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Effect of Oxidation and Mechanical Properties of Low Thermal Conductivity Material Coated on IN718 by Thermal Barrier Coating

K Mugesh[1], Dr. S. Sankarapandian[2]
[1, 2]Mechanical Engineering, Alagappa Chettiar Government College of Engineering & Technology.

Abstract: In this study the mechanical properties of air plasma sprayed YSZ, $AlCrO_3$+YSZ $AlCrO_3$+50% YSZ thermal barrier coating (TBC) coatings were evaluated and also compared with each other. The synthesized $AlCrO_3$ is blended to commercial YSZ on ratio of bare and 1:1wt, 1:2 wt, were coated on IN718. The thermal barrier coatings on IN718 material were characterized by mechanical properties and oxidation behaviour was studied. The $AlCrO_3$ is added as binding element to YSZ to improve the mechanical properties of TBC. The results of mechanical properties and oxidation graph are incorporated in this report. This work clears new pathways to achieved without bond coat to good adhesive strength and resist thermal expansion for TBCs.

Keywords: Thermal barrier coating, YSZ, tensile test, oxidation, $AlCrO_3$.

I. INTRODUCTION

Thermal barrier coating (TBCs) are generally utilized in the gas turbine to improve its strength and vitality proficiency. Yttria stabilized zirconia (YSZ) ceramic as the top coat material has been utilized for a considerable length of time because of its attractive properties including high fracture toughness, low thermal conductivity and high thermal expansion co-efficient. Be that as it may, the strength and unwavering quality of air plasma spray (APS) YSZ TBCs are confined for the propensity of break and untimely spallation because of the arrangement and development of thermally grown oxide (TGO) in administration. Oxidation is additionally another significant explanation behind the YSZ TBC disappointment .the thermally grown oxide (TGO) framed between the top coat and bond coat make a crisscross in warm extension of coating and the spallation of coating begins. In the interim, YSZ coatings are additionally found on gas turbines, utilized as thermal barrier coating (TBCs). With respect to their testimony procedure, different techniques have been utilized, for example, air plasma spray (APS), electron beam-physical vapour deposition (EB-PVD), sol-gel, vaporized statement. APS innovation is broadly utilized in modern scale to store YSZ coatings in light of high testimony rate, prudent proficiency and capacity to create thick coatings with high glue quality. Notwithstanding, a high porosity (around 5–8%) in fired coatings utilizing ordinary APS is practically unavoidable. High porosity in YSZ coatings is useful to thermal protection, for it normally lessens the successful thermal conductivity of coatings, while, it is harmful for hostile to oxidation reason. From one viewpoint, higher porosity implies progressively destructive species infiltrating into the coatings, therefore denser ceramics coatings display higher consumption obstruction. On the other hand, YSZ coatings may be secured by liquid salt when filled in as TBCs in the hot area of a motor. The infiltration of these contaminants through the permeable and small scale broke coatings may assault the hidden super composite by hot consumption instruments. Anyway this standard material has a constrained temperature ability because of quickened sintering and stage changes at high temperatures. As a rule, TBC material prevent to satisfy the vast majority of the accompanying necessities, for example, a steady stage, low thermal conductivity ($9\times10{-}6$ K−1), low sintering rate, and high break durability. An overall exertion has been attempted to recognize new possibility for a TBC application. In our gathering, we have arranged some antacid earth perovskites, for example, $SrCeO_3$ and $SrHfO_3$ and considered their appropriateness to the TBC materials. Against this foundation, we center around $AlCrO_3$ as the new TBC materials.$AlCrO_3$ is typical inter oxide in the Al_3O_3, Cr_2O_3 Thermal and mechanical properties are barely detailed.

II. MOLTEN SALT SYNTHESIS

Molten salt synthesis, one of the best conventional methods of preparing ceramic powders, involves the use of molten salt as the medium for preparing complex oxides from their constituent materials. The $AlCrO_3$ was synthesized by molten salt synthesis method. The A mixture of reactant and salt powders is heated at temperatures above the melting point of the salt. The reactants interact under the presence of the molten salt. After a predetermined heating stage, the product mass is cooled, and washed with a solvent (mainly water) to remove the salt. The product powder is obtained after drying. The flow chart of molten salt synthesis is shown fig-1

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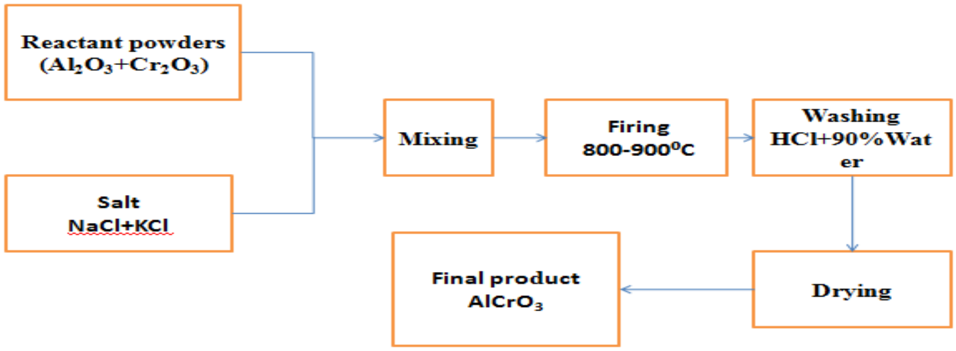

Fig.1 molten salt synthesis flow chart

III.FABRICATION OF COATING

Inconel 718 superalloy of Ni-19Cr-18.5Fe-5.1Nb-3Mo-0.9Ti0.5Al (wt%) substrate was cut for wire cut EDM. To achieve high coating adhesion and good mechanical bonding to the substrate, the surface of the substrate should be roughened Prior to spraying, the substrates were degreased by acetone and then grit blasted with alumina particles. During the APS process, the molten particles are quenched by impacting to the substrate giving rise to residual thermal misfit stresses in the coating and substrate. To reduce these stresses, the substrate preheating should be carried out Therefore, just before depositing the coatings, the substrates were preheated up to about 200°C. The mixture of $AlCrO_3$+ YSZ were used as feedstock for the deposition of coat material. The final thicknesses were approximately 100µm to 300µm for the top coat, respectively.

IV.RESULT AND DISCUSSION

A. *Tensile Test*

The tensile stress testing was carried out UTM. The test was performed in a universal testing machine (TiniusOlsen H20K) with a capacity of 20KN. The standard specimen for ASTM E8 is 165x20x3 mm Tensile test. In order to check the tensile strength of coating. Tensile tests were conducted in accordance with ASTM E8 for coated samples. Shown below is tensile test coated sample fig.2 and coating sample increases tensile stress show fig.3, ultimate force fig .4

Fig.2 coating sample tensile stress

TABLE I

Ratio	Ultimate Stress (MPA)	Ultimate Force (KN)	Break Distance (mm)
Bare YSZ	265.24	12.12	10.05
1:1	287.35	13.25	11.07
1:2	287.03	12.71	10.85

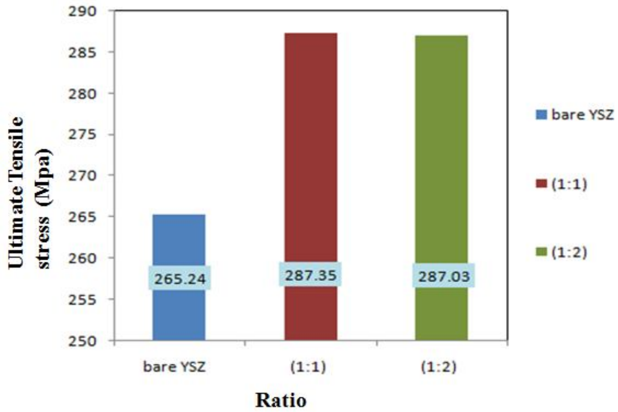

Fig .3 increases tensile stress

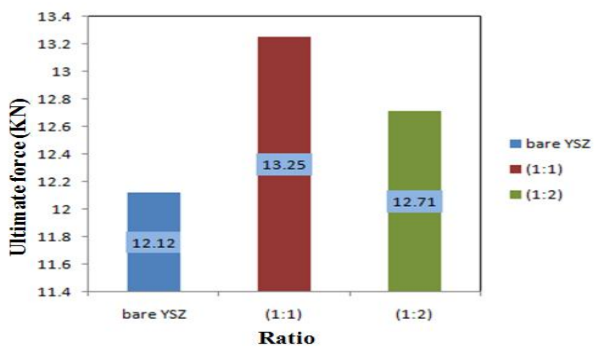

Fig.4 ultimate force

B. Microhardness Test

The hardness benefits of coating are acquired on Vickers smaller scale hardness mechanical assembly utilized. The load applied on the coating by indenter is 100g for 5sec. the hardness estimation of exposed YSZ coating is 550HV, $AlCrO_3$+YSZ (1:1) coating is 480HV and $AlCrO_3$+YSZ (1:2)is 516HV. the hardness estimation of uncoated compare coating is moderately high think about of other two coatng. This decrease of hardness benefit of coating is expected to $AlCrO_3$. The figure No.5 chart of hardness benefit of coating.

TABLE III

Ratio	Hardness Value (HV)
Bare YSZ	550
1:1	480
1:2	516

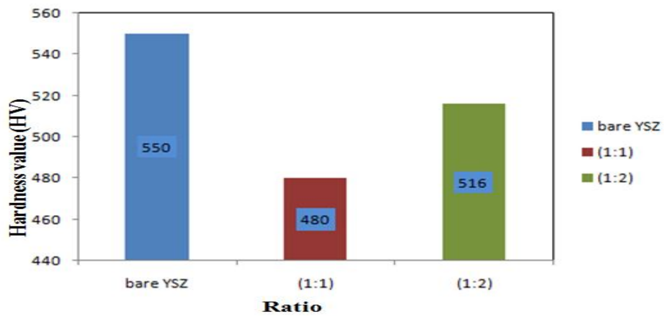

Fig.5 chart of hardness

C. Oxidation Kinetic

The oxidation kinetic tests were conducted on all the three pellets of bare YSZ , $AlCrO_3$+YSZ and $AlCrO_3$+%50 YSZ at 900 °C for the duration of 25 hr. The oxidation kinetic rate of weight gains were recorded on each sample by measuring the weight change using physical semimicro balance. The figure.6 shown below is oxidation of pellets sample. The figure.7 show below is oxidation graph.

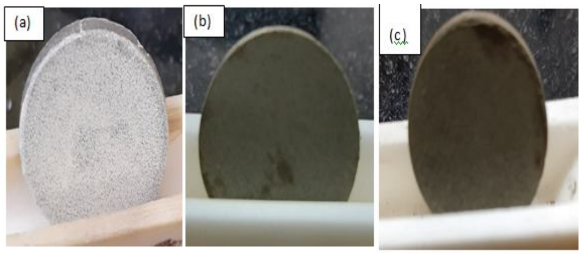

Fig.6(a. bare YSZ, b.$AlCrO_3$+ YSZ c. $AlCrO_3$+ 50% YSZ)

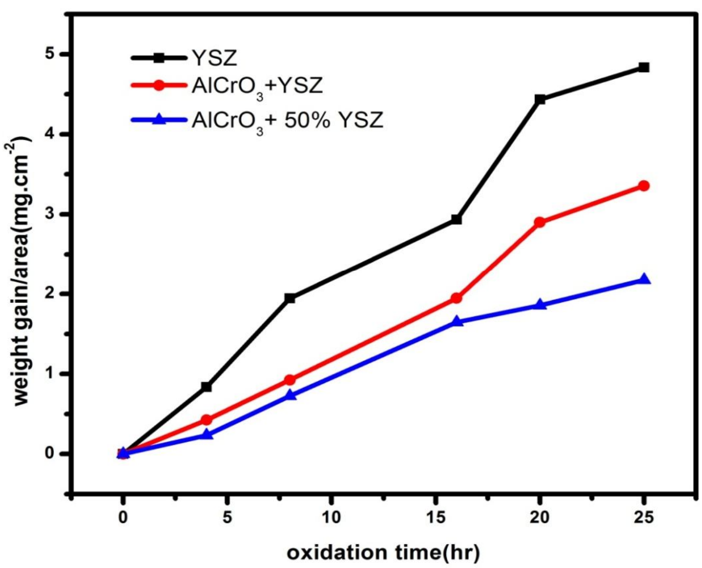

Fig.7 oxidation graph

V. CONCLUSIONS

In this paper, $AlCrO_3$+YSZ coatings were deposited using atmosphere plasma spraying. The effects of $AlCrO_3$ addition on the mechanical properties of the plasma sprayed $AlCrO_3$+YSZ composite coatings were investigated. The main conclusions are summarized as follows

A. The hardness value of blend coating is lower than commercial bare YSZ coating due to ductile properties.
B. The tensile properties of blended coating is increased compare to commercial bare YSZ coating.
C. The bare YSZ demonstrate higher oxidation rate in compared with $AlCrO_3$+YSZ in oxidation.

This work clears new pathways for the exploration with non bond materials for TBCs.

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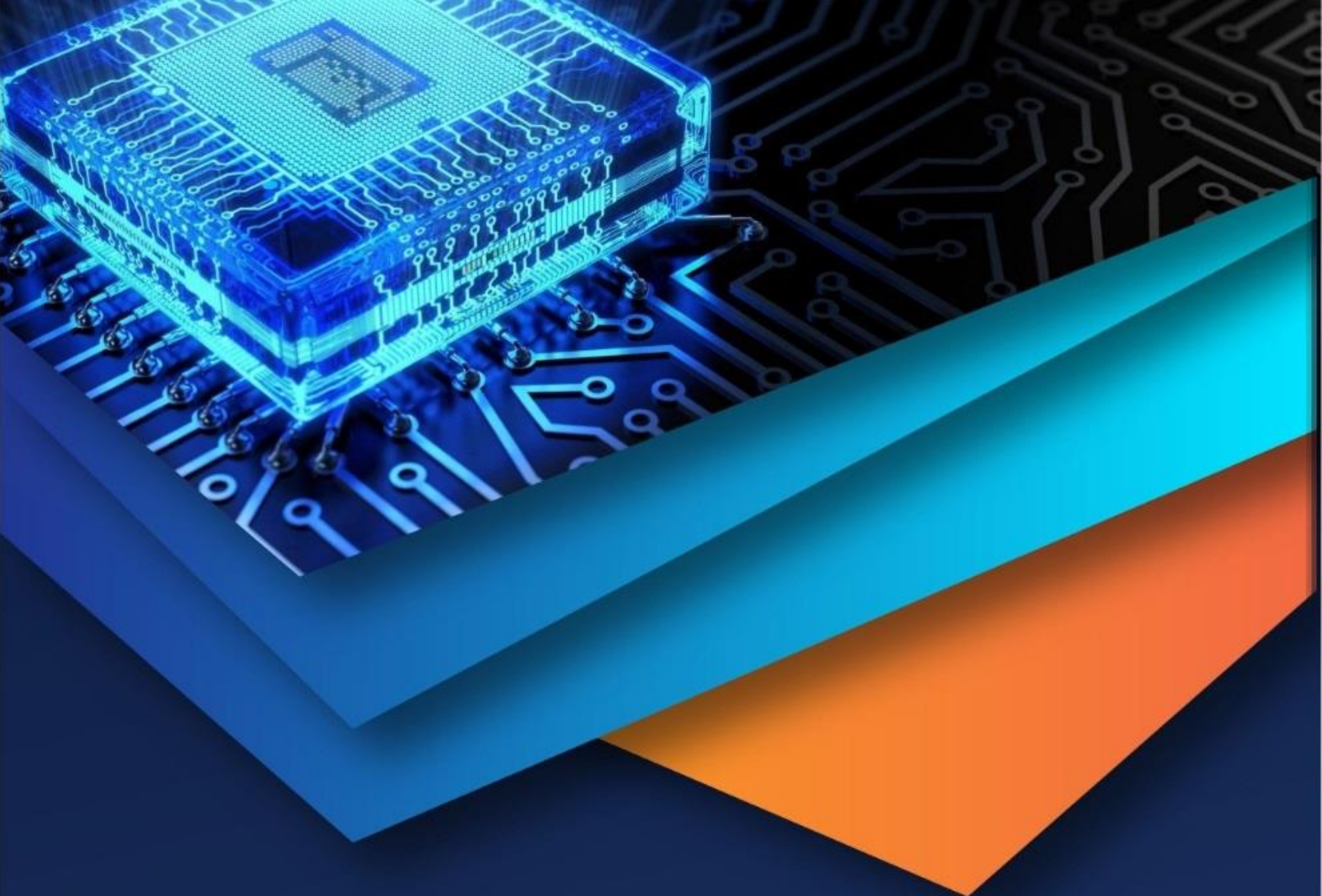

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