International Journal of Scientific Research in Mechanical and Materials Engineering
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Thermal Analysis in Heat Distribution on Compressor Fins using ANSIS

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Article Info
Volume 5, Issue 4
Page Number : 08-15

Publication Issue :
July-August-2021

Article History
Accepted : 20 July 2021
Published : 30 July2021

ABSTRACT

This paper provides an overview of Design and Analysis of Compressor Fins Thermal Distribution, starting with its background and a brief history. Then, the geometry, main components, classification, applications, materials and fabrication process of Compressor Fins are also discussed. In this paper In this project the fins mounted on the cylinder head are studied by means of thermal expansion. Steady state thermal analysis will provide the temperature distribution along the cylinder block and heat flux. If we apply same temperature for a defined time period then the nature of thermal expansion along with thermal flux should be studied well. Lastly the thermal deformation (Expansion), thermal stresses etc. is found to understand the behavior of cylinder block. For this reason cylinder block is firstly developed in CATIA V5R19 software. Further this CAD file is converted into neutral file format to import it into ANSYS Workbench 14.5 software. Conclusion is drawn on the basis of generated results.

Keywords : Air Compressor, Cylinder Block, CAD file, Thermal Stresses.

I. INTRODUCTION

In most industrial applications, compressed gas is measured as the "fourth utility", preceded by the 3 essential utilities; water, electricity and natural gas. Typically, an simple air compressor is an business tool that intakes ambient air and increases the pressure with reduction in volume by doing work on the working fluid, namely air or gas.

The main object of employing a compressor is to supply high pressure air using least possible power consumption. The compression can occur in any one of the 3 ways; adiabatic, isothermal or polytrophic. For an Adiabatic compression process, there's assumed to be no heat loss or gain from the system. When the temperature of air at inlet equals temperature of compressed gas at outlet, the compression process is Isothermal. Normally, a typical compression process involves Polytrophic Compression. The pressure, temperature and volume of air it inlet and outlet vary with the respective conditions. The least possible work of compression is gained in an adiabatic compression process as the net work done by the system is -0) . [1] The adiabatic efficiency is the max possible compressor efficiency and compressors are designed with compressor efficiencies such that, there's very little or no variation among the two.

As said earlier, compressed air taken into consideration a utility because of their various applications in various industrial and metallurgical operations. The compressed air supply is clean, convenient, harmless and flexible for use. Industrial uses can be attributed to when they are in connection with compressed air motors for functioning of pneumatic equipment, raw material conveying through ducts, in connection with a reservoir for storage of compressed air for future applications.

1.1Air compressor fins

Figure 1.6 shows the air compressor fins mounted on cylinder block. The fin material should preferably have high thermal conductivity. In most applications the fin is surrounded by a fluid in motion, which heats or cools it quickly due to the large surface area, and subsequently the heat gets transferred to or from the body quickly due to the high thermal conductivity of the fin. For optimal Heat transfer performance with minimal cost, the dimensions and shape of the fin have to be calculated for specific applications, and this is called design of a fin. A common way of doing so is by creating a model of the fin and then simulating it under required service conditions.

Fig.1.1 Air Compressor Fins mounted on cylinder block

1.2 Objectives

The primary objectives of this project can be summarized as follows:

i. Study of heat transfer through fins.
ii. Study of Literature available on heat transfer trough fins.
iii. Virtual CAD Model Preparation and Learning CAD Tool.
iv. Finite Element Method Learning and its implementation in our project.
v. Study of FEA Package like ANSYS and Thermal Analysis.

II. PREVIOUS WORK

Various researches carried out in past decade show that heat transfer through fins depend on number of fins, fin pitch, fin design, wind velocity, material and climate conditions.

Different literature surveys suggest that variations in the cross-section influence how thermal transfer across extended surfaces and the thermal transfer coefficient.

A. Charan et. al. (2018) has analyzed expanded surfaces that are often used in a broad range of engineering applications to improve convection heat transfer. It has been discussed thatthe conception of introducing perforations on the lateral surface of fin is to enhance heat transfer rate effectively.

B. Sangaj et. al. (2018) Experimental research to determine the thermal distribution of various materials and geometries within the pin fine, the state heat transfer analysis was carried out with the software ANSYS for the testing and validation of outputs using a finite element. The main objective of the work is to optimize thermal properties through various geometries, materials and fine thicknesses.

C. Rajesh et. al. (2017)The thermal properties of the fine and the thickness of cylinder fines have been analysed by varying geometry, material (Cu and Al alloy 6082). By variations in the circular geometry and also by varying fine thickness for both geometries, the Fins models are created. Pro / Engineer &UniGraphics are the 3D modeling software used. Cylinder fins are analyzed thermally to determine the temperature variation distribution over time. The analyzes are done with ANSYS. With thermal analysis on the fins of the engine cylinders, the heat dissipation inside the cylinders is beneficial. The theory used in this paper is the use of the invisible working liquid to maximize heat dissipation by air.

D. Jain et. al. (2017) Heat dissipation of fins was analyzed by changing their geometry. Parametric fine models to forecast the transient thermal behaviour have been developed. There are different geometries including rectangular, circular, triangular and extensive fines after models are made. CREO Parametric 2.0 is the simulation framework used. ANSYS 14.5 is used to analyze this. Current material is usually Aluminum Alloy 204, the thermal conductivity of which is 110-150W / m-°C. Analyzes were carried out with aluminum alloy 6061, which is about 160-170W / m-oC heat conductivity higher.

E. Kummitha et. al. (2017)Research carried out to determine the best material that ensures the highest heat transfer rate during the combustion processes keep the motor in secure operation and with high strength, low weight. A passion pro bike cylinder block was considered and based on GAMBIT software as well as thermal analysis with ANSYS software.

III. Procedure for ANSYS analysis

Static measurement of displacement, stresses, stresses and forces in structures or materials is used because hundreds do not result in significant inertia or damping. In response conditions, stable loading is assumed. Loading types that can be used for a static test include external forces and loads, regular domestic inertial forces, imposed (non-0) movement speed, temperatures (for thermal stress). A linear or nonlinear static analysis may be available. We don't neglect linear static analysis in our current work.

These key steps are the protocol for static analysis:

- Construction the model.
- Achieving the solution.
- Evaluation the results.

A structural examination is carried out using the ANSYS Workbench V.14.0 to carry out the finite element examination of the Fins models during the engine temperature transfer to the air with the aid of fins. At this stage research by the Fins involves a continuous thermal analysis and minor modifications in order to obtain designs. The fins model was built and saved in*.Igs in this file in Solid work 2016 and imported to the workbench in ANSYS.

Thermal analysis of compressor fins

To perform thermal analysis on compressor block we have selected temperature range of 4000C, 5000C, 6000C. Means we will conduct thermal analysis on three different incremental temperature values. The temperature is applied on the region where heat is generated (Cylinder Block Liner) due to piston movement. Figure 4.3 shows the temperature applied regions. Region A indicates the maximum (4000C) temperature. Similarly B region indicates room temperature. In other cases only maximum temperature will change. Other will be same as it is.

4.1 Following results are generated by performing Steady State Thermal analysis

4.1.1 Results for Maximum Temperature as 4000C

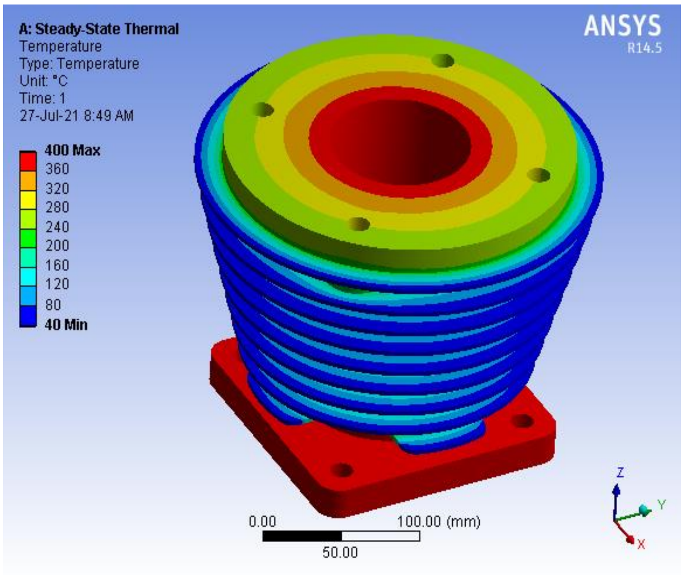


Fig.4.1 Temperature Contours obtained in Steady State Thermal Analysis

By observing temperature contours obtained in figure 5.4 we found the minimum temperature on the fin tip while heat is transferring through fin. On the cylinder liner the maximum temperature appeared which is reducing towards the fin

4.1.2 Results for Maximum Temperature as 5000C

By observing figure 4.2 we found that fins contains maximum of heat which dissipated into atmosphere through radiation. 1.91 W/mm2 heat contains found in compressor block fins which higher than previous case.

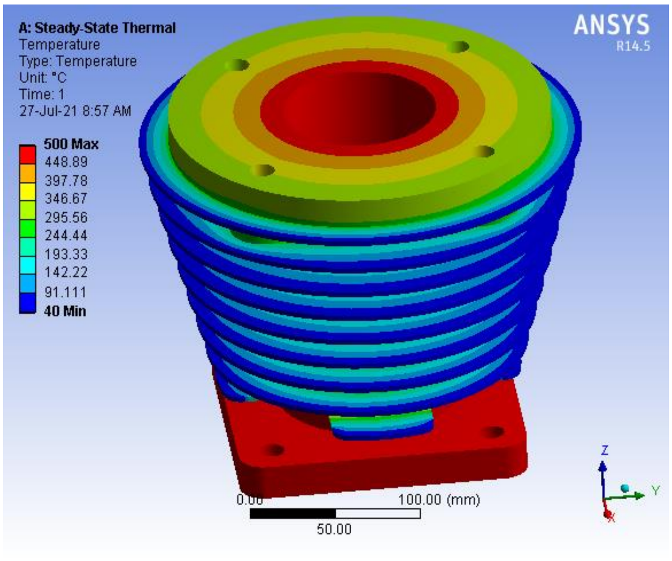


Fig.4.2 : Temperature Contours obtained in Steady State Thermal Analysis

4.1.3 Results for Maximum Temperature as 6000C

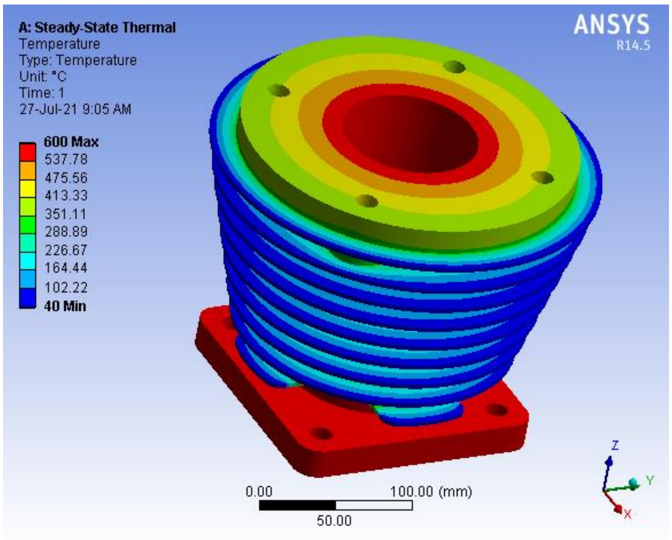


Fig.4.3 Temperature Contours obtained in Steady State Thermal Analysis

Heat flux rate is increased in this case while temperature contours are same.

IV. Thermo Structural Analysis

In this type of analysis we apply temperature to the compressor block and expansion in the form of deformation and other thermal stresses can generated. It needs both thermal and structural properties of metal.

5.1 Results for Maximum Temperature as 4000C

By observing all above results we found that the block expansion is about 0.57mm. But the Equivalent stresses and normal stresses are more than 400 PMa. Due to these higher stress values thermal cracks may develop. Additional cooling system can prevent such thermal crack propagation. Shear stresses are up to 200 PMa which are acceptable.

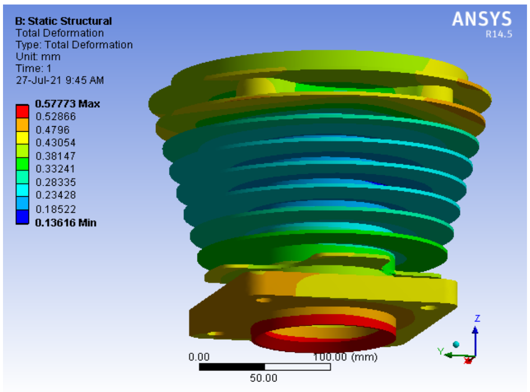


Fig. 5.1 Total Deformation due to 4000C Temperature Load

5.2Results for Maximum Temperature as 5000C

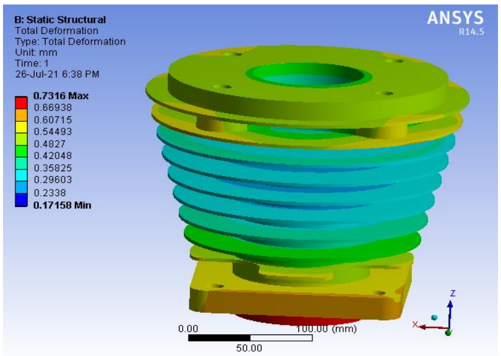


Fig. 5.2 Total Deformation due to 5000C Temperature Load

5.3 Results for Maximum Temperature as 6000C

By observing all above results we found that the block expansion is about 0.84mm. But the Equivalent stresses and normal stresses are increased with 750 to 600 MPa which is the case of worry. Due to these higher stress values thermal cracks may develop. Additional cooling system can prevent such thermal crack propagation. Shear stresses are up to 312 PMa which are acceptable.

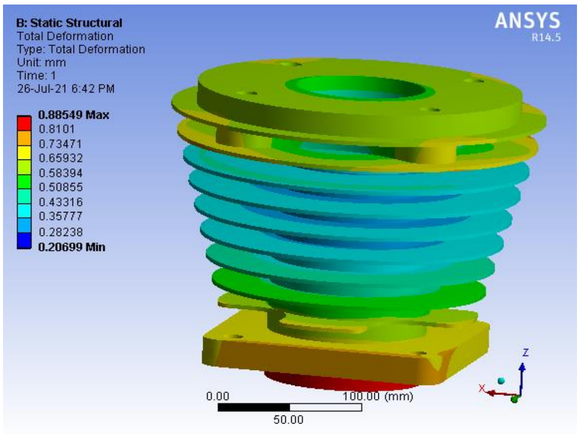


Fig. 5.3 Total Deformation due to 6000C Temperature Load

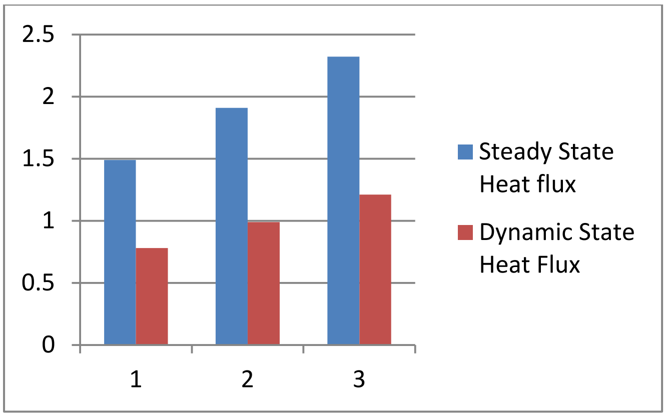
V. RESULT SYSNTHESIS

6.1. Tabulated Result Generation

By observing all above results we found that as temperature is increases, the stress values are also increases along with expansion. At higher temperature (6000C) Stress values beyond acceptance. Hence other cooling techniques like oil cooling can be used for controlling the heating effect. Fins are not sufficient in this case.

Table 6.1: Thermal Analysis Results

Sr. No.	Temperature (^{0}C)	Steady state Head Flux (W/mm^2)	Transient state Heat Flux (W/mm^2)	Expansion (mm)	Equivalent Stresses (PMa)	Normal Stresses (MPa)	Shear Stresses (MPa)
1	400	1.49	0.78	0.57	475.77	418.16	200.77
2	500	1.91	0.99	0.73	607.93	534.32	254.56
3	600	2.32	1.21	0.88	740	650.47	312.31



Graph. 6.1 : Comparison between steady state and dynamic state heat flux

By observing above figure 6.1, we found less heat flux in dynamic state. It is due to heat dissipation through fins.

VI. CONCLUSION

By observing all results generated through various types of thermal analysis we have concluded following points.

1) Alternate cooling arrangement is needed if Air compressor works regularly on higher temperature.

2) Fins can provide effective natural convection of heat. For better convection of heat, fan must be installed with the rotary air compressor.

3) Proper lubrication between piston and cylinder insure the less heat generation.

4) Porous fins also could be the better alternative for effective cooling which needs separate research.

5) Air compressor fins provide optimum natural convection effect. But it need fan to avoid heating effect due to continuous working of air compressor.

VII.REFERENCES

[1]. C. Willich, A.J. White, "Heat transfer losses in reciprocating compressors with valve actuation for energy storage applications". http://dx.doi.org/10.1016/j.est.2017.07.024 2352-152X/© 2017 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

[2]. Pascal Stouffs , Mohand Tazerout, Pierre Wauters, "Thermodynamic analysis of reciprocating compressors". Int. J. Therm. Sci. (2001) 40, 52–66 Ó 2001 Éditions scientifiques et médicales Elsevier SAS. All rights reserved, S1290-0729(00)01187-X/FLA

[3]. P.Ragupathi*1, Dr.V.R.Sivakumar, "Enhancing Heat Removal by Optimizing Fin Configuration in Air Compressor". [Ragupathi et al., 3(5): May, 2014] ISSN: 2277-9655 Scientific Journal Impact Factor: 3.449 (ISRA), Impact Factor: 1.852, http:

// www.ijesrt.com (C)International Journal of Engineering Sciences & Research Technology [111-116] International Journal of Engineering Sciences & Research Technology

[4]. Bhaumik Patel1, Ashwin Bhabhor2, "Thermal Analysis Of A Piston Of Reciprocating Air Compressor". International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

[5]. Bade Yellaji, Dr.D.Sreeramulu, S. Krishna Madhavi, "Thermal Analysis on Heat Distribution in Fins of Compressor Cylinder by Varying Profile Using FEM". International Journal and Magazine of Engineering, Technology, management and research, ISSN No:2348-4845

[6]. Vinay V. Kuppast1, Dr.S.N.Kurbet2, H.D.Umeshkumar3, Adarsh B.C4, "Thermal Analysis of Piston for the Influence on Secondary motion". International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 3, May-Jun 2013, pp.1402-1407

[7]. Angela Sodemann, Yaoyu Li and Xin Wu, Rick Lancaster, Mark Rucker, Jeff Carnagie and Andy Inman, "Smith Predictor Based Position Control for the Inlet Guide Vane of Centrifugal Air Compressor". IMECE2006-13101, https://www.researchgate.net/publication/216264063

[8]. Vijaykumar F Pipalia1*, Dipesh D. Shukla2 and Niraj C. Mehta3, "Investigation on Reciprocating Air Compressors - A Review". Available Online at http://www.recentscientific.com International Journal of Recent Scientific Research International Journal of Recent Scientific Research Vol. 6, Issue, 12, pp. 7735-7739, December, 2015

[9]. Vishnu R1, Prof. Deepika Vasanthakumar2, "PERFORMANCE ANALYSIS AND MODIFICATION OF AIR COMPRESSOR SYSTEM". International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 05 | Aug-2015 www.irjet.net p-ISSN: 2395-0072

[10]. Mr. Vinay D. Shinde1, Mr. Pratik P. Shinde2, Mr. Tanmay T. Revankar3, Prof. Rohit Bhandwale4, "THERMAL ANALYSIS OF PISTON USING ANSYS". International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 06 Issue: 02 | Feb 2019 www.irjet.net p-ISSN: 2395-0072

[11]. M Drewczynski and R Rzadkowski, "A stress analysis of a compressor blade in partially blocked inlet condition". Proc IMechE Part G: J Aerospace Engineering 0(0) 1–19, IMechE 2015 Reprints and permissions: sagepub.co.uk/journalsPermissions.nav DOI: 10.1177/0954410015601149 uk.sagepub.com/jaero

[12]. Ribas, Fernando A.; Deschamps, Cesar J.; Fagotti, Fabian; Morriesen, André; and Dutra, Thiago, "Thermal Analysis of Reciprocating Compressors - A Critical Review" (2008). International Compressor Engineering Conference. Paper 1907. https://docs.lib.purdue.edu/icec/1907, https://docs.lib.purdue.edu/icec

[13]. C. Zhang a, B. Yan a, J. Wieberdink a, P.Y. Li a, J.D. Van de Ven a, E. Loth b, T.W. Simon, "Thermal analysis of a compressor for application to Compressed Air Energy Storage". http://dx.doi.org/10.1016/j.applthermaleng.2014.08.014 1359-4311/© 2014 Elsevier Ltd. All rights reserved.

[14]. R. C. Chikurde, E. Longanathan, D. P. Dandekar, "Thermal Mapping of Hermetically Sealed Compressors Using Computational Fluid Dynamics Technique". Purdue University, Purdue e-Pubs, International Compressor

Engineering Conference School of Mechanical Engineering, 2002.

Cite this article as :

Prof. Dr. P. R. Wadnerkar, Gaurav G. Tijare, Prof. P. B. Ingle, "Thermal Analysis in Heat Distribution on Compressor Fins using ANSIS", International Journal of Scientific Research in Mechanical and Materials Engineering (IJSRMME), ISSN : 2457-0435, Volume 5, Issue 4, pp.08-15, July-August.2021
URL : https://ijsrmme.com/IJSRMME215316