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Study of Slurry Erosive Wear Behavior of Inconel 718 Coated Al6061

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ABSTRACT: Inconel 718 coated Al6061 is a promising combination for applications requiring high strength, corrosion resistance, and wear resistance. The slurry erosive wear behavior of this composite material is of great interest in various industries, including aerospace, automotive, and marine, where components are subjected to harsh environments and abrasive particles. Understanding the wear behavior of the coating is crucial for optimizing the performance and durability of these materials. Slurry erosive wear refers to the progressive removal of material from a surface due to the impact of solid particles suspended in a fluid medium. The erosive wear resistance of a material depends on several factors, including the properties of the coating, the characteristics of the slurry, and the operating conditions. The aim of this study is to investigate the slurry erosive wear behavior of Inconel 718 coated Al6061 and provide insights into the performance of this composite material in abrasive environments. By studying the wear mechanisms and analyzing the effects of various parameters, we can develop a comprehensive understanding of the material's response to erosive wear and propose strategies for improving its wear resistance.

KEYWORDS: Inconel 718 coated AL6061, Slurry erosive, Plasma spray coating.

I. INTRODUCTION

In the present industrial world, engineering components are being subjected to be increasing the demand of the environment. This has made the components prone for rapid degradation due to mechanisms such as wear, corrosion, erosion oxidation or failure under high heat load. Erosion is defined as the wear caused by hard particles hitting the surface carried by a gas stream or entrained in the liquid media. To achieve various industrial applications, effect has been made to enhance performance in terms of productivity & efficiency. Surface treatment technologies have been attracting a great deal of attention as it is a cost effective way to conflict degradation modes without sacrificing the bulk properties of the component material. Of all the surface phenomenon, the problem of wear is of high concern in most of the industrial components. Several forms of wear such as, abrasive, dry adhesive and wet erosion exists. However, wet erosion also termed as slurry erosion helps in determining the service life of the major components handling slurries containing hard abrasives in several chemical handling equipments, exposed parts in marine environments and in turbine blades of hydro electric power plants.

Slurry erosion can be defined as a type of wear or loss of material experienced by a component, when exposed to high velocity stream of slurry mixture of solid particles in a liquid, usually water. It is a major problem in many engineering applications. When the components are pulled down or carried in such environments, the design life of the component is highly reduced, resulting in great economic losses. The areas in which the component suffer from this problem includes mining machinery components, hydraulic transport of solids in pipelines, marine, oil gas and power generation industries. Different & Various surface modification technologies are now available. Among them, thermal spraying, which refers to a family of material deposition techniques, has emerged as an important tool of increasingly complicated surface engineering technology. Each thermal spray coating technique has its own way & unique features and is difficult to single out any one of them being the most useful, desirable or economical for all coating requirements. Therefore, one needs to be intellectual to make an ideal choice of the most suitable processes to be developed to meet any particular need for a protective coating.

II. LITERATURE REVIEW

In an extensive variety of industry the role of surface coating has been increased due to higher energy efficiency and longer life are projected more strongly for various plants and industries. Surface engineering is a multidisciplinary activity intended to tailor the properties of the surfaces of engineering components so that their function and serviceability can be improved and surface engineering as "treatment of the surface and near-surface regions of a material to allow the surface to perform functions that are distinct from those functions demanded from the bulk of the material" The desired properties or characteristics of surface-engineered components include:

- Enhanced Mechanical properties like toughness, hardness and fatigue etc.
- Better surface roughness of the engineered component. (dimensional accuracy, frictional and appearance)
- Improves fatigue and stiffness resistances.
- Improved corrosion resistance in gas turbine components.
- Improves the oxidation resistance in sheet metals components.
- Better wear resistance on surface of machinery equipments.
- Controlled Frictional energy. (sliding tools, bearing and dies)
- Good result on electronic or electrical properties.
- Superior Thermal insulation.
- Improves aesthetic appearance of the component.
- Life span of the product is increased.

Surface engineering techniques are used in all types of materials like metals, polymers, ceramics and composites. Metals can be coated on similar materials or dissimilar materials. These techniques are used in the steel, automotive, aerospace, missile, machine tool, electronic, biomedical, petroleum, petrochemical, chemical, cement, textile, construction industries.

THERMAL SPRAYING

Thermal spray first developed in 1908s by Dr M.U. Schoop. He was the first scientist to discover the possibility that a stream of metallic particles formed from molten metal might be used to produce coatings and thermal spraying technologies expanded in the year 1970, development of thermal plasmas, and the increasing demand of high temperature and wear resistant materials and coating systems. Especially in the period between the 1960 and 1990 when its wide application in various industries began.

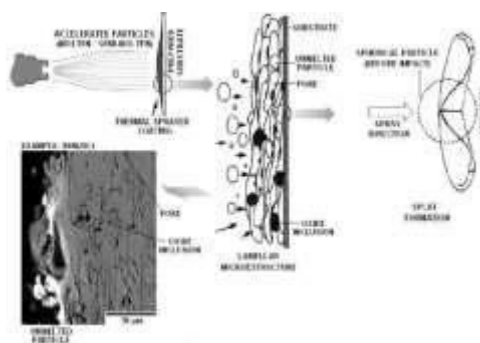


Fig : Schematic diagram showing Thermal spraying

PLASMA SPRAYING

Plasma spraying is a part of thermal spraying. It is group of processes in which finely divided metallic and non-metallic materials are deposited in a molten or semi-molten state on a prepared substrate. Plasma spraying is one of the most versatile thermal spraying techniques which has more applications due to its versatility of spraying all range of metallic and non metallic materials. This is why Plasma spraying is more suitable for spraying of high melting point materials like aero components, refractory ceramics material, cermets etc.

Plasma is considered to be the fourth state of matter. It is electrically neutral even after consisting of a mixture of

electrons, ions and neutral particles. The degree of ionization of a plasma is number of atoms that have lost or gained electrons and it is controlled by temperature in case of thermal plasmas.

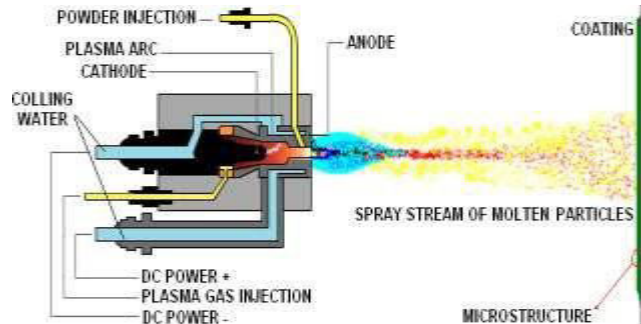
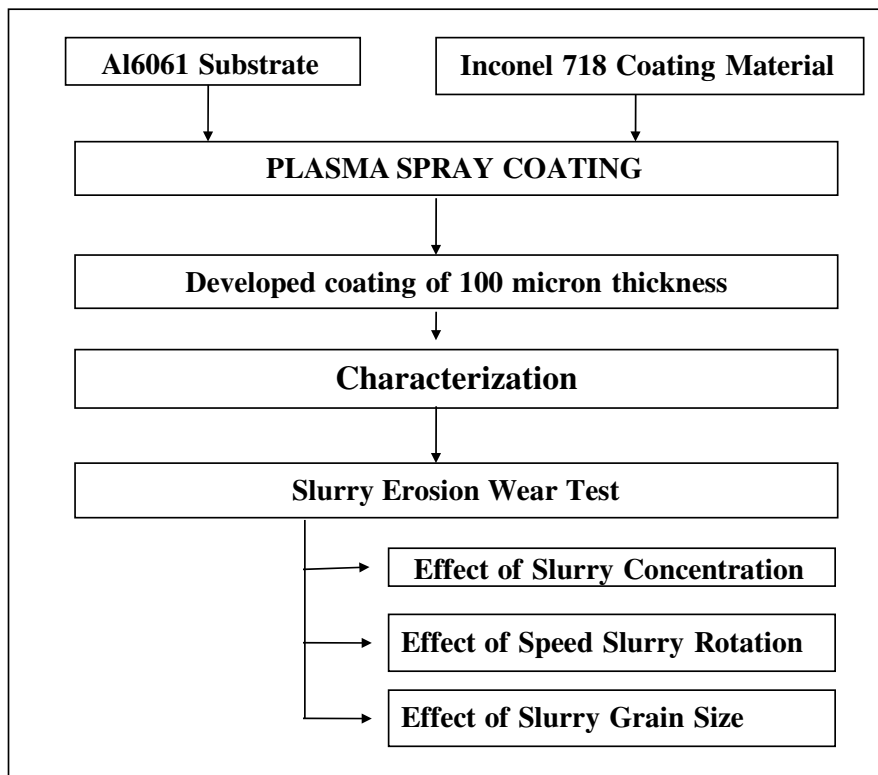


Fig. Conventional plasma spraying process

III. SCOPE OF PRESENT INVESTIGATION



OBJECTIVES

The study on the slurry erosive wear behavior of Inconel 718 coated Al6061 aims to achieve the following objectives:

- **Characterize Coating Performance:** Assess the wear resistance of the Inconel 718 coating on Al6061 under different slurry erosive wear conditions. Evaluate the coating's ability to withstand abrasive particle impact and resist material loss.
- **Identify Wear Mechanisms:** Investigate the wear mechanisms involved in the slurry erosive wear of Inconel 718 coated Al6061. Analyze the material removal processes and identify key factors influencing wear, such as particle size, velocity, and impact angle.
- **Determine Optimal Coating Parameters:** Study the effect of coating parameters, including thickness, roughness, and adhesion, on the slurry erosive wear behavior of Inconel 718 coated Al6061. Identify the optimal coating parameters that provide the highest wear resistance and minimize material loss.

- Analyze Surface Morphology: Examine the surface morphology of the coated samples after slurry erosive wear testing using scanning electron microscopy (SEM) and evaluate the presence of wear mechanisms such as plowing, cutting, or delamination. Characterize the wear tracks and analyze the evolution of surface damage.
- Quantify Wear Performance: Quantify the wear volume loss and wear rate of the Inconel 718 coated Al6061 samples under different slurry erosive wear conditions. Compare the wear performance of coated samples with uncoated Al6061 to determine the effectiveness of the Inconel 718 coating in enhancing wear resistance.

IV. EXPERIMENTAL SET UP AND METHODOLOGY

Coating Preparation: The Inconel 718 coating will be applied onto Al6061 substrates using a suitable deposition technique, such as thermal spray or electroplating. The coating thickness and quality will be carefully controlled to ensure uniformity and adhesion.

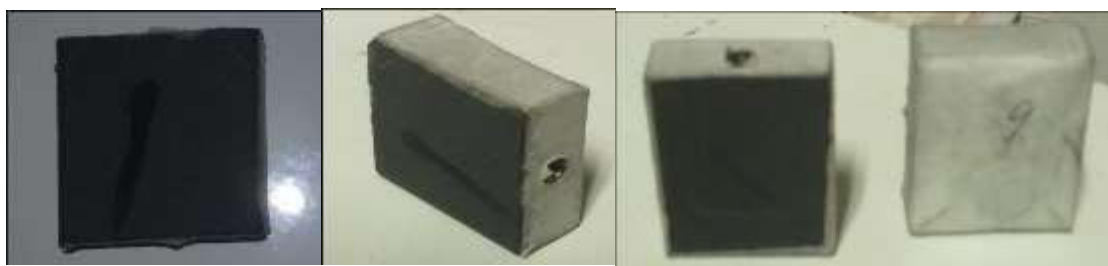


Fig.Schematic diagram showing Coated Specimen

Slurry Preparation: A representative slurry will be prepared with abrasive particles suspended in a carrier fluid. The particle size, concentration, and composition of the slurry will be chosen to simulate the erosive conditions encountered in specific industrial applications.



Fig.Schematic diagram showing Slurry Erosion wear test

Erosion Testing: The coated samples will be subjected to slurry erosive wear testing using a suitable apparatus, such as a slurry pot tester. The testing parameters, including the impact velocity, impact angle, and exposure time, will be carefully controlled to simulate real-world operating conditions.

Wear Measurement: The wear volume loss and wear rate of the coated samples will be quantified using suitable techniques, such as profilometry or weight loss analysis. Surface characterization techniques, such as scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS), will be employed to examine the wear tracks and analyze the wear mechanisms.

Statistical Analysis: The experimental data will be statistically analyzed to identify significant factors affecting the erosive wear behavior of Inconel 718 coated Al6061. Regression analysis and analysis of variance (ANOVA) will be performed to determine the relationship between the wear performance and the various parameters.

V. RESULTS AND DISCUSSIONS

1. EFFECT OF PARTICLE SIZE:

TABLE 5.1 Effect of Particle Size for coated Al6061

Sl. No.	Speed in rpm	Sand concentration	Time in hrs	Particle size in μm	Wt loss in gms
1	1000	100 gm/lit	5	212	0.0029
2	1000	100 gm/lit	5	425	0.0037
3	1000	100gm/lit	5	600	0.0056

TABLE 5.2 Effect of Particle Size for uncoated Al6061

Sl. No.	Speed in rpm	Sand concentration	Time in hrs	Particle size in μm	Wt loss in gms
1	1000	100 gm/lit	5	212	0.0038
2	1000	100 gm/lit	5	425	0.0042
3	1000	100gm/lit	5	600	0.0065

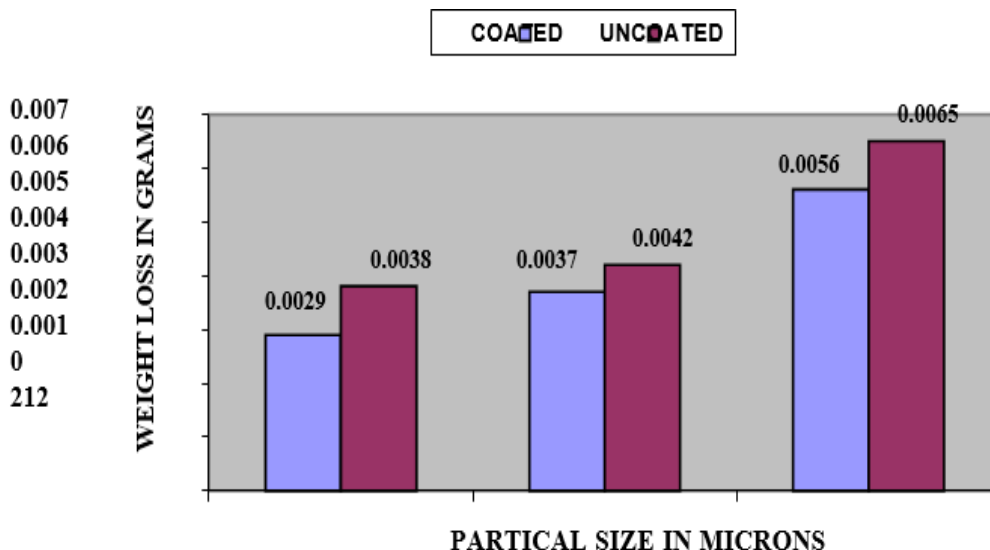


Fig 5.1 EFFECT OF PARTICLE SIZE

2. EFFECT OF SLURRY CONCENTRATION:

TABLE 5.3 Effect of Slurry Concentration for coated Al6061

Si No.	Speed in rpm	Sand concentration	Time in hrs	Particle size in μm	Wt loss in gms
1	1000	50 gm/lit	5	425	0.0032
2	1000	100 gm/lit	5	425	0.0046
3	1000	150 gm/lit	5	425	0.0055



TABLE 5.4 Effect of Slurry Concentration for uncoated Al6061

Sl.No.	Speed in rpm	Sand concentration	Time in hrs	Particle size in μm	Wt loss in gms
1	1000	50 gm/lit	2	300	0.0042
2	1000	100 gm/lit	2	300	0.0059
3	1000	150 gm/lit	2	300	0.0063

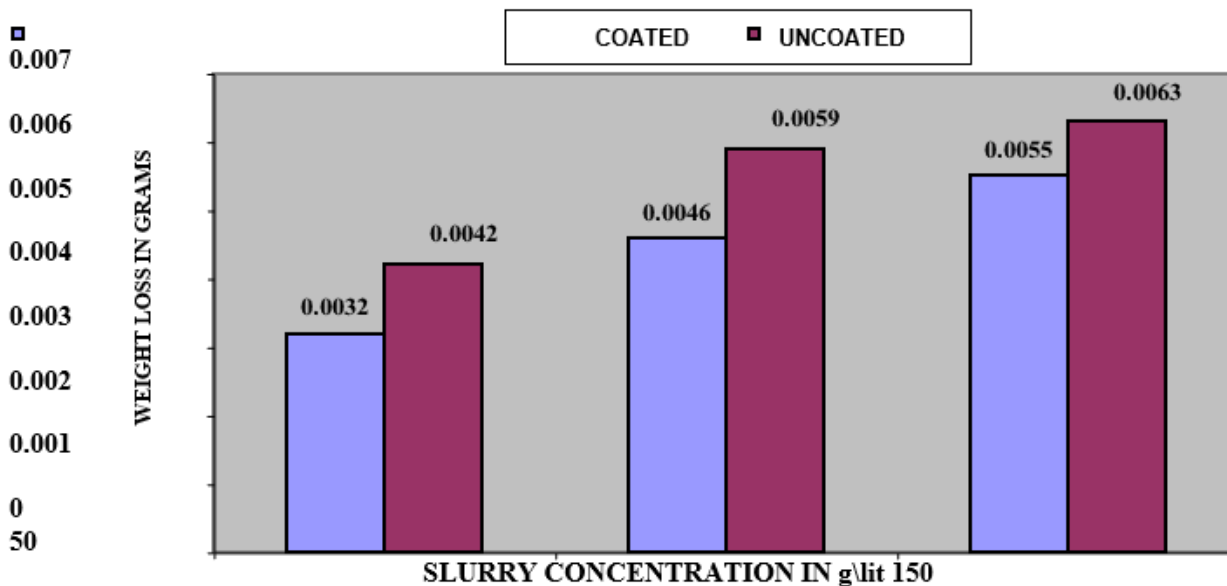


Fig 5.2 EFFECT OF SLURRY CONCENTRATION

3. EFFECT OF SPEED:

TABLE 5.5 Effect of Speed for coated Al6061

Sl.No.	Speed in rpm	Sand concentration	Time in hrs	Particle size in μm	Wt loss in gms
1	500	100 gm/lit	2	425	0.0010
2	1000	100 gm/lit	2	425	0.0056
3	1500	100 gm/lit	2	425	0.0066

TABLE 5.6 Effect of Speed for uncoated Al6061

Sl. No.	Speed in rpm	Sand concentration	Time in hrs	Particle size in μm	Wt loss in gms
1	500	100 gm/lit	2	425	0.0032
2	1000	100 gm/lit	2	425	0.0068
3	1500	100 gm/lit	2	425	0.0074

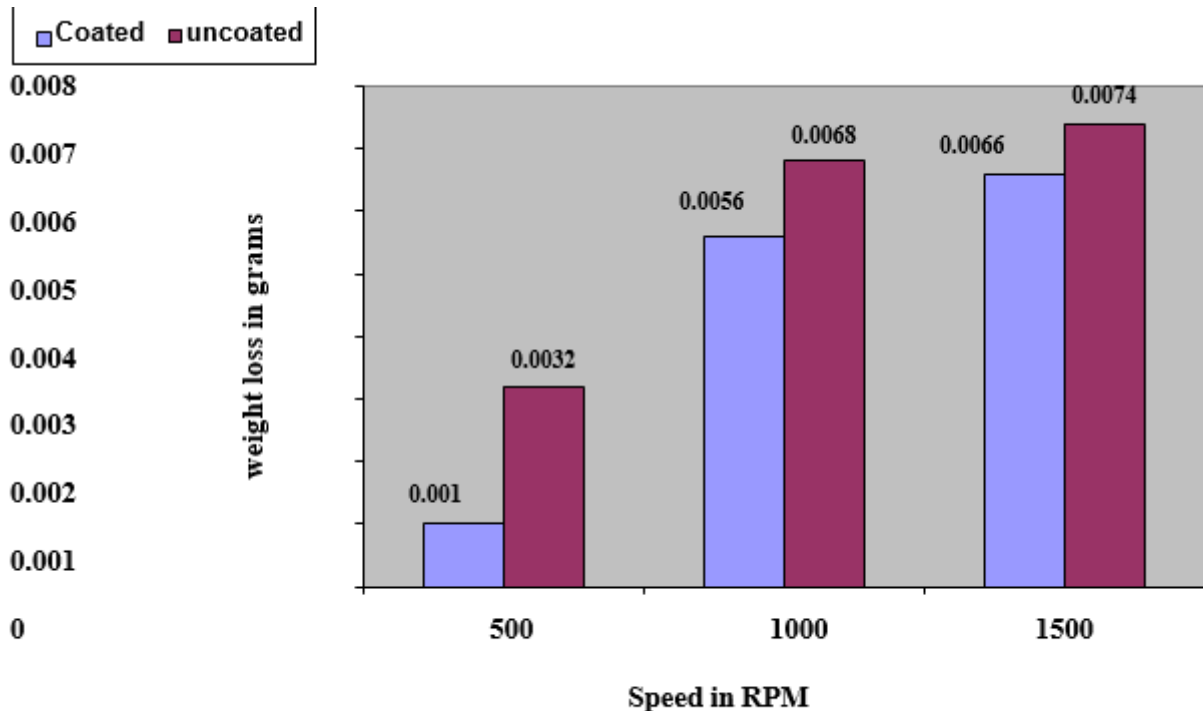


Fig 5.3 EFFECT OF SPEED

The slurry erosion wear rate of Al6061 coated with Inconel 718 with different speed of silica slurry rotation at constant time duration and slurry concentration is shown in fig 5.2 It is observed that increased speed of slurry rotation results in marginal increased mass loss for both uncoated and Inconel-718 coated Al6061. However the developed coatings exhibited a significantly reduced mass loss when compared with Al6061.

VI. CONCLUSIONS

The primary objective of the present work is to study the influence of Inconel 718 coatings on slurry erosive wear characteristics of industrial material Al6061. From the present study following conclusions were drawn;

1. Successful fabrication of Inconel 718 coatings is achieved on the surface of Al6061 substrates using plasma spray coating technique.
2. Slurry erosive wear tests conducted on the coatings revealed that with the increasing speed (500 to 1500 rpm), particle size (212 μm to 600 μm) and slurry concentration (50 to 150 gm/litre) the mass loss is found to increase.
3. Post slurry wear test, the worn surface analysis showed the formation of cracks and erosion of the coatings due to increasing speed and abrasive size which is mainly due to the high impact velocity of the abrasive particles. Further, coated and uncoated surfaces were characterized by plastic deformation, cracks, pits, wear debris, grooves, scratches and wear tracks.

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