

Resistance of Plasma Sprayed Redmud Coatings to Solid Particle Impingement

Alok Satopathy*, S. C. Mishra*, P. V. Ananthapadmanabhan+ and K. P. Sreekumar+

*National Institute of Technology, Rourkela – 769 008. India.

+Laser & Plasma Tech. Division, B.A.R.C, Mumbai – 400 085.

Abstract

Repeated impact by airborne solid particles causes erosion and degradation of engineering components. In this work, a self-made erosion apparatus capable of creating highly reproducible erosive situations for a wide range of particle sizes, particles fluxes and incidence angles was used to study the wear behavior of plasma sprayed redmud coatings by subjecting them to air jet solid particle impingement. The cumulative mass loss with impact time was evaluated by changing the impact angle (α). The wear rate was found to be minimum for $\alpha=30^\circ$ and maximum for $\alpha=90^\circ$.

Key words: Plasma spray deposition, redmud coating, tribological application, industrial waste utilization

1. Introduction

Solid Particle Erosion is a wear process where particles strike against surfaces and promote material loss. During flight a particle carries momentum and kinetic energy, which can be dissipated during impact, due to its interaction with a target surface. Different models have been proposed that allow estimations of the stresses that a moving particle will impose on a target [1]. The particle will also be subject to stresses and therefore it can undergo damage. The imposed surface damage will vary with the target material, erodent particle, impact angle, erosion time, particle velocity, temperature etc.[2,3].

2. Experimental System

Plasma sprayed coatings of redmud on MS substrates were prepared using a 40kW plasma spray system at the Laser & Plasma Tech. Division, BARC. Red mud is the waste produced during alumina production following Bayer's Process. The chemical analysis of the red mud shows Fe_2O_3 , Al_2O_3 , TiO_2 and SiO_2 as its major constituents. The set up used for redmud deposition is a typical atmospheric plasma spray system working in the non-transferred arc mode. The operating parameters used in the experiment are presented in Table 1. A self-made erosion test apparatus capable of creating highly reproducible erosive situations for a wide range of particle sizes, particles fluxes and incidence angles was used to study the wear behavior of these coatings by subjecting them to air jet dry sand particles (200-250 μm) impingement. The cumulative mass loss was evaluated for different impact angle (α).

Table 1: Operating Parameters for Plasma Spraying of Red Mud

Parameter	Range
Operating Power (kW)	6-16
Current (Amps)	200-350
Voltage (V)	30-50
Primary Plasma gas (Argon) flow rate (Lpm)	20
Torch to base distance (mm)	100

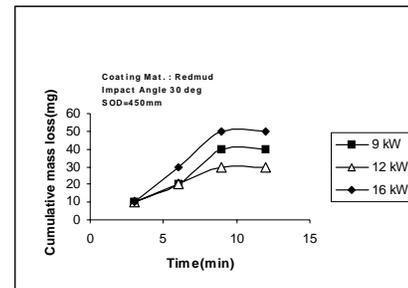


Fig. 1. Mass loss Vs impact time (30°)

3. Results and Discussion

The relationship between mass loss and impact time at different impact angles (30°, 60°, 90°) are illustrated in the Fig.[1, 2, 3]. It is observed that the cumulative mass loss occurs linearly with time for most of the samples, except for the sample at 30° impact angle, for which the mass gets stabilized after around 10 minutes of impact. The magnitudes of erosive mass losses are different for coatings deposited at different power levels. This variation may be attributed to the respective coating quality.

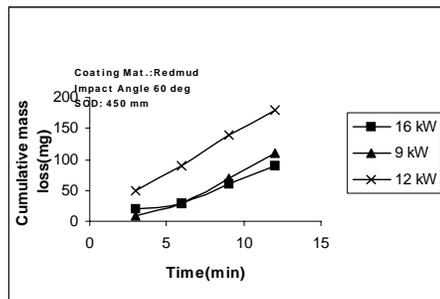


Fig. 2. Mass loss Vs impact time (60°)

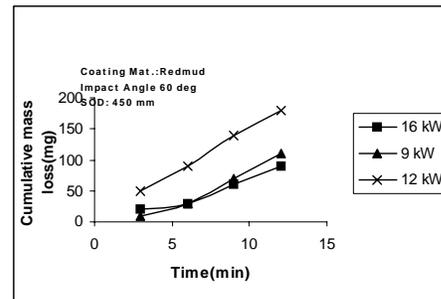


Fig. 3. Mass loss Vs impact time (90°)

According to some engineering model developed so far, for erosive wear, it has been established that the angle at which the stream of solid particles impinges the surface influences the rate at which the material is removed from the surface. This angle determines the relative magnitude of the two velocity components of the impact namely, the component normal to the surface and parallel to the surface. The normal component will determine how long the impact will last and the load. The product of this contact time and the tangential velocity component determines the amount of sliding that takes place. The tangential velocity component also provides a shear loading to the surface, which is in addition to the normal load that the normal velocity component causes. Hence as this angle changes the amount of sliding that takes place also changes as does the nature and magnitude of the stress system. Both of these aspects influence the way a material wears. In this

investigation, the mass loss at various impact angles for coatings deposited at all power levels have been recorded and it is found that the loss is minimum for $\alpha=30^\circ$ and is maximum for $\alpha=90^\circ$.

The dynamics of a coating buildup results in a layered structure with individual lamellae oriented differently to the substrate surface [4]. Pores exist between and inside lamellae. Brittle lamellae are frequently cracked. Shrinkage, thermal shock and linear expansion coefficient mismatch between substrate and coating are some of the factors responsible for coating cracking. Dimension and content of these features are determined by the spraying process parameters and feedstock material.

4. Conclusions

Red mud, the industrial waste can be used for depositing plasma spray coatings on metals. The coating sustains erosion by solid particle impingement substantially and therefore redmud can be considered as a potential coating material suitable for various tribological applications.

5. References

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