International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 07 | July 2020 www.irjet.net p-ISSN: 2395-0072

FEA AND EXPERIMEMTAL INVESTIGATION OF THE CERAMIC COATING ON ALUMINIUM PISTON MATERIAL BY PLASMA SPRAY AND HVOF COATING TECHNIQUE

Ramesh Kumar.M[1], Ramakrishnan.V[2], Ravivarman.A[3], Sanjeeve.R[4], Sannadi purushotham.S[5]

[1]Assistant professor, Dept. of Mechanical Engineering, DSCET, Chennai, Tamilnadu, India
[2-5]Student, Dept. of Mechanical Engineering, DSCET, Chennai, Tamilnadu, India

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Abstract - The top surface of a piston in a engine is coated with different ceramic powders like Alumina, Titania and Tungsten carbide by the plasma-spray technique, and its surface behavior is subsequently analyzed by Ansys software. From the Ansys results best suitable powder is identified. The purpose of this study is to analyze with Mechanical effects of surface coating for a piston in frictional mechanism. In this, with and without coated piton materials were modeled and it will undergo for the analysis by ansys and CFD software. From the obtained results, it is found that the tungsten carbide coated aluminium specimen having improved mechanical properties. The different test results like hardness, Microstructure and corrosion test were carried out. The ansys results will show less deformation, stresses, heat flux and thermal distribution among the various coated and uncoated piston. All the results will compare with that of uncoated specimen.

Key Words: **Coatings; Structure; Adhesion; Wear resistance; Plasma Spray Technique**

1. INTRODUCTION

Functionally graded materials are of widespread 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 (TBCs) in diesel engines lead to advantages including higher power density, fuel efficiency, and multifuel capacity due to higher combustion chamber temperature Using TBC can increase engine power by 8%, decrease the specific fuelconsumption by 15-20% and increase the exhaust gastemperature 200K.

Energy conservation and efficiency have always been the quest of engineers concerned with internal combustion engines. The diesel engine generally offers better fuel economy than its counterpart petrol engine. Even the diesel engine rejects about two thirds of the heat energy of the fuel, one-third to the coolant, and one third to the exhaust, leaving only about one-third as useful power output.

In this project, the main emphasis is placed on the study of thermal behavior of functionally graded coatings obtained by means of using a commercial code, ANSYS on aluminum and steel piston surfaces and the results are verified with numerical and experimental works.

2. COATING TECHNIQUE

Coating is a covering that is applied to an object. The aim of applying coatings is to improve surface properties of a bulk material usually referred to as a substrate.

2.1. PLASMA COATING PROCESS

In all thermal spray techniques, plasma spray is the most flexible one as it can reach a sufficient temperature to melt or heat any material, so the coating material types are almost unlimited. Plasma spray gun is composed of a small chamber with a cathode (electrode) and an anode (nozzle).

Broken down by high-intensity arc, the gas through the chamber forms plasma substance, and releases large amount of heat, which can reach the temperature of 6000 °C ~ 16000 °C. When the coating material is high-speedily injected into the gas flame, it is melted and impacts on the substrate surface.

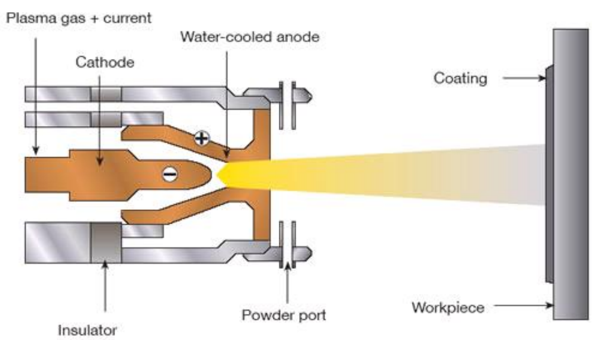


Fig -1: plasma coating technique

PLASMA SPRAYING PARAMETER

SUBSTRATE: Aluminium specimen

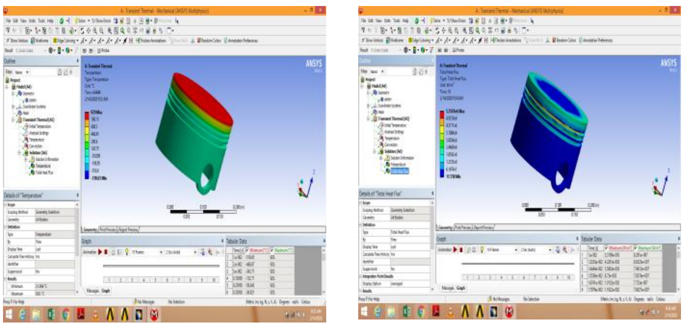
COATING MATERIAL: Ceramic powder(Zirconia)

Parameter	Range
Torch input power	10-18 Kw
Plasma gas(Ar) flow rate	100– 200 ± 5% (1/min)
Secondary gas(N2)flow rate	100 ± 5% (1/min)
Powder feed rate	40-50 g/min
Powder carrier gas flow rate	Up to 450 (m/s)
Torch to baseDistance	76.2 - 127 ± 10 % mm
Anode nozzleDiameter	8 mm
Arc current	250-450 amperes
Powder injection	Radial injectionthrough nozzle (near the exit)
Plasma gas injection	Vortex injection

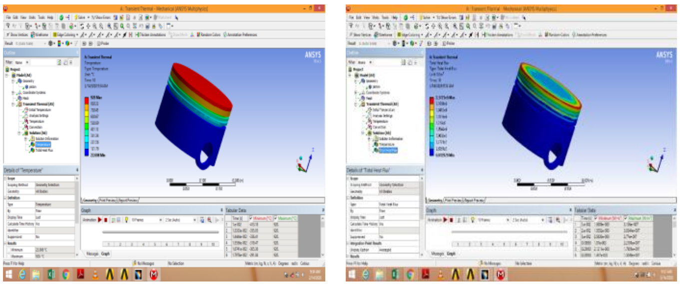
Table -1: Plasma spraying parameter

3. ANSYS EVALUATION

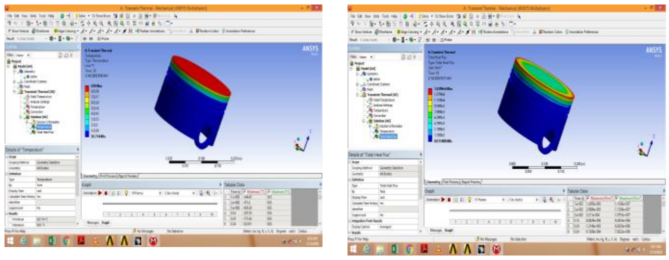
Uncoated(Thermal&Heat flux)



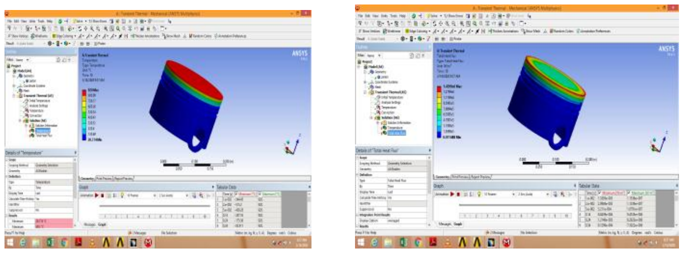
Alumina(Thermal&Heat flux)



Titaniam(Thermal&Heat flux)



Zirconia(Thermal&Heat flux)



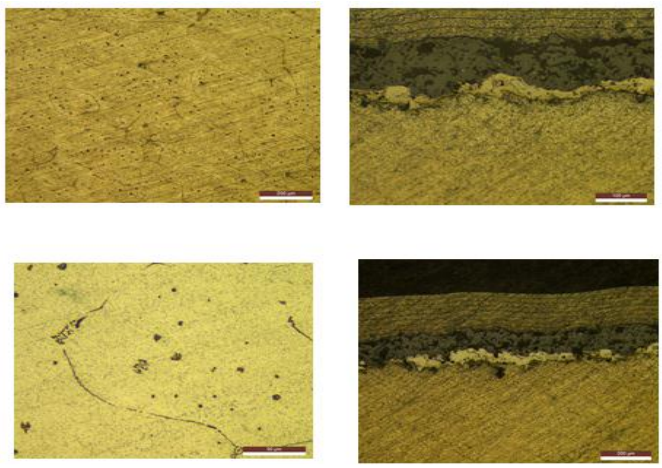
From the ANSYS evaluation it is cleared that among the four alternatives, Zirconia coated specimen has the low thermal conductivity.

4. RESULTS

4.1. MICRO-STRUCTURE - RESULTS

Uncoated

Zirconia



4.2. CORROSSION – RESULTS

SALT SPRAY TEST

Chamber temperature : 34.5 – 35.5
pH Value : 6.65 – 6.85
Vol ume of salt solution collected : 1.00-1.50 ml/hr
Concentration of solution : 4.80-5.30% of NACL
Air pressure : 14-18 Psi
Components loading in the chamber position : 30 degreeangle

Aluminium Alloy Specimen without coated	Aluminium ALLOY specimens with coated
White- rust formation	**No white rust**

Table -2 : Corrosion test result

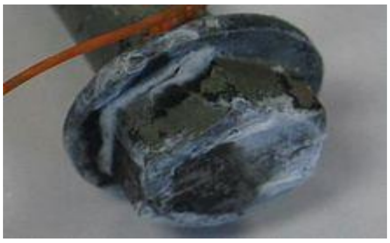


Fig - 2: Rusted material

4.3. HARDNESS - RESULT

Table -2 : Hardness test result

Method of testing	Aluminium Alloy Specimen without coated	Aluminium Alloy specimens with coated
Brinell hardness test	41.4	45.8
Vickers hardness test	44	49

5. COMPARISON OF RESULTS

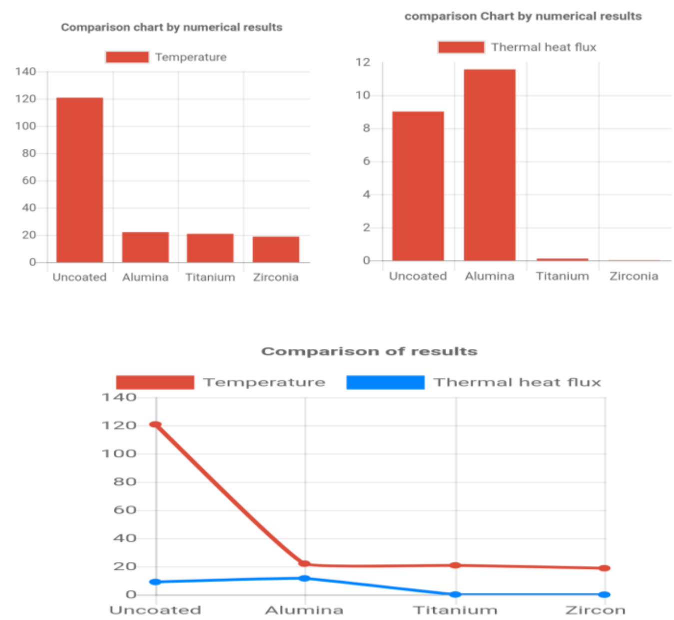


Chart 1: Comparison of numerical results of ANSYS evaluation

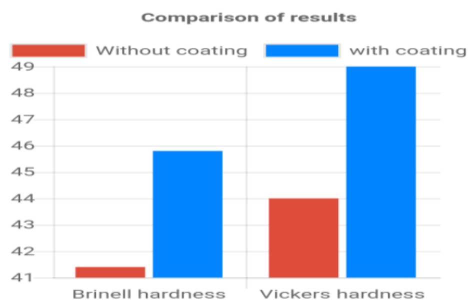


Chart 2: Comparison of numerical results of hardness test

6. CONCLUSION

From the obtained analysis and experimental work results it was found that, the coating on piston material like aluminium specimens by thermal spray coatings were investigated. The surface morphologies of the major and the minor faces were considerably different from each other. Due the coating on aluminium materials will improve the mechanical and thermal characterization. This will further improve the hardness, structural grains and thermal properties. Also the Zirconia coatings will provide the most dramatic improvements over other coating and un coated, in engine component applications where failure mechanisms that are driven by high temperatures and chemical diffusion are important for life. In lower temperature applications (lower speeds, discontinuous contact) the coating will still offer improved performance due to the effects of crystallite refinement, which provide a smoother surface and second phase crack arresting or deflection mechanisms that make the coating tougher. Due to coating on aluminium materials the hardness was increased, so that the wear rate will reduce during the combustion process. Also the corrosion resistance was increase due the zirconia coating.

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