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Coatability of Redmud on Metal Substrates

Alok Satapathy, S. C. Mishra
National Institute of Technology, Rourkela – 769008,e-mail : alok@nitrkl.ac.in
K. P. Sreekumar and **P. V. Ananthapadmanabhan**
Laser and Plasma Technology Division, B.A.R.C., Mumbai – 400085

Abstract

Plasma sprayed coatings of red mud (the waste generated in alumina plants) are developed on metal and steel substrates and are characterized. Coating adhesion strengths and deposition efficiencies are evaluated at various operating conditions. Maximum adhesion strength of about 8 MPa and deposition efficiency of about 27% are recorded. This work establishes 'red mud' as a potential coating material, which may be suitable for wear resistant applications.

Key words: Plasma spraying, red mud, waste utilization

1. Introduction

Red mud is the major waste produced during alumina production following Bayer's Process. Depending on the quality of the raw material processed 1 to 2.5 tonnes of red mud is generated per tonne of alumina produced. Red mud, as the name suggests, is brick red in colour and is slimy. It comprises of the iron, titanium and the silica part of the parent ore along with other minor constituents. It is alkaline, thixotropic and possesses high surface area in the range of 13-16m^2/g with a true density of 3.30 g/cc. The leaching chemistry of bauxite suggests that the physical and chemical properties of red mud depend primarily on the bauxite used . Residues from different bauxite have a wide range of composition: Fe_2O_3 20-60%, Al_2O_3 10-30%, SiO_2 2-20%, Na_2O 2-10%, CaO 2-8%, TiO_2 traces – 2-8%. [1]

Over the past three decades thermal plasmas have been used for processing various types of materials, some of which would not have been possible by conventional techniques [2]. In thermal plasma it is possible to spray all metallic and non metallic materials such as metal oxides, carbides, nitrides, silicides etc. [3]. The chemical analysis of the red mud shows that its major constituents are Iron Oxide (Fe_2O_3), Aluminum Oxide (Al_2O_3), Titanium Oxide (TiO_2) and Silicon Oxide (SiO_2) etc. Since all these are metal oxides can melt without sublimation, it was felt that red mud which otherwise is a waste, can possibly be spray coated. Moreover oxides of iron, aluminum and silicon are known to have high hardness, high wear resistance and good corrosion resistance which are the desired properties of any protective coating.

2. Experimental

Red mud collected from NALCO, Orissa was sieved to obtain a particle size of about 60-100 micron Experiments were carried out using a 40kW plasma spray system at the Laser & Plasma Technology Division, BARC . This is a typical atmospheric plasma spray system working in the non-transferred arc mode. A current regulated DC supply was used. A four stage centrifugal pump at a pressure of 10kg/cm^2 supplied cooling water for the system. Argon and Nitrogen taken from normal cylinders at an outlet pressure of 4kg/cm^2, were used as plasma gas and carrier gas respectively. Plasma spray red mud coatings are thus deposited over the selected substrates (Al, Cu , Mild Steel , Stainless Steel) of dimensions 50x20x3mm. Prior to coating all the substrates were sand blasted to get the required surface roughness. The operating parameters used in the experiment are presented in Table 1.

Parameter	**Range**
Operating Power (kW)	6-17.5
Current (Amps)	200-350
Voltage (V)	30-50
Primary Plasma gas (Argon) flow rate (Lpm)	20
Secondary gas (Nitrogen) flow rate (Lpm)	2
Torch to base distance (mm)	100
Powder feed rate (gm/min)	10
Powder carrier gas (Argon) flow rate (Lpm)	7

Table 1: Operating Parameters for Plasma Spraying of Red Mud

3. Results and Discussion

At any operating power some particles will melt and evaporate and at the same time some all-molten particles which solidify before hitting the substrate will bounce off. This considerably affects the deposition efficiency. Variation of deposition efficiency with operating power for various substrates has been illustrated in Fig.1. At the highest power level (17.5kW) the values lie in the range 20-30% for all substrates, which is reasonably good as far as plasma spray coatings are concerned.

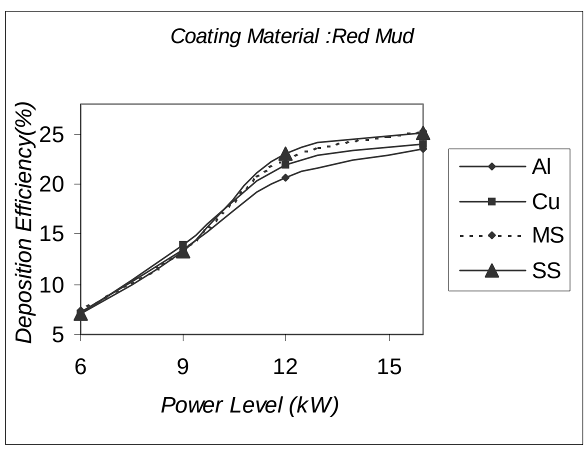

Fig. 1. Deposition Efficiency Vs Operating Power

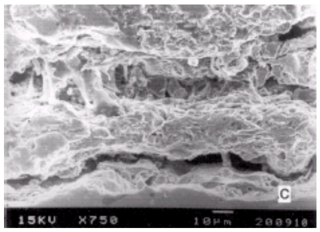

Fig. 2. Interface Microstructure at 12kW

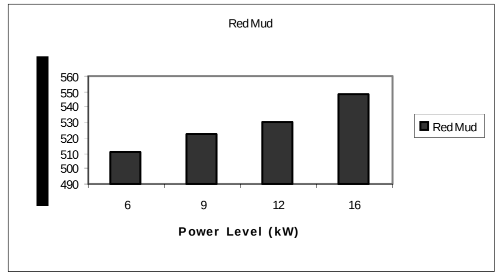

Fig. 3. Hardness of Coating sprayed at various power level

The adherence strength of the coating is measured using coating pull out method. It is found that with the increase in input power of the plasma gun there is an increase in the adherence strength up to a certain level of operating power and then it decreases with further increase in the power level. Although this trend is observed for all types of substrates the magnitude differs. The hardness of the coating is an important property for recommending its use for wear resistance purpose or for similar application. The polished cross sections of the coated samples were subjected to micro hardness measurement using a Leitz Micro-hardness tester. The hardness measurement [HV] was done with a load of 0.5 N along the coating and substrate cross-section. Maximum hardness of 560 HV has been recorded on the coating. [Fig.3]The interface structures for coatings deposited at different power levels are observed to be smooth and no crack is observed at the interface even for higher operating power levels. Longitudinal cracks are seen at the inter-particle layers of coating deposited on copper substrate at 12kW as shown in Fig.2, which reduce the adhesion strength. The interface homogeneity may be due to the higher thermal conductivity of copper that had helped in faster rate of conduction of heat from the sprayed powders to the substrate.

4. Conclusions

Red mud, the industrial waste can be used for depositing plasma spray coatings on metals. The coating morphology reveals that the coating is homogenous at intermediate power level. It was observed that the operating power appreciably influences the coating adhesion strength,hardness and deposition efficiency. This work establishes ‘redmud’ as a potential coating material, suitable for wear resistant applications.

5. References

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