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Analysis of Ceramic Coatings in Exhaust Manifold

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***Abstract*—**Exhaust manifold is one of the important components of internal combustion engine which plays a major role in the improvement of fuel consumption of the engine. Combustion efficiency of the engine can be improved by improving the exhaust manifold design in internal combustion engine. Performance of the engine increases if the exhaust manifold is of a good condition. In the present work, during this process, the exhaust manifold suffers from the thermal stresses causes blowholes on the manifold. In this study, to prevent the defects of the exhaust manifold, a different coating is applied using ceramic materials the 3D models of the coated and uncoated manifold have been developed using SOLIDWORKS 16 and analysed using ANSYS software using thermal analysis by finite elementmethodology.

***Keywords*—** Ceramic coating, Exhaust manifold, FEA methods.

I. INTRODUCTION

The exhaust manifold is used in a multiple cylinder IC engine which collects the exhaust gases from the cylinders into one pipe. During working it dissipates heat and emits harmful undesirable substances like noxious or toxic. Many research works like better change in design, coating, etc. are carried out to reduce these effects to increase the performance of the engine. Azadiet al [1]performeda review of thermal barrier coating applications in diesel engines to select a proper type and to find coating effects.

The coating system has effects on the fuel consumption, the power and the combustion efficiency, pollution contents and the fatigue lifetime of engine components. Dura Prasad et al [2] designed an exhaust manifold with different coatings and analyzed with modeling and finite element methodology techniques. Gopaal and Kumara Varma [3] used finite element analysis technique to reduce the design difficulties of exhaust manifold and concluded that the design made by them is safe and effective. K amylase and Stamatelos [4] used mathematical modeling and CFD software to analyze the heat transfer in the exhaust manifold.

Mahesh S Vasavan and Jotaniya [5] presented a detailed review on heat transfer analysis in automotive exhaust system.Mouna Challa and Imran Quraishi[6]explained the selection of advanced material using CES software fexhaust manifold based on the benefits and also suggested new manufacturing methods like deformation process, investment casting process, etc. for the exhaust manifold using new materials.Navaneethakrishnan and Vasudevan[7] iinvestigated the performance, emission characteristics of a single cylinder four stroke direct injection diesel engine operating on biodiesel.

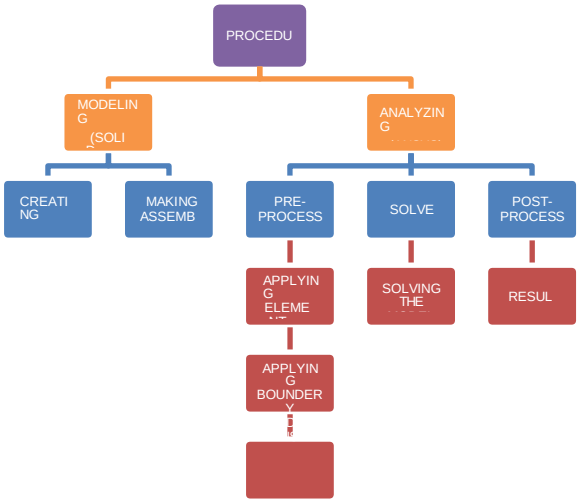
After comparisontheyrevealed that blends of TME, DEE with diesel up to 20% and 20% by volume provide better engine performance (BSFC and BTE) increased up to 3-4% and the exhaust emission is decreased dramatically. Prabhat Kumar Jhaet al [8] carried out experimental studies to reduce the exhaust gas temperature and gas emissions of a Spark Ignition (SI) engine by injecting water in the intake manifold gives better results. Serkan Saridag and Onjen Tak [9] investigated the mechanical properties of zirconia in the scientific literature and revealed that zirconia clearly measures up to any other equivalent manufactured material

II. MATERIALS ANDMETHODS

A. Specimen preparation forcoating

The waste exhaust gases corrode the manifold material due to this some blow holes will occur and noise pollution will increase. In order to avoid these type of failure, in this work some ceramic powders are used on both inner surface and outer surface of the cast iron exhaust manifold. The inner surface of the cast iron exhaust manifold is coated by zirconium powder to arrest the temperature in inside itself this will reduce the heat dissipation. The outer surface of the cast iron exhaust manifold is coated by alumina and titanium in the combination range of 60% - 40%. The coated anduncoated manifold which is used for this work is shown in Figure 1 (a)

and (b) respectively. The coating is performed using plasma spray technique. The coating for the cast iron exhaust manifold is doneby using plasma spray coating technique for a thickness of 250 µm.



B. Microstructure studies

Properties of the coated specimen using plasma spray process were analyzed by using SEM and EDX. The coating thickness achieved is in the order of 125µ. Optimum compositional and structural conditions of the coating component have been analyzed. The micro graph of the fracture surface of the uncoated and coated cast iron specimen samples is shown in Figure 3. The structure exhibited particles of both materials were deformed on impact during the plasma spray and melted on the specimen surface is shown in the Figure 3(c). From the microstructure images it is observed that the grain particles size is less for coated cast iron specimen when compared with a cast iron specimen without coated.

C. Hardnesstest

In this work specimens have been prepared to test the hardness of both coated and uncoated castiron material. Vickers hardness test has been carried out for testing the hardness of the specimens shown in Figure 4. The results are presented in Table 1. From the results it is observed that coated cast iron specimen is giving the best results.

Trail no	Coated	Uncoated
1	89	84
2	90	85
3	89	84

D. Corrosiontest

In this project salt spray test is used for testing the corrosion of a specimen. The salt spray test isa standardized and popular corrosion test method, used to check corrosion resistance of materials and surface coatings. Usually the materials to be tested are metallic and finished with a surface coating which is intended to provide a degree of corrosion protection to the underlying metal.The results are presented in Table 2. Input parameters considered for salt spray process is listed below

- Chamber temperature: 34.5 - 35.5°C
- pH value : 6.65 -6.85
- Salt solution collected : 1.0 – 1.5ml/hr
- Concentration of solution : 5%Nacl
- Air pressure : 14 – 18Psi
- Component loading in chamber position: 30 °angle.

Effect oftemperature

The performance and characteristics of the coated and uncoated cast iron exhaust manifold has been performed in the multi- cylinder engine. The outer surface temperature in the manifold is measured by the infrared thermometer testing machine. The inner surface temperature is measured by the thermocouple. The surface temperature obtained for both outer and inner coated and uncoated castiron exhaust manifold at various load conditions have been compared and presented in Figure 6. It is observed that the use of coated surface reduces the temperature developed when compared to theuse of uncoated surface. It is observed that the use of coated surface reduces the temperature developed when compared to the use of uncoated surface. From the temperature study it is asserted that the zirconia coated exhaust manifold arrest the temperature when compared to uncoated exhaust manifold.

So this results show that heat dissipation is decreased in the coated exhaust manifold.

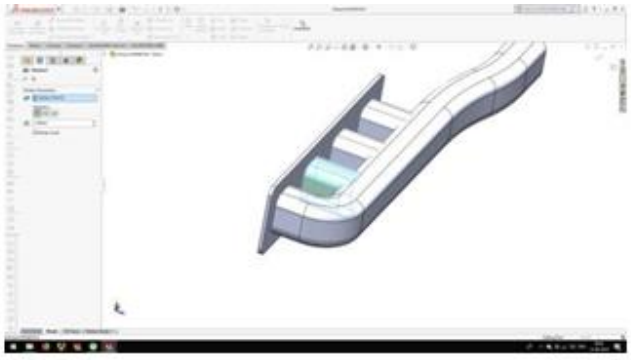


Fig .1.Modeling (3D)

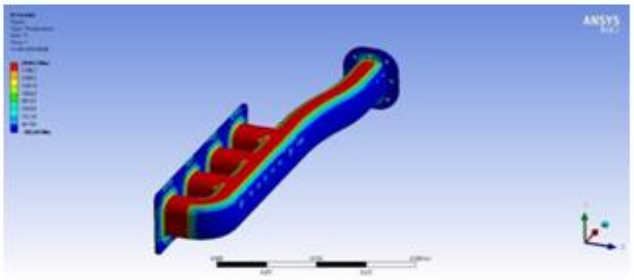


Fig.2. Heat Dissipate

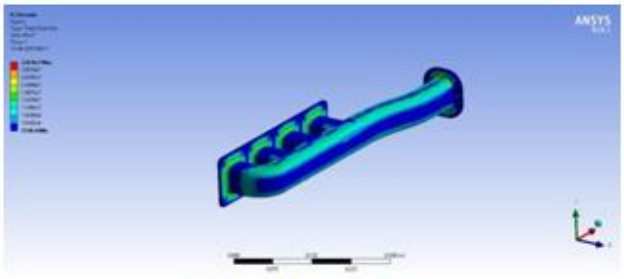


Fig.3.Thermal Stress

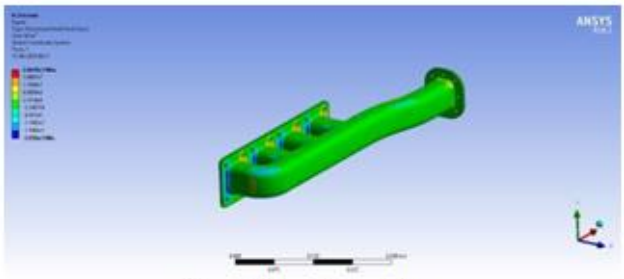


Fig.4.Heat Total Flux

III. CONCLUSION

Based on the experimental results it is concluded that The surface temperature, carbon monoxide emission and nitrogen oxide emission isminimized by coating the exhaust manifold at rated load.Hardness is increased in the coated manifold. No rust formation in the coated manifold. Finally it is concluded that the coated cast iron gives better performance than the uncoated cast iron exhaust manifold.

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