A Review Study of FEM of $La_2Ce_2O_7$ Coated Piston used in a Diesel Engine

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Abstract— The main objective of this research is to analyze the effect of Lanthanum Cerate ($La_2Ce_2O_7$) coating on the piston to reduce the emission of the engine as well as improve the thermal efficiency. In this study, the surface of the piston in a diesel engine is coated with a Lanthanum Cerate material using a plasma-spray technique. The Al–Si piston is used in this analysis and the material which is used for coating the crown is Lanthanum Cerate ($La_2Ce_2O_7$). Temperature distributions are investigated and further compared with an uncoated piston. All the investigations are performed by using finite element method (FEM) based on the software CATIA Workbench.

Keywords: FEM, Piston, Diesel Engine

I. Introduction

In case of Internal Combustion Engines, most of the heat generated during combustion process is absorbed by piston. This is direct heat loss to the piston. This reduces Indicated Power and in turns the performance of Internal Combustion Engine. Engine coating with a ceramic thermal barrier can be applied to improve reliability and durability of engine performance and efficiency in diesel engines. In a conventional diesel engine, about 30% of the total energy is rejected to the coolant and it was reported that the engine coating may be a good solution. Main advantages of the engine coating concept were such as improved fuel economy, reduced hydrocarbon, smoke and carbon monoxide emissions, reduced noise due to lower rate of pressure rise and high energy in the exhaust gases. Thermal barrier coatings are generally applied on the cylinder head, piston and valves by plasma spray method. Coating these parts with ceramic also limits the negative effects of wear, friction, heating, corrosion and oxidation. It was also reported in a theoretical diesel cycle analysis that more the heat transfer decreases, the less energy will be lost, thus increasing the work output and the thermal efficiency.

II. Literature Review

In this section research papers are discussed related to the present work. Published papers are highlight in this section.

1) S. Sathyamoorthi, M. Prabhakaran

Presented work on the FEA results, the maximum temperature value of the coated piston was shown at the piston's combustion chamber. Therefore, this area must be coated intensively. The maximum surface temperature of the coated piston with material which has low thermal conductivity has improved approximately by 14%. Because of reduced heat losses, efficiency will improve. According to the experimental results, brake thermal efficiency and indicated thermal efficiency have improved by 5.89% and 11.14% respectively.

2) Jai Sharma, Ratan Jain

Presented work on the numerical analysis of ceramic coated piston, it is clear that La2Ce2O7 help to increases the temperature of the piston. The finite element modelling clearly shows that the piston’s temperature depends upon the coating thickness. The temperature obtained was found maximum on the piston crown surface for all the coating thicknesses considered. It has been observed that at the top of ceramic coated surface, a temperature that is higher than that of the un-coated piston. In comparison with the un-coated piston, the maximum temperature increased is 45.5%, 69.3%, 84.1%, and 94.1%. It is hereby concluded that by using TBC, the combustion chamber temperature inside the engine becomes higher and it leads to an increased in thermal efficiency. The temperature at the piston’s substrate surface is reduced which will have a positive impact on the performance and efficiency of the engine.

3) A. R. Bhagat, Y. M. Jibhakate

Presented work on Piston skirt may appear deformation at work, which usually causes crack on the upper end of piston head. Due to the deformation, the greatest stress concentration is caused on the upper end of piston, the situation becomes more serious when the stiffness of the piston is not enough, and the crack generally appeared at the point A which may gradually extend and even cause splitting along the piston vertical. The stress distribution on the piston mainly depends on the deformation of piston. Therefore, in order to reduce the stress concentration, the piston crown should have enough stiffness to reduce the deformation.

4) Neeraj Pandey, Neetesh Yadav

It is observed that although fatigue is not the responsible for biggest portion of damaged piston rings, but the stresses induced are the major factor for piston ring failure. Also from analysis various Results are obtained. The maximum displacement occurred about 1.260×10-3 mm due to the application of 55 bar gas pressure on piston ring. 3.694×101 N/mm2 of maximum von misses stress is observed and 1.286 N/mm2 of minimum von misses stress. Also maximum temperature of 2000C is observed. Thus we conclude that piston ring of grey cast iron is suitable to use.

5) Preeti Kumari, Anamika

Thermal analysis shows the thermal load on different areas of the piston .it helps in predicting the critical areas of the piston so that we can choose the suitable material for the piston and also structure of the crown of the piston. It can be demonstrated from the above graphical data and figures that reduced skirt length piston temperature reduced by 10-20’ as compared to simple piston while boundary conditions are same. Similarly total heat flux variation also reduced in case of reduced skirt length piston as compare to simple piston. Piston failure occurs because of thermo-mechanical overload by insufficient inter cooling thermo mechanical overload by over fuelling.

III. CONCLUSION

The piston plays a major role in the engine performance; the piston material is made up of impacts on the strength of the piston. The maximum stress intensity is on the bottom surface of the piston crown in both the materials, as it is expected. Maximum displacement is absorbed on the top of the piston of aluminum alloy and grey cast iron. Highest value of maximum temperature found in piston is due to thermal conductivity of the materials and the total maximum heat flux is absorbed in both the piston materials. Thus, further research can be carried with the advance materials and different designing, analysis tools. designs for which the analyses are carried out, the stresses and total deformations observed in concave shaped piston which are larger than the convex shaped piston. So, this justifies the usage of concave or cup shaped pistons in IC Engines which use diesel as fuel and for large sized engines.

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