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An Investigation of Ceramic Coating on Aluminium Piston by Ansys

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Abstract: The reason of this research is to find out the effect of Ceramic Coating on Aluminium Piston In this work, the surface of a piston in a diesel engine is coated with Zirconia by the plasma-spray technique, and its surface working method is subsequently analyzed ceramic coating on piston to improve the thermal efficiency with reduction in emission of engine. In this work, the surface of a piston in a diesel engine is coated with Zirconia material with depth of 100 microns using plasma-spray technique. The field temperature distribution is subsequently analyzed using Finite Element Analysis method which is carried using ANSYS software. An experimental work is conducted to find the change in engine behaviour with the influence of functionally graded coating material. The experimental setup design was constructed and results were obtained for thermal efficiency, emissions and Performance . The obtained results were compared between uncoated and Zirconia coated piston. Validations between the experimental and analysis reports were made and the values were matched proving the potential application of using this project in real time scenario. This work aims in converting a conventional engine into a low heat rejection (LHR) Engine method.

Keywords: Ceramic coating, Plasma spray coating method, Engine performance and Emission characteristics.

I. INTRODUCTION

The graded materials are of widely used interest because of their superior properties such as corrosion, erosion and oxidation resistance, high hardness, chemical and thermal stability at cryogenic and high temperatures. These properties make them useful for many applications, including Thermal Barrier Coating (TBC) on metallic substrates used at high temperatures in the fields of aircraft and aerospace, especially for thermal protection of components in gas turbines and diesel engines. Thermal barrier coatings have been successfully applied to the internal combustion engine, in particular the combustion chamber in order to simulate adiabatic changes. The objectives are not only for reduced in-cylinder heat rejection and thermal fatigue protection of underlying metallic surfaces, but also for possible reduction of engine emissions and brake specific fuel consumption. The use of TBC reduces the heat loss to the engine cooling-jacket through the surface exposed to the heat transfer that the cylinder head, liner, piston crown and piston rings. The insulation of combustion chamber with ceramic coating affects the combustion process and performance ,exhaust emissions characteristics of the engine is improve. On the other hand, the desire of increasing the thermal efficiency or reduce fuel consumption of engines lead to the adoption of higher compression ratios, in particular for diesel engines, and reduced in-cylinder heat rejection. Both of these factors cause increased mechanical and thermal stresses of materials used in combustion chamber.

II. DESIGN AND MODEL OF PISTON

Piston is a part of reciprocating engines, pumps and gas compressors. It is palced in a cylinder and is made gas-tight by piston rings. In engine, its use is to transfer force from expanding gas in the cylinder to crankshaft via a piston rod and/or connecting rod. In a pump module the function is reversed and force is transferred from crankshaft to the piston for the purpose of compress or eject the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall.

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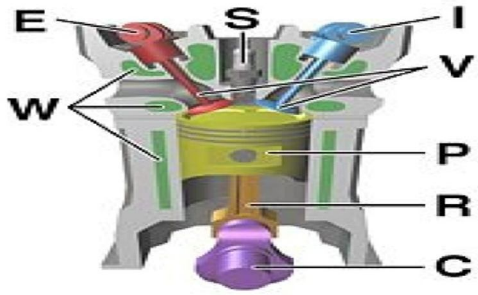

Fig 1 Components of Diesel engine,
(E) Exhaust camshaft, (C) Crankshaft, (W) Water jacket for coolant flow, (I) Intake camshaft,
(S) Fuel Injector ,(V) Valves, (P) Piston, (R) Connecting rod, (W) Water jacket for coolant flow.

III. TYPES OF STRUCTURAL ANALYSIS

Types of structural analyses available in the ANSYS family of products are listed below

A. Static analysis
B. Modal analysis.
C. Harmonic analysis
D. Transient dynamic analysis
E. Spectrum analysis
F. Buckling analysis
G. Explicit dynamic analysis
H. Ansys ls-dyna

IV. MATERIAL MODEL INTERFACE

If we are using the GUI, we must specify the material we will be simulating using an intuitive material model interface. This interface uses a hierarchical tree structure of material categories, which is intended to assist in us choosing the appropriate model for our analysis.

A. Types of Solution Methods

Two solution methods are available for solving structural problems in the ANSYS family of products: the h-method and the p-method. The h-method can be used for any type of analysis, but the p-method can be used only for linear structural static analyses. Depending on the problem to be solved, the h-method usually requires a finer mesh than the p-method.
The p-method provides an excellent way to solve a problem to a desired level of accuracy while using a coarse mesh. In general, the discussions in this manual focus on the procedures required for the h-method of solution.

B. Structural Static Analysis

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading that can be applied in a static analysis include:

1) Externally applied forces and pressures Steady-state inertial forces (such as gravity or rotational velocity)
2) Imposed (nonzero) displacements
3) Temperatures (for thermal strain)
4) Fluences (for nuclear swelling)

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V. COMPARISON OF RESULTS

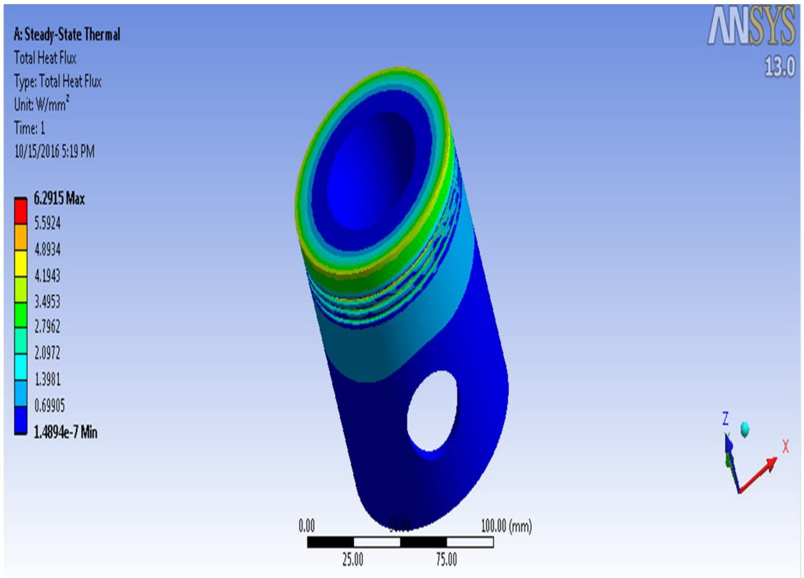

Fig 1 Ansys Design

TABLE 1 Alminium Properties

Properties of Outline Row 4: ALUMINIUM

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	2700	kg m^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
4	Coefficient of Thermal Expansion	2.31E-05	C^-1		
5	Reference Temperature	20	C		
6	Isotropic Elasticity				
7	Derive from	Young's M...			
8	Young's Modulus	7E+10	Pa		
9	Poisson's Ratio	0.3			
10	Bulk Modulus	5.8333E+10	Pa		
11	Shear Modulus	2.6923E+10	Pa		
12	Isotropic Thermal Conductivity	205	W m^-1 C...		

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TABLE 2 Titanium Properties

Properties of Outline Row 6: TITANIUM

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	4430	kg m^-3		
3	Isotropic Secant Coefficient of Thermal Expansion				
4	Coefficient of Thermal Expansion	8.6E-06	C^-1		
5	Reference Temperature	25	C		
6	Isotropic Elasticity				
7	Derive from	Young's M...			
8	Young's Modulus	1.1E+11	Pa		
9	Poisson's Ratio	0.32			
10	Bulk Modulus	1.0185E+11	Pa		
11	Shear Modulus	4.1667E+10	Pa		
12	Isotropic Thermal Conductivity	21.9	W m^-1 C...		

VI. RESULT AND DISCUSSION

Performance analysis of coated piston The performance characteristics of Zirconium coated piston diesel engine was investigated and compared with standard engine is displayed in figures (6- 17). The results obtained from the experiments conducted on the engine are discussed. The brake thermal efficiency of uncoated piston is 34.95%. Maximum brake thermal efficiency of coated piston is 38.87%. Because of zirconium oxide coating 5.79% of brake thermal efficiency improved. Maximum indicated thermal efficiency of uncoated piston is 43.28%.Maximum indicated thermal efficiency of coated piston is 55.52%.Because of zirconium oxide coating 11.23% of indicated thermal efficiency improved. of indicated thermal efficiency improved.

VII. CONCLUSION

In this study, the surface of a piston in a diesel engine is coated with Zirconia by the plasma-spray technique, and its surface behavior is subsequently analyzed. The purpose of this study is to analyze with tribological effects of surface coating for a piston in frictional mechanism. In, with and without coated specimen, the microstructure, hardness, corrosion test were carried out. From the obtained test results, it is found that the coated specimen having improved properties in towards the diesel engine performance. In the results show lower deformation and fewer scratches as compared to uncoated one. Also The aim of the investigation is to compare the mechanical , thermal properties and wear resistance of the piston with Zirconia coating deposited on substrate material as aluminum by plasma spray technique.

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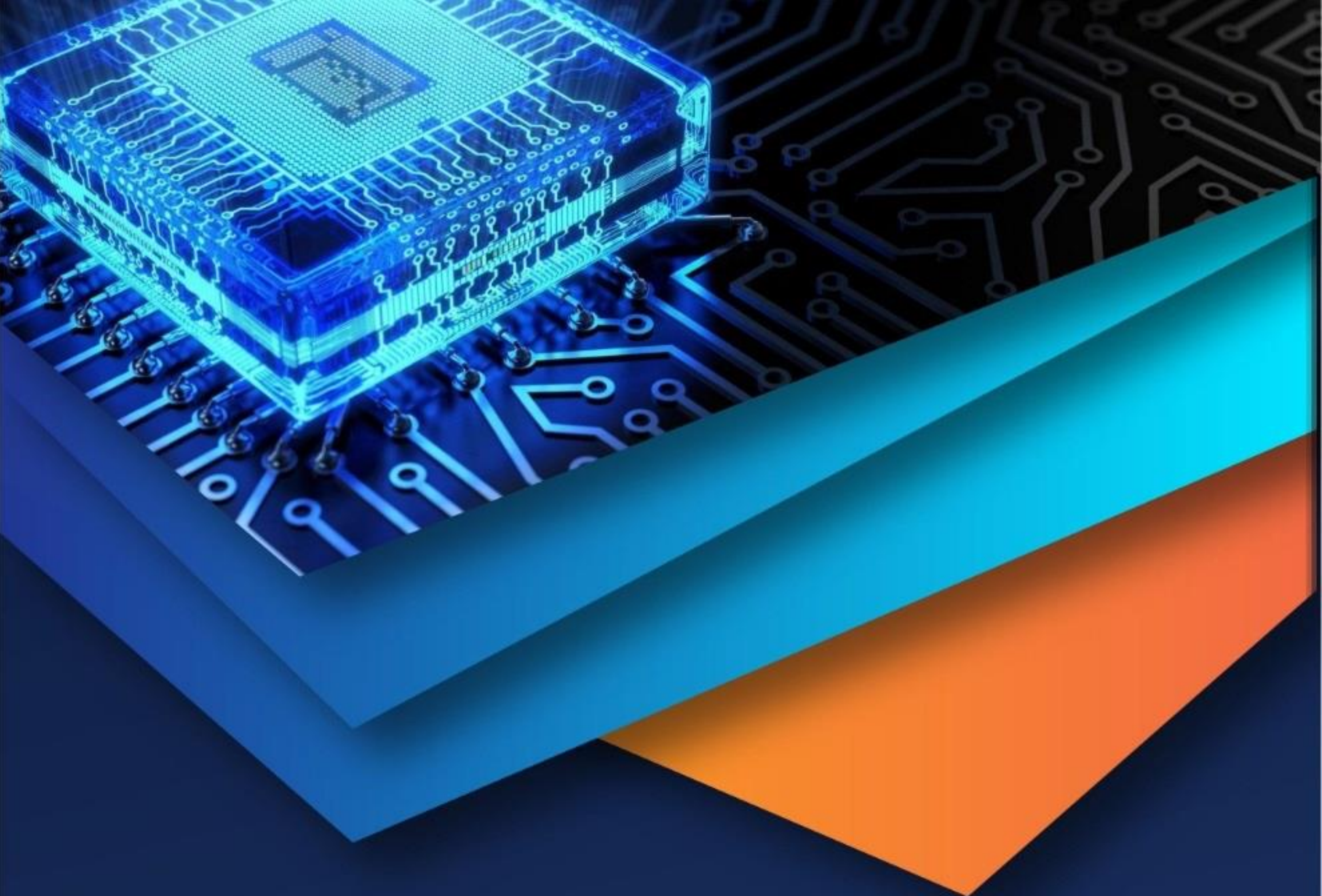

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