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Optimization of Heat Transfer Rate in Fins by CAE

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Abstract: Overheating and excessive increase in the temperature of the compressors body causes thermal loading on the compressors surfaces. The life of the compressor mainly depends upon the abrupt change in the thermal stresses and the pressure stress induced in the body. The life of the compressor can be successfully improved and optimized by working on the compressor body. Specifically speaking the compressors fin areas is the heat affected area. Change in small cross section area can significantly change the convective heat transfer. This paper focuses on providing economical methods which are optimized and easily implementable solutions in the existing manufacturing setup. The above techniques are implemented on compressor head body. All possible attempts are made to change the cross section and the shape of the heat transfer areas so that maximized heat transfer reached in the operating process. The implementation of the optimize techniques is carried out by analysing different cross sections such as straight, trapezoidal and parabolic. The scope of revising the strategies ultimately helps to increase productivity, efficiency, pointing to increase the profit. The only aim to propose the solution is to optimize the heat transfer rate by the change in the design
Keywords: Heat Transfer, Fins, Compressor, Cross section, efficiency

I. INTRODUCTION

A. Compressor- Heat Transfer Medium

Compressor becomes almost an integral part of the mechanical industry and many other commercial applications. The compressed air is used in many other applications such as the Mechatronics system where high amount of high pressurized air is required. The electrical energy is not only used for increasing the pressure of the fluid or the gas, but there is simultaneous increase of the temperature of the fluid as well. In most case the heat is removed by some passive means since the temperature is not high as the IC engines. Still the increase of the temperature is quite enough for creating the temperature patterns which increases the thermal loading and the thermal stresses. This generated temperature stresses as well as the flow induced stresses are quite enough for the defining the overall effective operating life of the compressor.

This removal of the heat transfer becomes an essential issue while designing the compressor body. The distribution of the heat is totally taken care by the fin design that is present on the outer surface of the compressor body. The only aim that is related while designing is to increase the maximum surface area so that the heat is dissipated through the fins. The convective heat transfer is enhanced by addition of the fins. Similarly, if the change in the flow from laminar to turbulent is focused in that scenario there is effective mixing of the hot and cold air removes heat quickly. [1]

Figure 1.1: Aluminium die casted Automobile component having fins.

The CFD approach has almost replaced the experimental technique method which saves the time and the cost involved. Figure 1.1 shows the fin design of an automobile component.

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B. Aluminium Material

Selecting Aluminium material is the best option due to it physical characteristics. Aluminium alloys that are use for die casting process have a specific gravity of approximately 2.7 g/cc, placing them among the lightweight structural metals. Six major elements constitute the die cast aluminium alloy system: silicon, copper, magnesium, iron, manganese, and zinc. Each element affects the alloy both independently and interactively. Different types of material that are generally used for die casting process are presented in Appendix A. [2-7]

Figure 1.2: Aluminium material for die casting. [8]

C. Statement of the Problem

The designs of the fins that are present of the any mechanical component for the purpose of the heat dissipation are very important as far as the life of the fin body is concerned. The components where the fins are used are not subjected electrical energy that increase the pressure but also increase the temperature of the respective body. This inculcation of the heat as well as the temperature is responsible for creating different types of thermal loading which is responsible for defining the life span of the fin body. The problem identified for dissertation work is to concentre on the designing and manufacturing of the compressor head having fins. Optimizing of different design parameters is proposed to increase the life of the compressor head body. Parameters such as the thickness of the fin, length, cross section of the fin, the pitch between adjacent fins are some parameter which is closely assessed for increasing span by improving the thermal conditions of the physical component.

D. Objective of the Study

Following objectives are coin for the die casting of automobile components viz:

1) Increasing the life span of the compressor body.
2) Increase the heat transfer rate through the body.
3) Finding the various heat transfer rate distribution for the same body by changing the cross section such as rectangle, trapezoidal and parabolic

E. Limitations of the Study

The analysis is done on the compress body having the fixed bore diameter. The diameter can’t be altered since it’s a constraint of the physical assembly. The heat transfer can be enhanced by increasing the diameter of the bore i.e. increasing the physical heat transfer area.

II. LITERATURE REVIEW

Shivdas Kharche et al. [1] has reported the possible attempts can be made in cross section areas of the fin. The authors have much more focus on the analysis of the rectangular fin. As per author experimental analysis and the theoretical testing of the rectangular fin is made. There are two case analyzed for plotting the optimized heat transfer in case of fins. In case I normal testing is done on a rectangular cross section which is also called as the single flow chimney pattern figure 2.1 shows the details for the same, similarly in case II a notch is made in a rectangular section. The rectangular notch is present at the centre of one of the edges, which will in turn create a “c” section for the analysis figure 2.2 shows the notched fin.

The author reveal about the material saying that a lot of work is carried on aluminium material. Hence the above test is carried on copper material which can be used as one of the alternative material for aluminium.

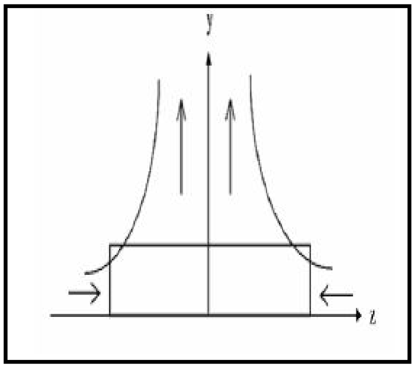

Figure 2.1: Un-notched Fin [1]

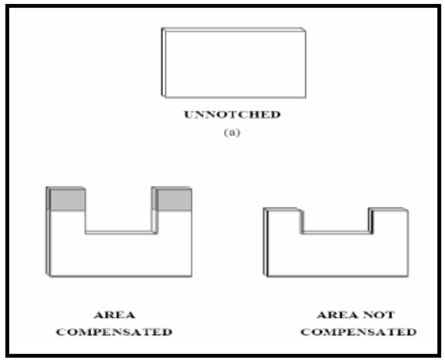

Figure 2.2: Notched Fin [1]

As per the author the best material for fin design is the aluminium and copper. Conclusion can be laid by considering the parameters such as fin spacing, fin height, fin length and the fin temperature difference. The experimental setup is shown in figure 2.3.

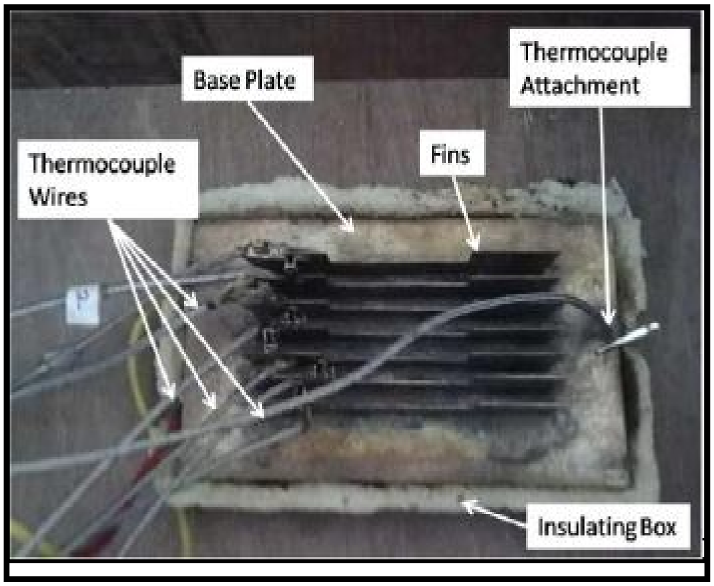

Figure 2.3: Experimental setup for notched Fin [1]

The author finally reveals about the results about the test carried for the above design parameters which are as follows, the heat transfer is increased by increasing the height(H) of the fin and decreasing the length(L) of the fin. H/L ratio is responsible for the increasing the heat transfer rate.

Further P. Raghupati and Dr. Sivakumar [2] explains about thickness to length ratio to be taken for an ideal design for optimization of the heat transfer rate through the compressor body. In the test carried by the author the number of fins in the test are taken are constant. These are 10 in numbers. The alteration for maximum heat transfer is obtained by the change in the thickness to length ratio. Depending on the economical aspect of the material thickness lies between 2-3 mm. Necessary length for maximum heat transfer is found out by physical testing for different lengths.

The author carried out 2 tests for 3mm thickness keeping the length of the fins as 45mm and 49 mm respectively. Another test of 3.5mm thickness was carried out on 47mm length. The results shows that temperature difference obtained for 3 mm thickness is 345K and 343K for 45 and 49mm respectively, similarly 345K is obtained for 3.5mm thickness. The results are tabulated in table no 1 [2]. Refer figure 2.5-2.7

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Table 1: Comparison of maximum heat transfer for different thickness [2]

Trial No.	No. of fins (N)	Thickness of fins (T, in mm)	Length of fins (L, in mm)	Max. temperature obtained (in K)
Existing	10	3	45	345
1	10	3.5	47	345
2	10	3	49	343
3	10	2.5	51	342

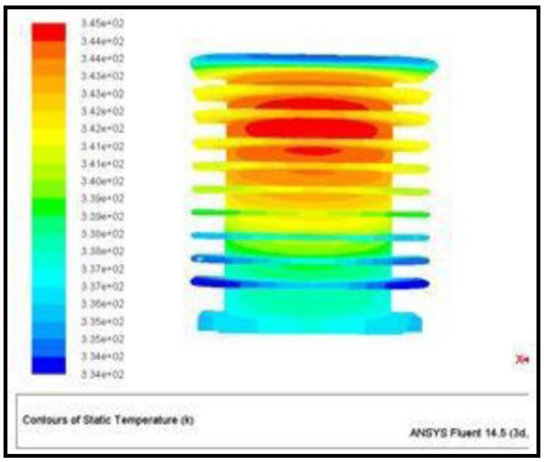


Figure 2.5: Trail no 1 [2]

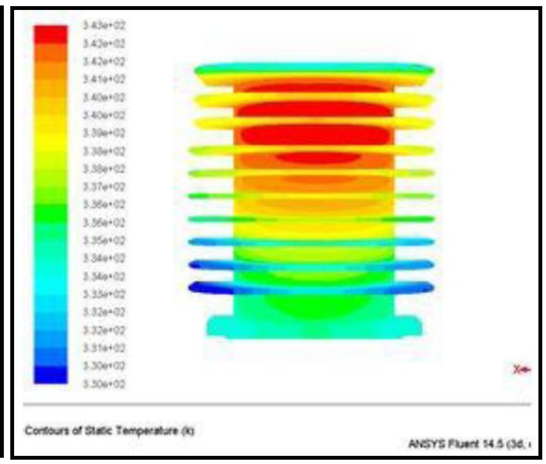


Figure 2.6: Trail no 2 [2]

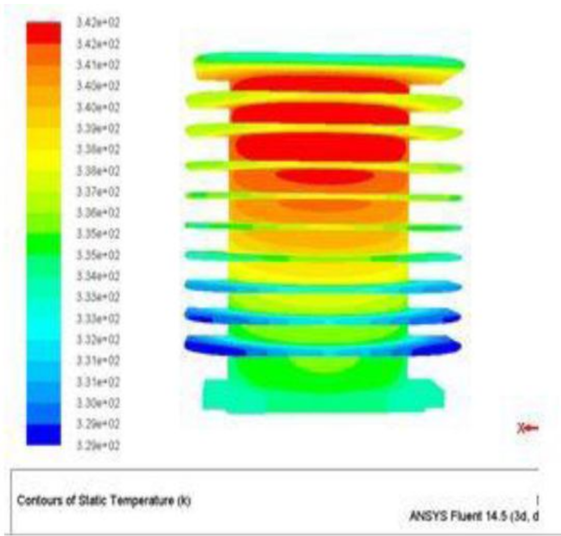
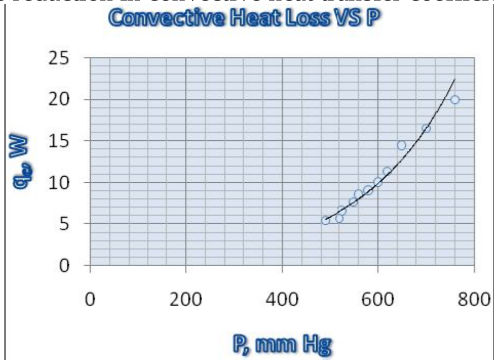
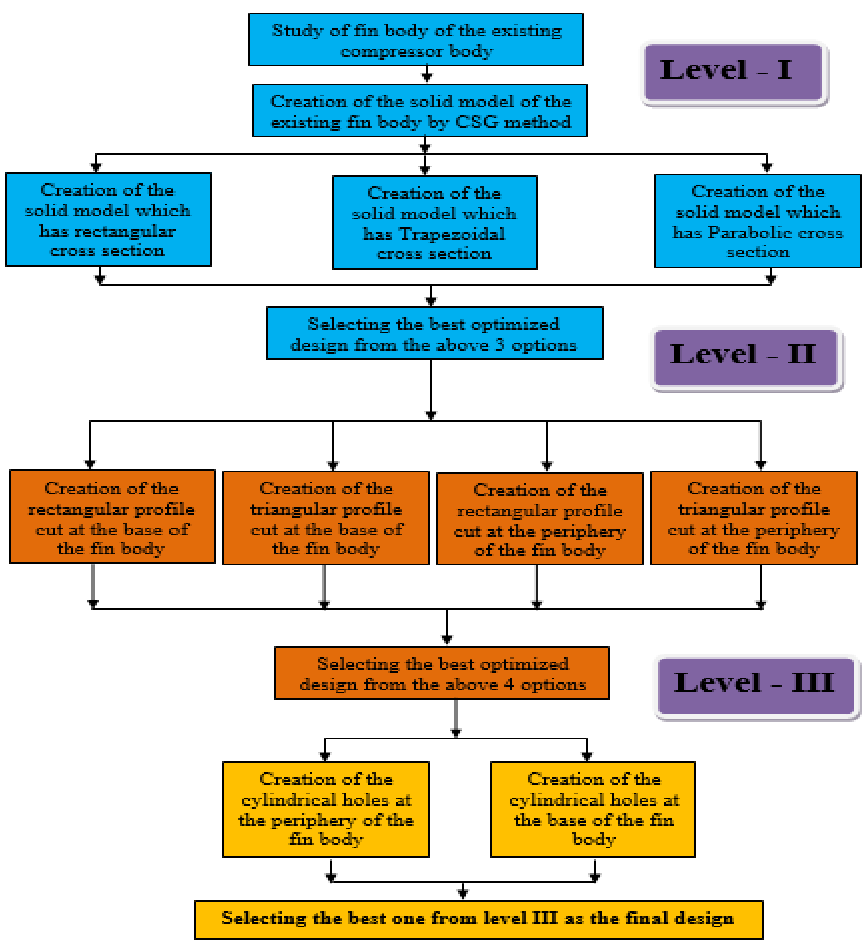


Figure 2.7: Trail no 3[2]

Mohammad Mashud et al. [3] have discussed much more on the keeping cylindrical fin as the base fin. Some minor changes are brought in act on the cylindrical profile which will be responsible increase in the heat transfer through the compressor body. The analysis for heat transfer is carried out on a plain cylindrical fin, circular cylindrical fin and threaded cylindrical fin. The diameter of the cylindrical fin is 20mm with a length of 150mm. Convective heat loss reduces sharply as pressure is decreased. It is because as the pressure inside the pressure reduction chamber is reduced, a low-density situation arises. In low-density circumstances the mean free path of the gas molecules is large enough, and as density reduces this distance increases. The larger this distance becomes, the greater the distance required to communicate the temperature of a hot surface to a as in contact with it. This means, it cannot be assumed that the layer or air in the immediate neighbourhood of the surface of the fin will not have the same temperature as the heated surface. This causes a considerable reduction in convective heat transfer coefficient, h [3]. Refer figure 2.8



III. WORK METHODOLOGY FOR PROJECT



IV. DESIGN: CREATION OF CYLINDRICAL SLOT

Parabolic fin body with rectangular slots at base with combinations of cylindrical slots at the base of the fin body

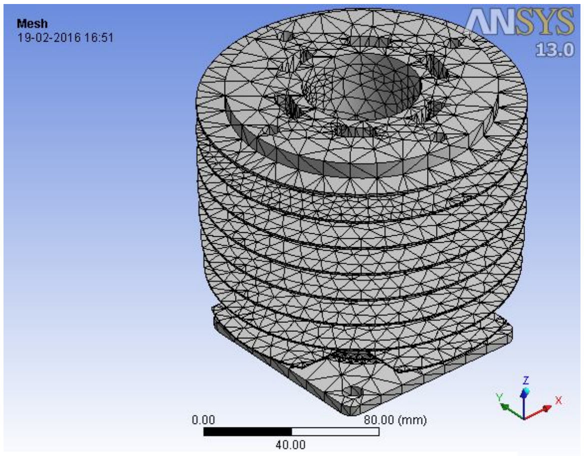
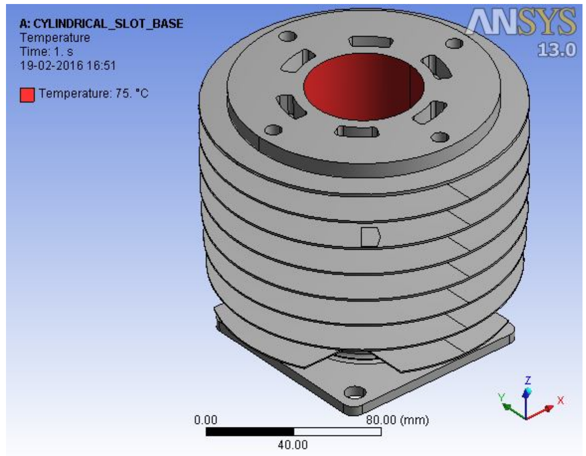


Figure: Meshed Body (Parabolic Fin body with rectangular slot & cylindrical slots at the base)



FFigure : Temperature Input in the Meshed Body (Parabolic fin body with rectangular slot & cylindrical slots at the base)

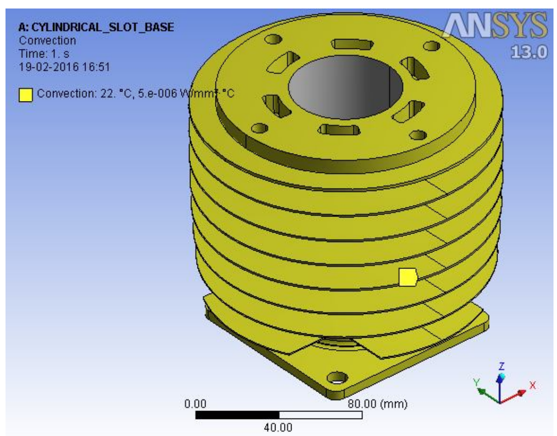


Figure : Convective Heat Input in the Meshed Body (Parabolic fin body with rectangular slot & cylindrical slots at the base)

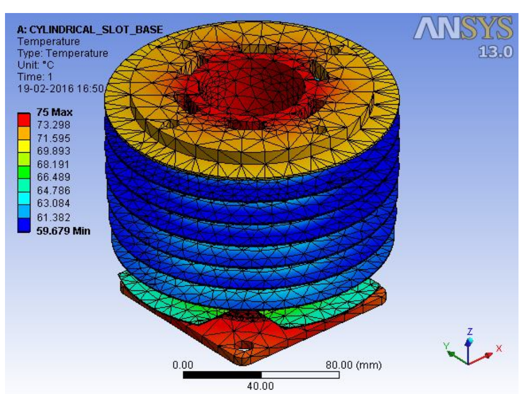


Figure Temperature Distributions in the Meshed Body (Parabolic fin body with rectangular slot & cylindrical slots at the base)

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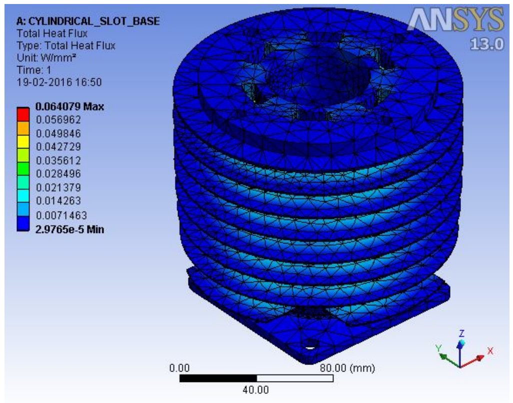


Figure Total heat flux (Parabolic fin body with rectangular slot & cylindrical slots at the base)

Parabolic fin body with rectangular slots at base with combinations of cylindrical holes at the periphery of the fin body:

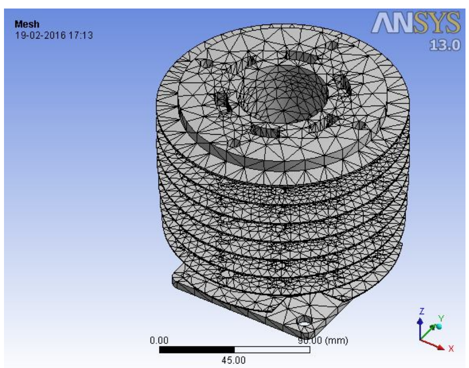


Figure : Meshed Body (Parabolic Fin body with rectangular slot at the base & cylindrical slots at the periphery)

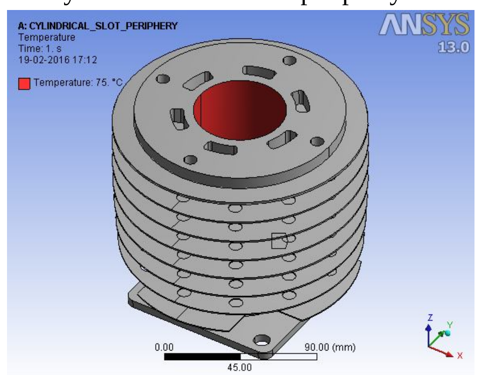


Figure : Temperature Input in the Meshed body (Parabolic fin body with rectangular slot at the base & cylindrical slots at the periphery)

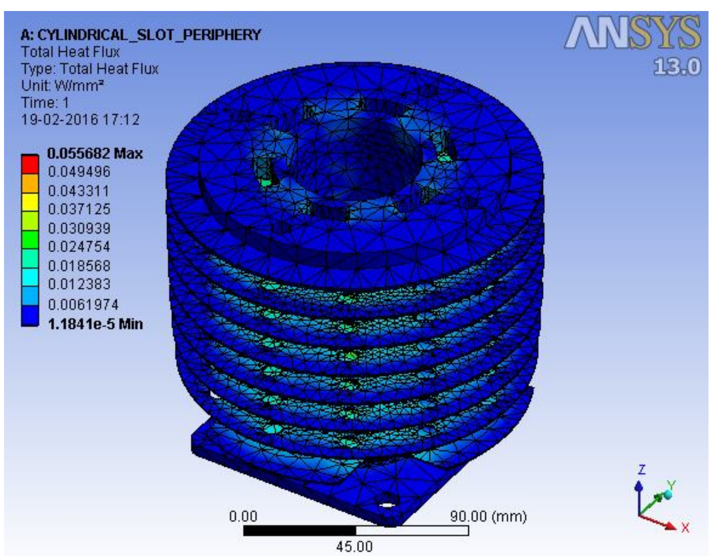
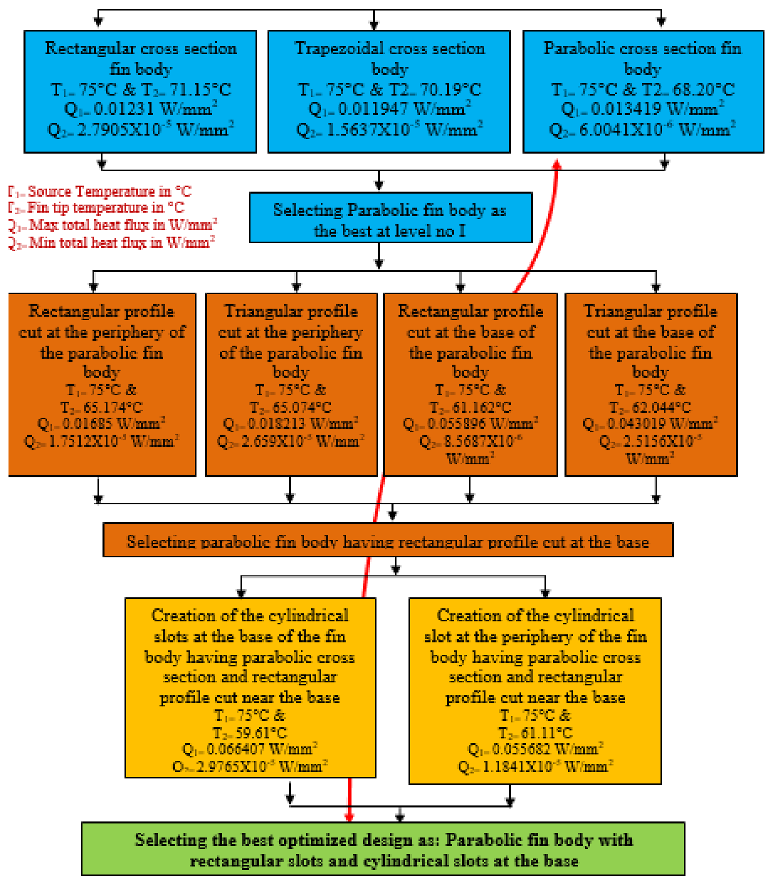


Figure Total heat flux (Parabolic fin body with rectangular slot at the base & cylindrical slots at the periphery)

V. RESULTS AND DISCUSSION

A. CAE - Results of the Various Compressor fin Body Model at a Glance.



B. Discussion

1) In the complete project due the specific constraint of the 3D model and the actual assembly conditions that are present, the only parameter that is consider for improving the maximum heat transfer is the cross section of the fin and the surface area of the fin.
2) In level I design analysis is done on cross section area such as rectangular, trapezoidal and parabolic. The results show that most optimized fin is the parabolic one.
3) The parabolic curve has more heat dissipating area for the same length of the fin.
4) The temperature gradient (Δt) that is obtained between the source temperature and the tip of the fin is highest in the parabolic fin body i.e. 75°C -68.20°C = 6.8°C
5) The second highest temperature gradient (Δt) that is obtained is that of the trapezoidal fin body i.e. 75°C -70.19°C =4.81°C.
6) The third highest gradient (Δt) that is obtained is that of the rectangular fin body i.e. 75°C -71.15 = 3.85°C
7) The ascending order of the ideal heat dissipating fin bodies can be stated as a) parabolic fin body b) trapezoidal fin body c) rectangular fin body.
8) Selecting parabolic fin body as the best and optimized one at level I is done on the above obtained results.
9) Four different options are considered at level II design, i.e.
10) Rectangular profile cut at the periphery of the parabolic fin body.
11) Triangular profile cut at the periphery of the parabolic fin body.
12) Rectangular profile cut at the base of the parabolic fin body.
13) Triangular profile cut at the base of the parabolic fin body.
14) The rectangular profile cut at the base of the parabolic curve gives the highest temperature gradient Δt = 75°C -61.762°C = 13.838 °C

15) The area kept on the fin and the cut must be proportional, hence 50% in profile cut and rest 50 remaining on the base of the fin is kept as the best option for obtaining the maximum heat transfer as well as for proving good strength.
16) Triangular profile at the base of the tip will definitely leave more material at the base of the tip as compared to fin body having rectangular cut at the base. This will allow the fin to take maximum heat transfer and give maximum temperature gradient (Δt), hence selecting parabolic curve with rectangular slot at the base as the best optimized fin body at level II.
17) Further improvement in the temperature gradient (Δt) can be done which will take care of the strength as well provide maximum heat transfer is done at level III
18) At level III circular slots of diameter 8mm are made at 62.00mm PCD and at 38.00mm PCD respectively. The 62.00mm PCD appears at the periphery side where as the 38.00mm appears on the base side.
19) Results shows that the circular slots at the base of the fin shows the highest temperature gradient(Δt) 75°C -59.61°C = 15.39 °C

VI. CONCLUSION AND FUTURE SCOPE

A. Conclusions

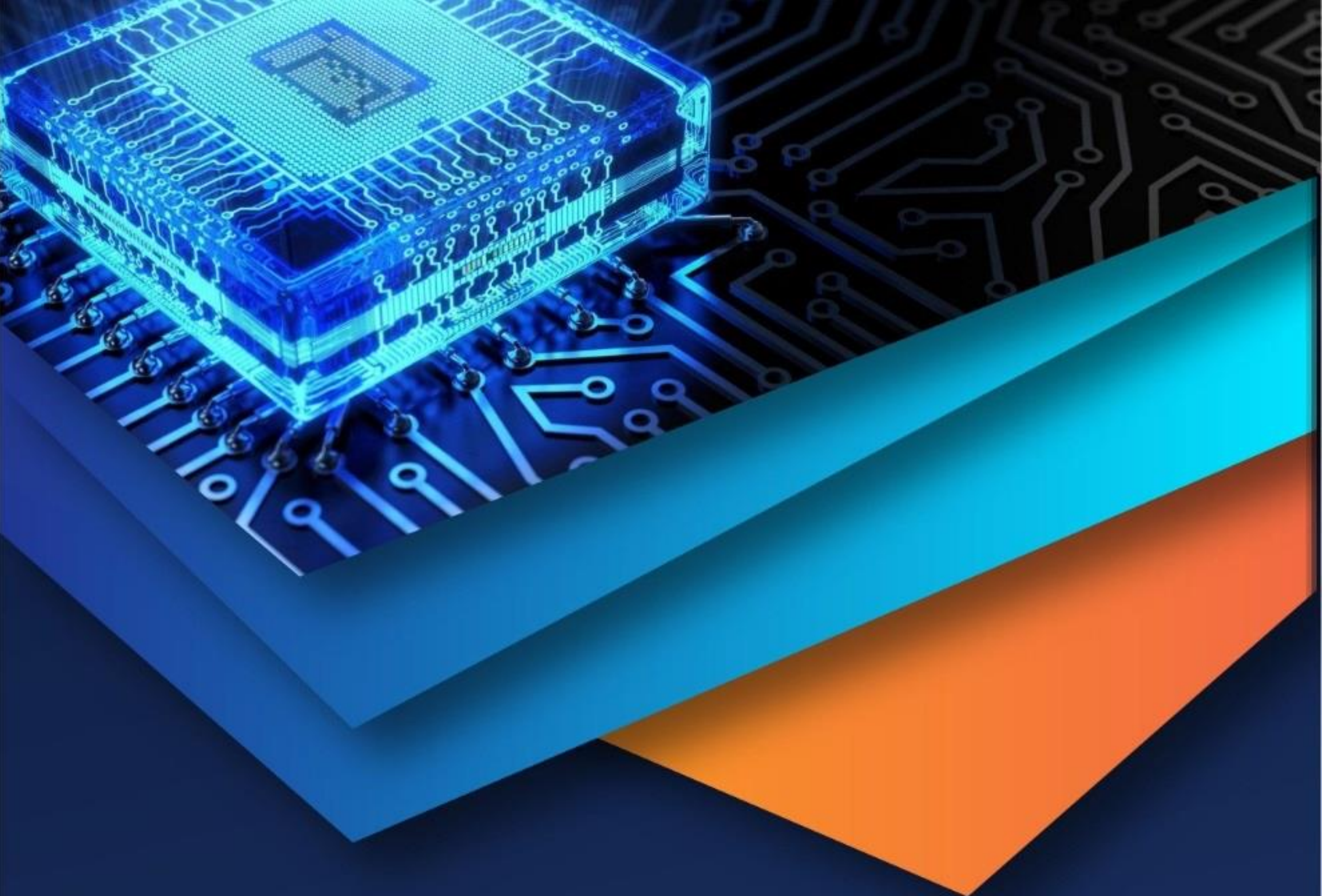
The results that are plotted in Ansys shows that fin body having parabolic cross section with rectangular profile slots at the base in combination with circular holes at the base are the best optimized design in all design sets.

B. Future Scope

Since in the complete design sets, the size of the overall envelope of the fins body remains constant. In the analysis that is performed in complete design sets the variation of the body dimensions are not done. If the body dimensions are changed then there is a scope revisiting the body shapes, profile cuts that are made over the complete body which will lead exploring new parameters explored.

REFERENCES

[1] P. Ragupati, Dr V. R. Sivakumar, "Enhancing heat removal by optimizing fin configuration in air compressor," Journal of Engineering science and Research Technology, ISSN 2277-9655, May-2014
[2] Sp. G. Pantelakis, N. D. Alexopoulos, A. N. Chamos, "Mechanical Performance Evaluation of Cast Magnesium Alloys for Automotive and Aeronautical Applications", Journal of Engineering and Technology, 422 / Vol. 129, July 2007. Avedesian, M., and Baker, "Magnesium and Magnesium Alloys", ASM Specialty Handbook, ASM International, Metals Park, OH.
[3] Davis, J. R., 1993, "Aluminum and Aluminum Alloys," ASM Specialty Handbook, ASM International, Metals Park, OH.
[4] Alexopoulos, N. D., and Pantelakis, Sp. G. , "Evaluation of the Effects of Variations in Chemical Composition on the Quality of Al–Si–Mg, Al–Cu, and Al–Zn–Mg Cast Aluminum Alloys," Journal of Materials Engineering and Performance, 12(2), pp. 196–205, 2003
[5] S.Selvaraja, P.Venkataramaiah, "Design and Fabrication of an Injection Moulding Tool for Cam Bush with Baffle Cooling Channel and Submarine Gate" International Conference On Design And Manufacturing, IConDM 2013, Procedia Engineering 64, 1310 – 1319, 2013
[6] B. Vijaya Ramnath, C.Elanchezhian, Vishal Chandrasekhar, A. Arun Kumar, S.Mohamed Asif, G. Riyaz Mohamed, D. Vinodh Raj ,C .Suresh Kumar, "Analysis and Optimization of Gating System for Commutator End Bracket", 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014). Procedia Materials Science 6, 1312 – 1328, 2014
[7] Esmail M.A. Mokheimer, "Performance of annular fins with different profiles subject to variable heat transfer coefficient, International" Elsevier, Journal of Heat and Mass Transfer 45, 3631–3642, 2002
[8] S. H. Barhatte, M. R. Chopade "Experimental and Computational Analysis and
[9] Optimization for Heat Transfer through Fins with Triangular Notch" International Journal of Emerging Technology and Advanced Engineering Website, ISSN 2250-2459, Volume 2, Issue 7, July 2012.
[10] Sikindar Baba, Md Nagakishore.S, Prof.M.Bhagvanth Rao "Thermal Analysis on a Finned Tube Heat Exchanger of a Two Stage Air Compressor International Journal for research in applied science and engineering technology, IJRASET Volume 2 Issue V, ISSN: 2321-9653, May 2014



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