# Application of Waste Fly Ash on Metal Substrates by Plasma Spraying Technique to Improve the Wear Resistance

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## Abstract

Emerging portable applications and the rapid advancement of technology have posed rigorous challenges to Metallurgical engineers for development of an efficient material which can sustain for long period at any type of environment. The foremost objectives are to develop required surface properties with economical process. Now-a-days the investigation explores the coating potential of industrial wastes. Fly-ash emerges as a major waste of thermal power plants.

Plasma spraying is gaining acceptance for development of quality coatings of various materials on a wide range of substrates. Utilization of such kind of industrial waste as coating material minimizes the cost of plasma spray coating deposition, which posed to be the major hindrance to its wide spread application due to high cost of the spray grade powders.

Fly-ash+quartz+illmenite composite mixture can be used as a potential coating material suitable for depositing plasma spray coating. It also opens up a new pathway for value added utilization of this industrial waste and low-grade ore mineral.

## Keywords

Plasma spray, Fly ash, wear resistance.

## Introduction

Currently emerging technologies contains some of the most prominent ongoing developments, advances, and innovations in various engineering field to improve surface property by using different type of modern technology. Because for higher efficiency and productivity across the entire spectrum of engineering and manufacturing industries has ensured that most modern day components are subjected to increasingly harsh environments during routine operation. Critical industrial components are, therefore, prone to more rapid degradation as the parts fail to withstand the rigors of aggressive operating conditions and this has been taking a heavy toll of industry's economy.

Treatment of Surface is an established provider of advanced materials processing and coating technologies for a wide range of applications in the automotive, Aerospace, Oil & Gas, Semiconductor, missile, power, electronic, biomedical, textile, petroleum, petrochemical, chemical, steel, power, cement, machine tools, construction industries. The development of a suitable high performance coating on a component fabricated using an appropriate higher mechanical strength metal/alloy, offers a promising method of meeting both the bulk and surface property requirements of virtually all imagined applications. A protective coating is deposited as a barrier between component's surfaces and the aggressive environment that it is exposed to during operation is now globally acknowledged to be an attractive means to significantly hinder damage to the actual component by acting as the first line of defence. Along with the traditional one, the newer surfacing techniques are eminently suited to modify a wide range of engineering properties. There are several properties that can be modified by adopting the surface engineering approach include tribological, mechanical, thermo-mechanical, electrochemical, electrical, electronic, magnetic/acoustic and biocompatible, optical properties.

During the last decade, a large number of investigations have been carried out for new development of plasma spray coating material by using industrial waste and low-grade ore [1]. Fly ash is a finely divided powder generated as a solid waste in huge quantities in thermal power plants. A small fraction of fly ash is used in the development of high value products. New ways of utilizing fly ash are being explored in order to minimize the plant wastage and provide a safeguard to the environment. Fly ash is a fine powder which can be used as refractory material in industry. Now-a-days fly ash composite has a number of useful applications [2]. However, increase in the demand of its applications; have led to the development of new fly-ash composite coatings. Fly-ash composite coatings, such as fly-ash+redmud and fly-ash+zinc coatings , fly-ash+jute-polymer [3], fly-ash+ Na-geo polymer [4], fly ash+illmenite [5], fly-ash+quartz [6], have been studied. According to recent investigations composite fly-ash coatings can obtain high corrosion resistant, in addition to increased wear resistance.

## Literature Review

In the early 1900s, M.U. Schoop was the first scientist to explore the possibility that a stream of metallic particles formed from molten metal might be used to produce coatings. But the thermal spraying technologies expanded in the 1970s due to development of thermal plasmas, and the increasing demand of high temperature and wear resistant materials and coating systems[7]. In the 1990s thermal spraying was demandingly available and had become a standard tool for improving surfaces in about all industries. Thermal spraying is the application of a material (consumable) to a substrate by melting into droplets and impinging the softened or molten droplets on a substrate to form a continuous/ pulsed coating [8]. Thermal spray consumables can be metallic, ceramic, alloys or polymeric substances. Any material can be sprayed as long as it can be melted by the heat source employed and does not undergo degradation during heating [9].

## Materials to be used

Fly ash of 60 weight percentage premixed with 20 weight percentage of quartz and 20 weight percentage of illmenite are mechanically milled in a FRITSCH-Planetary ball mill for 3 hours to get a homogenized product. There are 4 numbers of zirconia balls of 20gm and 20 numbers of zirconium balls of 2gm present in the planetary ball mill. The powders obtained were sieved by the help of a Roto-Tap Sieve Shaker Machine by using Laboratory test sieves (ISOR565).

Two Commercially available metal: Mild Steel and Copper have been chosen as substrate materials. These substrates were circular disc having dimension of 1 inch diameter and 3mm thickness. The specimens were grit blasted at a pressure of 3 kg/cm2 using alumina grits (grit size of 60). Stand-off-distance was kept between 120-150 mm for blasting. Surface roughness of the substrates was approximately 5 Ra. The grit blasted specimen surface was cleaned with acetone in an ultrasonic cleaning unit. Plasma spraying was immediately carried out after cleaning.

In plasma torch input power level was varied from 11kW to 21 kW, by controlling the gas flow rate, voltage and the arc current. The powder injection was external from the nozzle and directed towards the plasma. Argon and hydrogen plasma mixture gas used as carrier gas. The powder feed rate of 15 gm/min was kept constant, using a turntable type volumetric powder feeder. A four stage closed-looped centrifugal pump (water cooling) used for cooling the system, regulated at a pressure of $10kg/cm^2$ supply.

## Conclusion

In this investigation, it is found that the adhesion strength increases up to a certain limit (i.e. up to 18kW) then further increasing in power level there is no significant change in adhesion strength. Same observation also seen in case of deposition efficiency. This is a measure of the amount of material deposited per unit surface area. It is observed that the coating thickness acquires a maximum at 15 kW input power and then decreases. The porosity in the coatings is also found to be maximum at nearly same input power level. The increased amount of porosity in case of low and high power levels may be the cause of low adhesion strength. Variation of coating hardness with power level reveals that, there might be formation/transformation of allotropic forms and their compositional variations during spray deposition.

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