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A Review on the Performance Analysis of Four Stroke Diesel Engines Piston Using Ceramic Coating Material and Compare with Uncoated Piston

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Abstract

The increasing trends and demands in the automotive world, there is always tug and tie between the designer and customer. To cope with the existing competition in the modern times there is always need for great improvement in compatibility of the engine models. The efficiency of IC Engine is reduced and fuel consumption is increased. The Lots of research works are carried out to increase the efficiency of IC Engine and reduce fuel consumption by using method such as Laser Surface Textured (LST) method, Thermal Barrier Coating (TBC) method. Piston is the one of the main part of IC engine. The function of piston is transfer the pressure to the crank through the connecting rod. Generally piston is made by cast iron and aluminum alloy. As we know that by using of ceramic material coating on piston, the performance of IC Engine can be increased. The study is a comparative evaluation was made between the temperature distributions of the uncoated aluminum silica alloy piston and the ceramic coated piston. The Ansys is done by using Ansys 16.0 software.

Keywords: *Thermal Barrier Coating (TBC), Laser Surface Textured (LST), Ceramic materials, aluminum silica alloy, piston, ANSYS 16.0 software*

I. INTRODUCTION

Today's the use of diesel fuel is increase in the world. People do not use diesel only for transportation but also for agriculture therefore the environment becomes more polluted. The automobile industries are facing a serious challenge to increase the fuel efficiency and do hard work to reduce the emission. So many research works are continue on alternate fuel of diesel engine or efficient use of diesel fuel into diesel engine. As we know that the piston is heart of the C.I. engine. The function of piston is to compress the air during compression stroke and transmit the gas force to the crank through connecting rod during expansion stroke. The piston of C.I. engines are generally made of cast iron, cast steel and aluminum alloy. The thermal expansion coefficient of piston made from aluminum alloy material is greater than the thermal expansion coefficient of cast iron. When combustion of fuel takes place inside the cylinder into C.I. engine, high heat is generated. 30% of the heat supplied is lost through the coolant and 30% is wasted against friction and other losses, thus remaining 30% of heat can be utilize for working purpose. It leads to reduce thermal efficiency and increase the fuel consumptions of C.I. engine..There are so many methods are used to improve the efficiency of diesel engine and reduced fuel consumption. For this purpose one of the technologies is used that is ceramic coated IC engine .It is also known as Thermal barrier coating (TBC) or low heat rejection engine (LHRE).

Finite element method (FEM) is widely used in almost all fields of engineering such as thermal, temperature, fluid flows, structural, pipe and channel flow, dynamics analysis etc. Finite element analysis is used for the thermal analysis of ceramic uncoated and coated piston of various thicknesses from 0.1 to 0.8mm.By applying various thickness coating of ceramic material with different material of ceramic and compared with uncoated piston.

List of methods of coating:

- There are different methods of coating. Those are following:

- Thermal spray coating: Plasma spray, wire flame spray and powder flame spray, electrical arc spray, detonation gun technique and high speed oxy fuel system

- Chemical ceramic coating: Sole-gel, slurry, chemical vapour

dimension, physical vapour dimension, hard coating.

- Laser coating
- Arc spark alloying
- Ion enrichment method

Types of Ceramic material:

- Yittria Stabilized Zirconia (YSZ)
- Partially Stabilized Zirconia (PSZ)
- Mullite
- Alumina

Advantage of Ceramic Coated piston

The basic intent of ceramic coated is to be considerably enhancing the performance of C. I. Engine. When performance of C.I. engine takes place with ceramic coated piston by experiment and finite element analysis, it offers the following advantages:

- Reduction in friction
- Low cetane fuels can be burnt.
- Improvements occur at emissions.
- Waste exhaust gases are used to produce useful shaft work,
- Increased effective efficiency,
- Increased thermal efficiency,
- Using lower-quality fuels within a wider distillation range,
- The ignition delay of the fuel is considerably reduced,
- The faster vaporization and the better mixing of the fuel,
- Reduced specific fuel consumption,
- Multi-Fuel capability,
- Improved reliability,
- Smaller size,
- Lighter weight,
- Decreased the heat removed by the cooling system,
- The first start of engine on cold days will be easier,
- Decreasing knocking and noise caused by combustion

LITERATURE SURVEY

A.I. PANDEY [1]In this paper, the study is carried out on performance analysis of 4 stroke diesel engine with ceramic coating material .The paper also study the different types of ceramic material and the types of coating method. This paper also mentioned the advantage of ceramic coated piston. The objectives of literature review paper are Increase the thermal efficiency Increase the mechanical efficiency, Decrease the fuel consumption, Reduction in emission.

Muhammet Cerit, Mehmet Coban [2] The goal of this paper is to determine both

temperature and thermal stress distributions in a plasma-sprayed magnesia-stabilized zirconia coating on an aluminum piston crown to imp rove the performance of a diesel engine. Effects of the coating thickness on temperature and thermal stress distributions are investigated, including comparisons with results fro m an uncoated piston by means of the finite element method. Temperature and thermal stress analyses are performed for various coating thicknesses from 0.2 to 1.6 mm excluding the bond coat layer. Temperature at the coated surface is significantly higher than that of the uncoated piston. It is observed that the coating surface temperature increases with coating thickness by decreasing rate. Increase in the maximum temperature according to the uncoated piston is 64.3% for 1.0 mm thick coating. The higher combustion chamber temperature provided by means of coating results in the better thermal efficiency of the engine.

M. Cerit, V. Ayhan, A. Parlak, H. Yasar [3] This paper shows that the Effect of partially thermal barrier coating on piston temperature distribution and cold start HC emissions of a spark ignition (SI) engine are investigated numerically and experimentally. A Thermal analysis was performed for both standard and coated pistons by using a commercial code, namely ANSYS. The engine tests were conducted on a single cylinder, water cooled SI engine for both standard and coated cases. Analysis results show that the surface temperature of the coated piston part was increased up to 100 °C, which leads to an increase in air–fuel mixture temperature in the crevice and wall quenching regions. Thus, cold start HC emissions considerably decrease compared to the standard engine without any degradation in engine performance. Maximum decrease in HC emissions was 43.2% compared to the standard engine.

Ekrem Buyukkaya [4] Functionally graded coatings are coating systems used to increase performances of high temperature components in diesel engines. These coatings consist of a transition from the metallic bond layer to cermet and from cermet to the ceramic layer. In this study, thermal behavior of functional graded coatings on AlSi and steel piston materials was investigated by means of using a commercial code, namely ANSYS. Thermal analyses were employed to deposit metallic, cermet and ceramic powders such as NiCrAl, NiCrA l + MgZrO3 and MgZrO3 on the substrate. The numerical results of AlSi and steel pistons are compared with each other. It

was shown that the maximum surface temperature of the functional graded coating AlSi alloy and steel pistons was increased by 28% and 17%, respectively.

Ravindra Prasad, N.K. S amria [5] In this paper, an isothermic distribution in the piston body and heat flow rates to cooling water and air below the piston at four different engine loads are depicted for cases both with and without insulation coating. The results indicate a 6% reduction in heat loss through the piston with the use of an insulation coating on the cylinder wall.

I. Taymaz, , K. Çakır, A. Mimaroglu [6] The combustion chamber surfaces (cylinder head, valves and piston crown faces were coated with ceramic materials. Ceramic layers were made of CaZrO3 and MgZrO3, by using plasma -coating method onto the base of the NiCrAl bond coat. The ceramic-coated research engine was tested at the same conditions as the standard (without coating) engine. The results showed a reduction in heat loss to the coolant and an increase in effective efficiency.

X.Q.Cao, R. Vassen, D. Stoever [7] The main objective of this paper is to study about ceramic materials. Ceramics, in contrast to metals, are often more resistance to oxidation, corrosion and wear, as well as being better thermal insulators. Except yttria stabilized zirconia, other materials such as lanthanum zirconate and rare earth oxides are also promising materials for thermal barrier coatings.

Ilker Turgut Yilmaz, Metin Gumus [8] It is known that the efficiency of internal combustion diesel engines changes %38-42. It is about %60 of the fuel energy dismissed from combustion chamber. To save energy, combustion chamber component are coated with low thermal conduction materials. In this paper, give an eye to thermal barrier coating and ceramic materials which are used for making low heat released engines.

Aravinth P1, Subramanian S P1[9] It is well known fact that about 30% of the energy supplied is lost through the coolant and the 30% is wasted through friction and other losses, thus leaving only 30% of energy utilization for useful purposes. There have been numerous research papers in recent years describing the theoretical benefits obtained from the use of ceramic components in reciprocating engines, but

that describes practical results is very limited.

Thermal Barrier Coatings (TBC) in internal combustion engine have advantages such as imp roved thermal efficiency and combustion, reduction in weight by eliminating cooling systems, etc. however, practical problems are faced in implementing these coatings in internal combustion engines. The problem presently faced in implementing of TBC as engine cylinder is thermal is match which mainly occurs due to improper adhesion and difference in thermal expansion coefficient between bond coat and cylinder materials.TBC must also withstand wear an d tear. The disadvantage of the TBC method is that NOx emission is increased.

Vikram A. Mistry[10]This paper deals with temperature distribution analysis of the conventional (uncoated) and ceramic material coated IC engine combustion chamber components. In this study, firstly, thermal analyses are investigated o n a conventional (uncoated) diesel piston and cylinder head, made of aluminum silicon alloy and cast iron respectively. Secondly, thermal analyses are performed on pistons and cylinder head, coated with ceramic material MgZrO3 by means of using a commercial code, namely ANSYS. After that, the results of ceramic coated components are compared with conventional one. The effects of coating on thermal behaviors of components are investigated. In which noted that the maximum surface temperature of the coated pis ton and cylinder head is increased about 479.4 0C and 108.6 0C respectively.

Ravikumar T, Kiran K [11] The depletion of supply of fossil fuels and their increased cost has driven the attention towards energy security. The energy security can be partially achieved by imp roving the efficiency of energy producing equipment's. Diesel fuels can be used more efficiently in lo w heat rejection engines (LHR), in which the temperature of combustion chamber is increased by creating thin layer of ceramics, a thermal barrier. Also the use of thermal barrier coatings (TBCs) to increase the combustion temperature in diesel engines has been pursued for over 20 years. Increased combustion temperature can increase the efficiency of the engine; decrease the CO and unburnt Hydrocarbons (UBHC). TBCs have not yet met with wide success in diesel engine applications. To reach the desirable temperature of 850-900°C in the combustion chamber from the current

temperature of 350-400°C, a coating with a thickness of order 1mm is required.

E. Sateesh1, Erra Saidulu [12] The thermal stress distributions of the conventional and ceramic-coated diesel engine pistons were obtained, respectively. The present study is a comparative evaluation was made between the temperature distributions of the uncoated aluminum silica alloy piston and the ceramic coated piston. The calculated results obtained by wavelet finite-element method were compared with test results and the simulation results gained by ANSYS 17.0 software. Through analyzing the calculation results, the wavelet finite-element method was convergent and had higher analysis precision than the traditional finite-element method. The wavelet finite-element method avoids the numerical oscillation during analysis of the transient-state thermal stress fields of the piston. The wavelet finite-element method showed advantages for analyzing the high gradient problems. The wavelet finite-element method provides a preferable theoretical basis for optimizing the design of the ceramic-coated diesel piston.

Objective of literature review paper

The objectives of literature review paper are:

- Increase the thermal efficiency. By coating piston with different type of ceramic material with various coating thickness.
- Increase the mechanical efficiency
- Decrease the fuel consumption
- Reduction in emission

CONCLUSION

By this literature review, it is conclude that by using ceramic material can increased thermal efficiency, fuel consumption can be reduced and emission can be reduced except NOx. The types of ceramic materials used and method of coating of ceramic material. The advantage of using ceramic material coating.

FUTURE SCOPE

The efficiency of diesel engine can be increased by using of TBC method of various coating thickness. The reduction in an exhaust gases. The increase in thickness and decrease in length of piston can increase efficiency and reduce exhaust gases and also decrease fuel consumption. In future alternative material will be used to make piston to increase thermal efficiency, decrease fuel consumption and reduce emission gases. In short, overall efficiency of diesel engine will be increase by using alternative material.

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