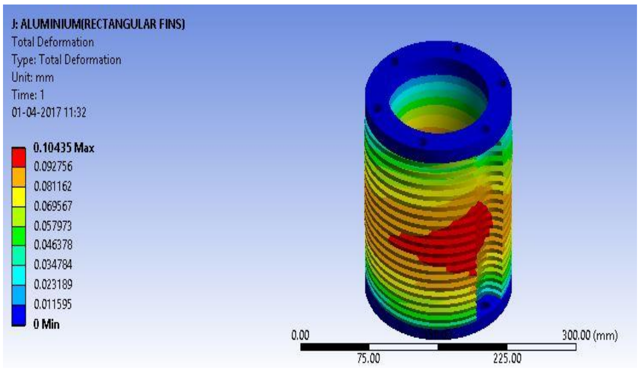


Fig. 2 Deformation model for the diesel engine cylinder fins

The equivalent stress model for the diesel engine cylinder fins is as shown in the Fig. 3

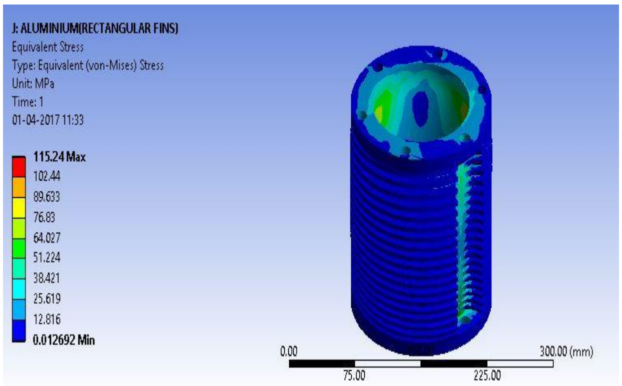


Fig. 3 Equivalent stress model for the diesel engine cylinder fins

The modeled fins were subjected to convective boundary conditions on the inner and outer surface and the displacement boundary condition on the ends. Since only a small vertical section of the tube was considered for analysis, the heat flux through the tube material can be safely ignored. Thus the top and bottom surface of the horizontal section of the tube has been kept as insulated.

The Temperature Contours for the diesel engine cylinder fins are as shown in the Fig. 4

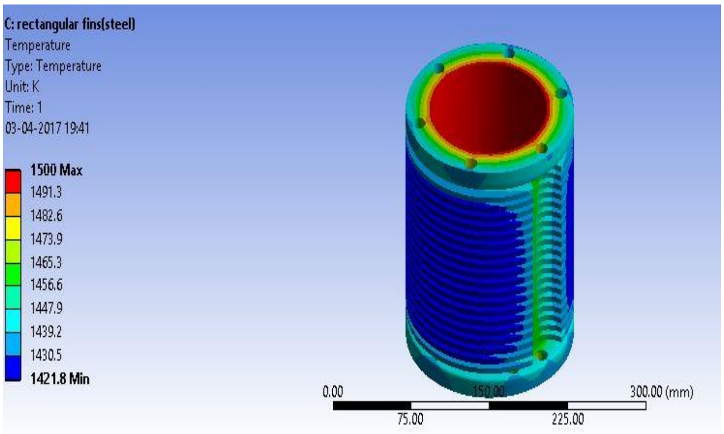


Fig. 4 Temperature Contours for the diesel engine cylinder fins

The heat flux Contours for the diesel engine cylinder fins are as shown in the Fig. 5

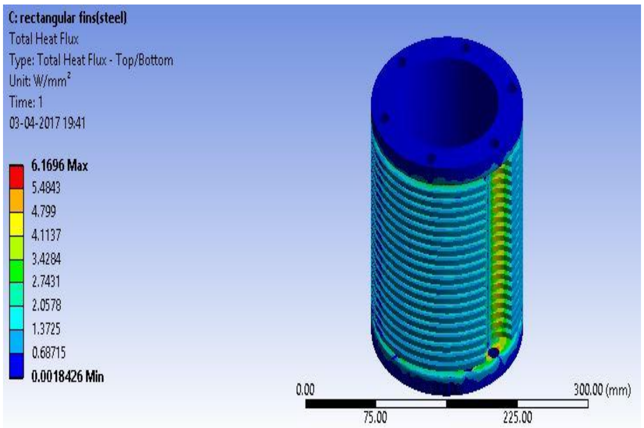


Fig. 5 Heat flux Contours for the diesel engine cylinder fins

The heat that is generated produced (or) developed in the system that conducts through the walls or boundaries is to be continuously dissipated to the surroundings or environment to keep the system in steady state condition. Large quantities of heat have to be dissipated from small area as heat transfer by convection between a surface and the fluid surroundings. It can be increased by attaching thin strips of metals called fins to the surface of the system. In that case the design model of fin is to be changed in various model fin blades.

The intent is to mimic those boundary conditions experienced by the Engine Fins during normal plant operation. It is important to note that heat transfer coefficients are calculated for the regions shown in Fig. 5: (1) the internal surfaces of the Pressure Housing, (2) the external surfaces of the Pressure Housing below the Engine Fins, (3) the external surfaces of the Engine Fins and (4) the external surfaces of the Pressure Housing above the Engine Fins. The Engine Fins heat transfer coefficient is calculated by treating the Engine Fins as a flat plate;

V. RESULTS AND DISCUSSION

Without surface coatings:

The results obtained for diesel engine Cylinder fins without surface coatings are as shown in the below Table. 1

Table 1 Results obtained for diesel engine Cylinder fins without surface coatings

Materia l	Weight	Without coating			
		Temp	Flux	Stress	Deform
CI	9.2975	1240.1	0.918	115.92	0.066
AL	3.577	1411.3	1.044	115.24	0.104
SS	10.137	1270.5	0.960	115.96	0.036
CGI	9.27	1166.9	0.864	116.02	0.048

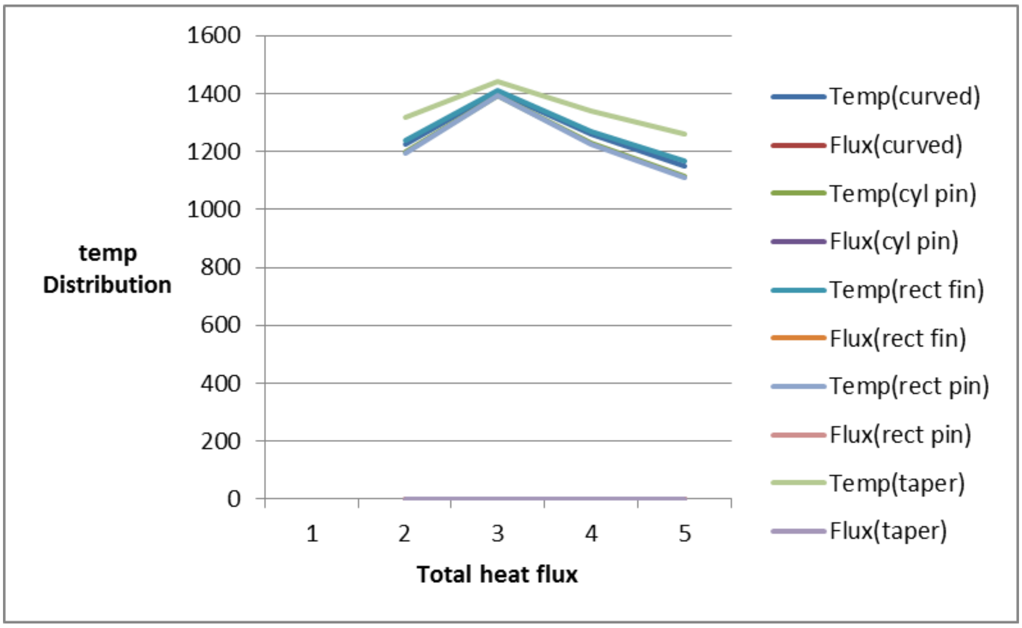
With surface coatings:
The results obtained for diesel engine Cylinder fins with surface coatings are as shown in the below Table. 2

Table 2 Results obtained for diesel engine Cylinder fins with surface coatings

With surface coating			
Temp	Flux	Stress	Deform
1412.3	6.406	154.56	0.00022
1463.6	4.009	153.65	0.00034
1421.8	6.169	154.25	0.00012
1398.6	6.66	154.69	0.00016

Temp distribution vs total heat flux graph for different geometries and materials:
The Results obtained for Temp distribution vs total heat flux graph for different geometries and materials are as shown in the below Table. 6.3

Table 6.3 Results obtained for Temp distribution vs total heat flux graph for different geometries and materials



VI. CONCLUSIONS

The following conclusions can be outlined by considering the analysis on different diesel engine cylinder fins. The modeling is done in Creo Parametric 2.0 modeling software. The thermal analysis is performed in Ansys 15.0 workbench. The solutions obtained were then converted to plots and contours using the post processing interface of solver. In this project, a cylinder fin body of an IC engine is designed in CREO software. In this, analysis is done on ANSYS workbench. In this analysis was done by changing the geometry of the fins and material of the fins. Present used material for fin body is Grey cast iron. In this project other materials are considered which has more thermal conductivity.

REFERENCES

[1] Deepak Guptha, Wankhade S.R , "Design and Analysis of Cooling Fins", International Journal of Science Engineering and Advance Technology, IJSEAT, Vol. 3, Issue 9.
[2] Pradeep singh, Harvinder lal, Baljith Singh , "Design and Analysis of heat transfer through fins with extensions", International Journal of innovative research in science (IJIRSET) e-ISSN: 2319 -8753 Volume: 03 Issue: 05 | May-2014..
[3] D. Merwin Rajesh, "Design and thermal analysis on cylinder fin by varying its geometry and material", Interanational journal and magzine of engineering ,ISSN no: 2348-4845 Volume: 01 Issue:12 | Dec-2014.
[4] Mr Manir Alam, M. Durga susmitha "design and analysis of engine cylinder fins of varying geometry and material", International journal of computer engineering in research trends(IJCERT) , Volume:3 Issue:2 |Fed-2016.
[5] Aravind S.Soraditya, Ashis kumar, N.Parmar "Review paper on effect of cylinder block fin geometry on heat transfer rate of air cooled 4s SI engine" International journal of research development in engineering and technology(IJRDET) ISSN:2347-6435 Volume:2 Issue:1 |Jan-2014.
[6] Weineng Zhang, Xiaohui Cao "Structure analysis and improvement of desile engine block", 2nd internatinal conferanceof electronic and mechanical engineering and infomrmation technology(EMEIT) ISSN : 2248-9622, Vol. 4, Issue 3(Version 1), March 2012.
[7] Dr. Steve Dawson " compacted graphite iron: mechanical and physical properties for engine design" based on paper presented at:Werksoff und automobilantrieb Germany Oct
[8] M. Anand Kumar , A.A.V.Prasad Rao, J Hari Narayana Rao, "Design and Analysis of Dry Cylinder Liners Used in Diesel Engines", International Journal of Science Engineering and Advance Technology, IJSEAT, Vol. 3, Issue 9
[9] K. Srinivasa Rao , K.Srinivas , B.Vinay , D.Aditya , K.V.Vamsi Krishna , K. Siva Rama Krishna, "Analysis Of Engine Cylinder Liners", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 02 Issue: 09 | Dec-2015.
[10] Nagesh Goel, "Case Study: Failure Analysis of Diesel Engine Cylinder Liners", An AEIS Case Study.

