ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Thermal Analysis of Turbocharger Outer Casing by Applying Ceramic Coatings Like Sic, Basalt Fibreslurry, Zirconia, Alumina on Nickel Based Alloy Inconel 718, Alloy A – 286 Based Substrates

D.Mohan
Department of Mechanical Engineering,
Visakha Technical Campus,
Visakhapatnam, Andhra Pradesh 530027, India.

C.H.L.Aslesha
Department of Mechanical Engineering,
Visakha Technical Campus,
Visakhapatnam, Andhra Pradesh 530027, India.

ABSTRACT:

The turbocharger of an internal combustion engine (ICE) is to extend the ability density of the engine or called the retrenchment of the engine. Large amount of heat energy is wasted through the exhaust manifold, coolant, convective and radiate heat transfer. The amount of heat loss generated to the encircling by operational rotary engine volute can have an effect on the service lifetime of some automotive elements. The current material metal used for serious duty automotive rotary engine volute casing is heavier and dear if to match to a replacement prompt material nickel based mostly alloys like alloy 718,ALLOY A – 286 with thermal barrier ceramic coating as an alternative like silicon carbide(SIC), basalt fiber slurry(silica+basalt), zirconia(ZrO2), alumina(Al2O). Thermal barrier coating is another technique for insulating. It is cheaper and lighter engineering elements operational in hot temperature condition. In this, turbo charger model constructed using ansys CFD software the thickness of coatings vary from 0.2mm-1.6mm with an interval of 0.2mm and changing various coatings NiCral is used as bind layer between substrate and coating layer by maintaining same temperature and velocity of inlet exhaust gas temperature is 350^{0}c.Finallycompared the performance of each coating material with the given uncoated substrate. We observed that zirconia exhibited better performance at 0.4mm thickness than other ceramic coatings,moreover basalt fiber slurry is profitable coating material at low temperature operating conditions

Keywords: ***Turbocharger outer casing, Ansys CFD software, ceramic materials, nickel based alloys***

1. INTRODUCTION

In present days, people are using the automobiles in a passion manner and it reduces the effort of people to reach long distances in short time. Now a days automobile industries are trying to give best mileage vehicles to customers, fuel usage may depend on many factors the chemical energy of fuel convert into heat energy to move vehicles. Now we have to focus on prevent the loss of heat at engine cylinder and other depend components like turbocharger is a crucial part in heavy vehicles to give more density of fuel to engine .In this project work, focused on turbocharger outer casing which expose to high temperature. At present we are using high temperature resistant materials like INCONEL, SUPER ALLOY A-286 e.t.c. But their life time also reduces in short period, hence if the same base materials coated with high insulating materials like SiC,SiNe.t.c. increases life time of substrates .In this work we selected INCONEL 718, Alloy A – 286 Based Substrates for coating with different ceramic materials. For that we construct turbo charger model using ansys CFD software by varying the thickness of coatings from 0.2mm-1.6mm with an interval of 0.2mm and changing various coating materials. NiCral is used as bind layer between substrate

Cite this article as: D.Mohan & C.H.L.Aslesha, "Thermal Analysis of Turbocharger Outer Casing by Applying Ceramic Coatings Like Sic, Basalt Fibreslurry,Zirconia,Alumina on Nickel Based Alloy Inconel 718, Alloy A – 286 Based Substrates", International Journal & Magazine of Engineering, Technology, Management and Research, Volume 6 Issue 9, 2019, Page 47-51.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

and coating layer, the input temperature and velocity of inlet exhaust gas is same in all cases temperature is 350^0c.Finally compared the performance of each coating material with the given uncoated substrate. We observed that zirconia exhibited better performance at 0.4mm thickness than other ceramic coatings. Moreover basalt fiber slurry is profitable coating material at low temperature operating conditions

2.Definition of Computational FluidDynamics:

CFD could be a set of numerical srategies applied to get approximate solutions of issues of fluid dynamics and warmth transfer.CFD is not a science by itself but a way to apply the methods of one discipline (numerical analysis) to another (fluid flow and heat transfer). The procedure 0.5 just merely suggests that the study of the fluid flow mistreatment numerical simulations, which involves using laptop programs or software system packages performed on high speed digital computers to attain the numerical solutions.

Computational FluidDynamics was used. This method is mainly used to solve the problems such as numerical simulation of aerodynamic profiles, the admission and flow of gas mixture in engines and so on. This has been done for a particular position of the headlight dome and for a given velocity of air flow

Different disciplines involved in Computational Fluid Dynamics:

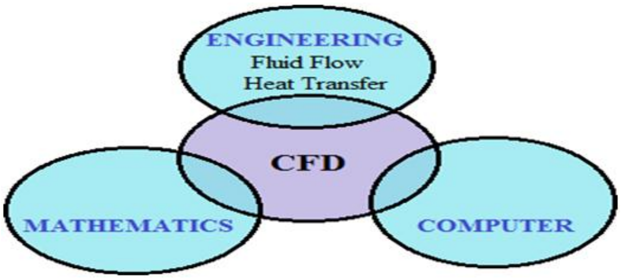


Figure 1.1: Different disciplines

3.PROBLEM DEFINITION

Day by day the demand for high efficient engines is increasing for that we have to provide better material to meet this requirement for that high thermal conductivity materials as well as high insulating materials to be developed some for transmit the heat through them to environment and some to arrest the heat to protect the environment

So that we have to protect the turbocharger from high pressurized gases during exhaust stroke for that cover the turbocharger outer casing interior side with low thermal conductivity materials as in thin layer form with high specific heat like ceramic material then compare the performance of coated turbocharger and uncoated turbocharger.

In this work we focused to investigate the best ceramic coating material with profitable thickness to reduce quantity of coating material as well reduce cost of product. For this work we selected INCONEL & SUPER ALLOY based alloys as Substrates for coating with different ceramic materials.

For that we construct turbocharger outer casing model using ansys CFD software and simulated by using STEADY STATE THERMAL MODULEby altering the dimension of layer thickness with an incremental of 0.2mm thickness of coatings 1.6mm NiCral is used as bind layer between substrate and coating layer by maintaining constant temperature of inlet exhaust gas is 350^oc.And finally we compare the performance of each coating material with the given uncoated substrate. And will finalize the suitable coating material with optimized thickness

4.SIMULATION OF TURBO CHARGER OUTER CASINGITS IMPELLER SIZE IS 49.5MM AND BASE SUBSTRATE IS INCONEL-218 GEOMETRY CREATION OR MODELING

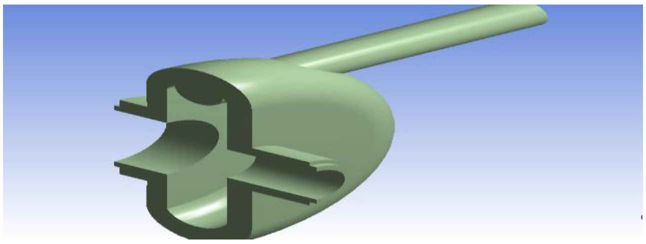
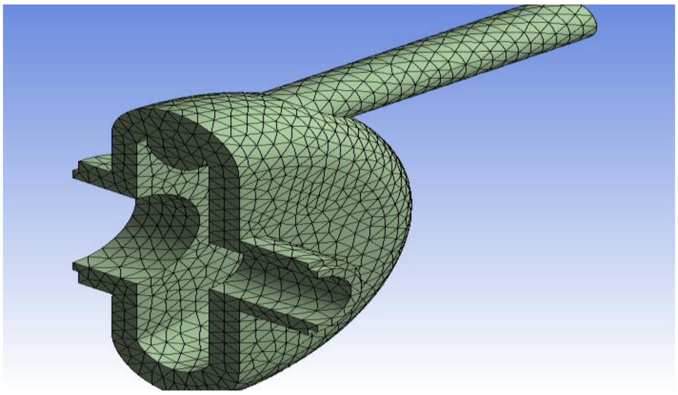


Figure 4.1: Geometry of SECTIONAL VIEW OF TURBOCHARGER

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

MESHING:



RESULTS OF PURE INCONEL AND SUPER ALLOY COATED WITH DIFFERENT CERAMIC MATERIALS

5.1.1Temparature distribution of different ceramic coated INCONEL

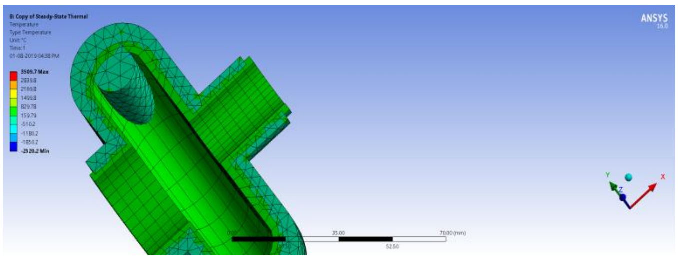


Fig.5.1.TEMPERATURE DISTRIBUTION OF PURE INCONEL

Above figure shown the temperature propagation of pure INCONEL alloy when constant temperature 350^0c applied at inner surface of turbocharger it reveals that base material maintain maximum 250^0c only and maximum heat located at wall and edges portion of turbocharger with this value we compare other properties of material

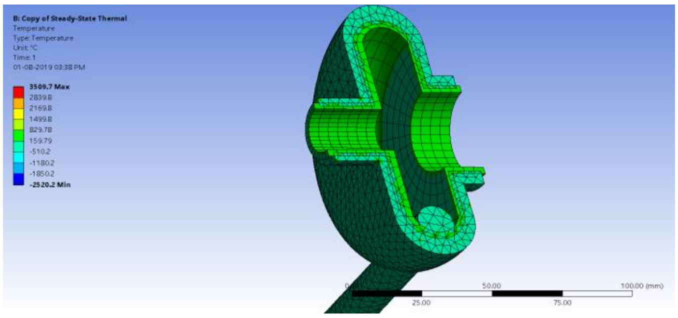


Fig.5.2..TEMPERATURE DISTRIBUTION OF INCONEL-Alumina

Above figure shown the temperature propagation of pure INCONEL alloy when constant temperature 350^0c applied at inner surface of turbocharger it reveals that base material maintain maximum 159^0c only and maximum heat located at wall and edges portion of turbocharger with this value we compare other properties of material

TABLES AND GRAPHS

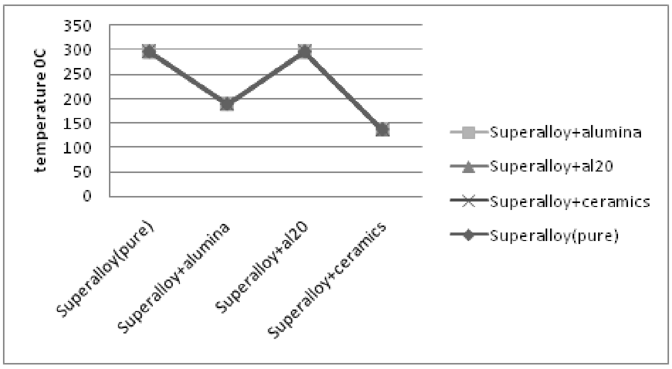
Table7.1.1Thermal results of INCONEL-718 coated with different ceramic material (input temp. is 3500C)

Sl.No.	Material	Temparature ^{0}C	Total Heat Flux W/mm²	Directional Heat Flux W/mm²
1	Inconel (Pure)	250	12	5.5
2	Inconel+ Alumina	159	12	5.5
3	Inconel+ Zirconia	181	6.3	1.8
4	Inconel+ Mullite	159	13	6.5
5	Inconel+ YSZ	149	9.5	5.5

Table7.1.2Thermal results of SUPERALLOY A-286 coated with different ceramic material

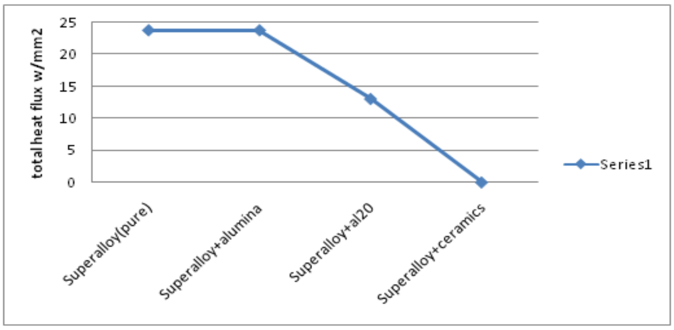
Sl.No.	Material	Temperature ^{0}C	Total heat flux w/mm²	Directional heat flux w/mm²
1	Super alloy (pure)	297	23.7	12.9
2	Super alloy+ alumina	189	23.7	23
3	Superalloy+al_2O	297	13	12.9
4	Superalloy + ceramics	137	0.00032	0.000106

7.2. Graphical representation of coated super alloy



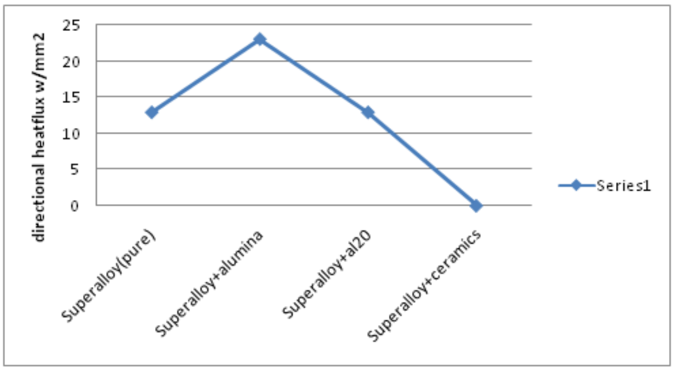
Graph.7.2.1.Temperatures of various ceramic coated super alloy

Above graph7.2.1.shown that super alloy coated with ceramic will reduce the loss of heat from turbo casing with input temperature is 350^0C



Graph.7.2.2.Total heat flux ofvarious ceramiccoated super alloy

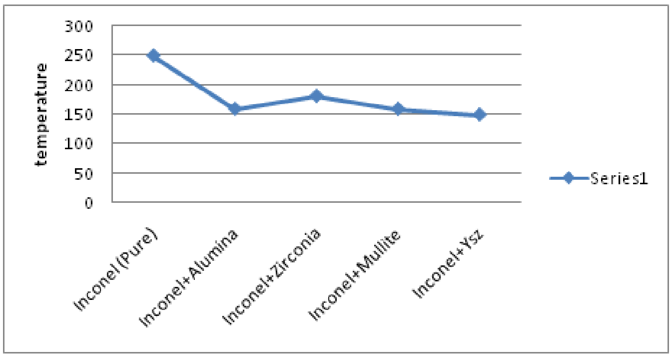
Above graph7.2.2.shown that super alloy coated with ceramic has less heat flux hence reduce the loss of heat from turbo casing with input temperature is 350^0C



Graph.7.2.3.Total directional heat flux ofvarious ceramiccoated super alloy

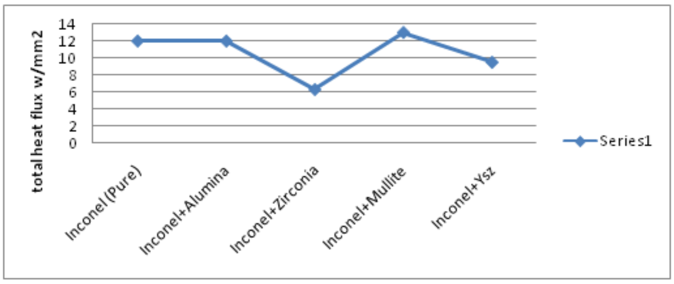
Above graph7.2.3.shown that super alloy coated with ceramic has less heat flux hence reduce the loss of heat from turbo casing with input temperature is 350^0C

7.3. Graphical representation of coated INCONEL alloy



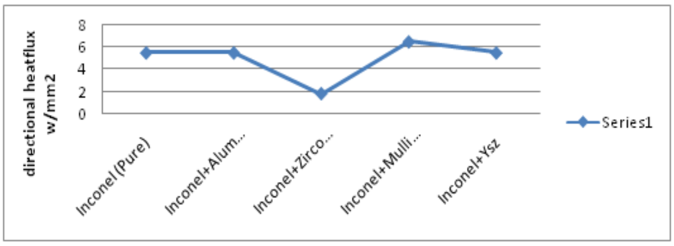
Graph.7.3.1.Temperatures of various ceramic coated INCONEL alloy

Above graph7.3.1.shown thatINCONEL alloy coated with yatrified silicon zirconia will reduce the loss of heat from turbo casing with input temperature is 350^0C



Graph.7.3.2.Total heat flux ofvarious ceramiccoated INCONEL alloy

Above graph7.3.2.shown that INCONEL alloy coated with zirconia has less heat flux hence reduce the loss of heat from turbo casing with input temperature is 350^0C



Graph.7.3.3.Total directional heat flux ofvarious ceramiccoated INCONEL alloy

Above graph7.3.3.shown that INCONEL alloy coated with zirconia has less heat flux hence reduce the loss of heat from turbo casing with input temperature is 350^0C

SCOPE FOR EXTENSION

Similar kind of experimentation can be performed for different ceramic materials by changing different base materialsto improve the efficiency of thermal equipment and we can reduce the size of thermal equipmnts if better solution existed large amount of burning fuel can reduce someextent.the life of boilers and funaces will inceases

CONCLUSIONS

- From the analysis the below points concluded
- For all cases the input temperature is 350^0C
- INCONEL alloy coated with yatrified silicon zirconia maintains maximum 1490C temperature only it will reduce the loss of heat from turbo casing.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

- INCONEL alloy coated with zirconia allows less heat to escape outside the heat flux is 9.5 W/mm2
- Super alloy A-286 coated with ceramic(Sic+Zrco2) shows maximum outercase temperature is 137^{0}C and heat flux is 0.00032W/mm2
- Simulation results on both the alloy materials shows that super alloy with yatrified silicon zirconia , shows favorable conditions to minimize the loss of heat from the turbocharger outer case.
- Pure ceramic offered good insulation for loss of heat but exhibits poor heat flux
- For medium or low temperatures mullite exhibits excellent characteristics compare to silicon oxide, alumina and aluminium oxide
- The thickness is a function of temperature more thickness more insulation ,while applying thickness in 0.2mm incremental manner in between 0.4-0.6 exhibited good thermal characteristics
- With less thickness we can minimize 75% of heat loss
- We observed that zirconia exhibited better performance at 0.6mm thickness than other ceramic coatings,moreover basalt fiber slurry is profitable coating material at low temperature operating conditions different factors

REFERENCES

[1]R. B. Sharma, Ram Bansal, “CFD Simulation for Flow over Passenger Car Using Tail Plates for Aerodynamic Drag Reduction”, vol.7, pp.28-35,2013

[2]R.A. Lukes, J.H. Hart, J. Potts, S.J. Haake, “A CFD analysis of flow around a disc”, vol.72, pp.685-690,2014

[3]Yoakunwang, Zhiqiang wan, Chao yang, Yunzhenliu, “Static aero elastic response analysis of air craft’s based on CFD pressure distribution”, vol.3, pp.488-494,2012

[4]Li-XinGuo, Yi-Min Zhang, Wei-Jun Shen, “Simulation analysis of Aerodynamics characteristics of different Two-Dimensional Automobile shapes”, vol.6, pp.999-1005,2011

[5]Wind tunnel performance analysis report by KailashKotwani from Center for Aerospace System and Design Engineering, Department of Aerospace Engineering, Indian Institute of Technology,Bombay.

[6]Ansys Workbench, Mesh, Fluent 14.5 Users Guide

[7]R. B. Sharma, Ram Bansal, “CFD Simulation for Flow over Passenger Car Using Tail Plates for Aerodynamic Drag Reduction”, vol.7, pp.28-35, 2013

[8] Microsoft Encarta Premium, Piston, WA: Microsoft Corporation, 2009.

[9]T.McNish, ”Piston Manufacturing Process,” http://www.ehow.com/pistonproduction.html, February

[10] T. Garrett, K. Newton, and W. Steeds, The Motor Vehicle, Reed Educational and Professional Publishing Ltd., Jordan Hill, Oxford, 2001.

[11] T. Jaana and S. Carl-Erik, “Piston Ring Tribology: A literature survey,” Espoo 2002. VTT Tiedotteita-Research Notes. December, 2002, Pp. 105.

[12] K. Steve and G. Arthur, Computer Numerical Control Basics, Industrial Press Inc., 200 Madison Avenue, New York, 2009

[13] E. P. Degarmo, J. K. Black and R. A.Kohser, Materials and Process in Manufacturing, Wiley; ISBN 0-471-65653-4, 2003.

[14] K. Chris and J. S. Baek, “Modern Machine Shop,” International journal of refrigeration, Vol. 28, pp. 141-151, May, 2012.

[15] K. Derek, “Reverse Engineering in Fabrication of Piston Crown,” Eurojournals publishing Inc, Vol. 15, pp29-32, January 2009.