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A Review on Plasma Spray Coatings and its characterization

Lachake Harshad Sanjay[1], Prof. Bhamre V.G.[2], Prof. Londhe B.C.[3]Prof. Ghodake A.P.[4]

[1]PG Student (DesignEngg.), SavitribaiPhule Pune University, SND COE & RC Yeola, Maharashtra, India
[2]HOD, Dept. of Mechanical Engineering, SND COE & RC Yeola, Maharashtra, India
Associate Professor, Dept. of Mechanical Engineering, SND COE & RC Yeola, Maharashtra, India

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Abstract- *Plasma spraying coating technique is a area of research in many areas of applications because of its surface properties. This review elaborates surface property of plasma sprayed mild steel. Here minerals (i.e. Chrome Oxide + illmenite + quartz), used as materials which is to be coated on mild steel samples. The main objectives are to improve various surface properties by low cost process.*

Chrome oxide mixed with illmenite and quartz are providing good protection against erosion and abrasive wear. Chrome oxide + quartz + illmenite (weight ratio: 40:30:30) is coated on m.s. samples by plasma spraying and after that characterization of the coatings is carried out.

Key Words: ***Plasma Spraying, Surface properties, substrates, erosion, abrasive wear,***

1. INTRODUCTION

Plasma spray is a process by which the powders of metallic/non-metallic materials are melted and sprayed them onto a sample. The process is used to apply protective coatings on components to protect the materials from corrosion, wear, and high temperatures. Coatings having thickness between 200-250 micron is used for number of applications. A major task in formation of plasma coating technology is to meet the requirement for new materials to sustain in progressively more sever operating conditions.

It utilizes the properties of plasma medium to affect physical, chemical or metallurgical reactions to produce new functional properties to m.s. materials. The chemical analysis of a mixture of chrome oxide, quartz and illmenite shows that major constituent are iron oxide (Fe3O4), titanium oxide (TiO2), Silicon oxide (SiO2), aluminum oxide (Al2O3) etc. As all these are metal oxides, the mixture of chrome oxide+quartz+illmenite can possibly be coated on m.s. samples. Since chrome oxide, quartz and illmenite are plenty available from low grade ore, the cost is very low. Present study focuses on development of plasma spray coating on m.s. samples using these materials. A mixture of chrome oxide+ Quartz+ illmenite is used for coating on Mild steel samples.

The mixture is plasma sprayed at different operating input power level from 30 to 40 Kw. Deposition efficiency is evaluated for the deposited coatings. Hardness measurement is carried out on the polished cross section of the samples. Coating thickness is measured on the polished cross-sections of the samples using digital elco meter.

Coating surface & interface morphology is studied with Scanning Electron Microscope. Erosion wear behaviours of these coatings are studied by "Air Jet Erosion Test Rig".

2. LITERATURE REVIEWS

2.1. Problem Statement

Wear is the process of removal of material from one or both of two solid surfaces in solid-state contact. It occurs when solid surfaces are in sliding or rolling motion relative to each other. In a well-designed tribological system, the removal of material is a very slow process, but it is continuous. Similar to friction, the wear behavior of a material is also a very complicated phenomenon in which various mechanisms and factors are involved.

Several type of wear phenomena occur. It is necessary to experimentally evaluate and measure the corresponding friction and wear. The test to be carried out under different operating conditions and under controlled conditions. With a view to generate new performance data, we have chosen Minerals. Experiments are to be carried out on standard erosion tester machine, at room temperature and under dry operating condition.

Therefore, the purpose of this work is to determine the erosion wear. The surface of Mild steel in air is covered with oxide film. M.s. is susceptible to localized corrosion and erosion in atmosphere. In the presence of chloride ions, the corrosion of mild steel increases significantly, the protective properties of a passive/oxide film at the surface of mild steel is drastically reduced, which results in damage of surface.

2.2 Objectives of Research

1. The objectives of the present investigation/ experiment are as follows:
2. To explore the coating potential of chrome oxide + quartz +illmenite on m.s. samples by plasma spraying.
3. To develop plasma sprayed coating from chrome oxide +quartz+illmenite on metal samples and to find out surface hardness, coating thickness and wear properties etc.
4. Micro-structural characterization (surface and interface morphology) to evaluate the soundness of the coatings.
5. Measurement of hardness of the coatings.
6. Sustainability of the coatings against erosion wear with solid particle erosion test.

To analyze the experimental results using some statistical techniques so as to identify the factors/interaction parameter set by which one can get better plasma surface property.

3. METHODOLOGY

3.1. Introduction

This chapter explains about procedure of different experimental processes used to prepare the coatings and to characterize. Before preparation of coating, some basic process required for substrate material i.e. size measurement of coating powder, Grit blasting & cleaning of substrate. After plasma spraying, the coated materials have been subjected to a series of characterization test i.e. micro structural characterization of the surfaces and micro structural characterization of substrate-coating interface,

3.2. Development Of Coatings

3.2.1. Preparation of Powder

This chapter deals about procedure of different experimental processes used to prepare the coatings and to characterize. Before preparation of coating, some basic process required for substrate material i.e. size measurement of coating powder, Grit blasting & cleaning of substrate. After plasma spraying, the coated materials are subjected to a series of characterization test i.e. microstructural characterization of the surfaces and microstructural characterization of substrate-coating interface,

3.2.2. Preparation of Substrate

The commercially available metal M.S. has been chosen as substrate material. The substrate was circular disc having dimension of 150 mm dia. and 8mm thickness. The specimens were sand blasted at a pressure of 5 kg/cm2 using grits (grit size of 60). Surface roughness of the substrates was approximately 5 Ra. Plasma spraying was immediately carried out after cleaning.

3.2.3. Plasma Spray Coating Deposition

The plasma spray coating will be carried out at plasma spray processors, Mumbai. 80kW DC non-transferred arc mode Conventional atmospheric plasma spray (APS) set up will be used.

In plasma torch input power level will be varied from 30kW to 40 kW, by adjusting the voltage and the arc current. The powder injection is from the nozzle and aim towards the plasma. Argon and hydrogen plasma mixture gas will be used as carrier gas. The powder feed rate of 38 gm/min is kept constant. The typical arrangement of the plasma spray equipment and schematic of the process are shown in Fig 1.The equipment consists of the following units:

1. Plasma spraying equipment
2. Control console
3. Powder feeder
4. Power supply
5. stand-off-distance of torch
6. Torch cooling system (water)
7. carrier gas supply
8. Hoses, cables, gas cylinders and accessories

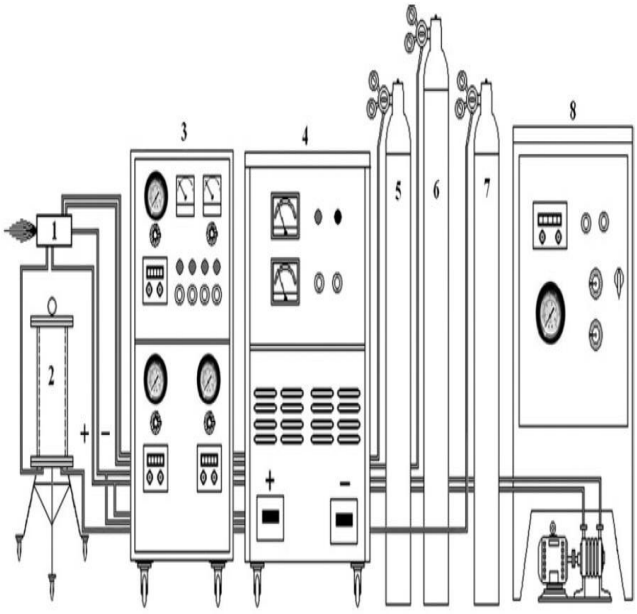

Fig-1 General Arrangement of Plasma Spraying Equipment

Table -1: Operating Parameters During Coating Deposition

Sr. No	Operating parameters	Values
1	Plasma arc current(amp)	500
2	Arc voltage (volt)	60,70,80
3	Torch input power(kW)	30,35,40
4	Plasma gas(argon) flow rate(IPM)	80
5	Secondary gas(N2) flow rate(IPM)	15
6	Carrier gas(Ar) flow rate(IPM)	37
7	Powder feed rate (gm/min)	38
8	Torch to base distance(TBD)(mm)	100

3.3.Characterization of Coatings

3.3.1. Scanning Electron Microscopic Studies

By using scanning electron microscope (SEM), microstructure of raw powder and plasma sprayed coated specimens will be study. The surface morphology as well as the coating-substrate interface morphology of all coatings will be observed under the microscope. Here SEM mostly using the secondary electron imaging

3.3.2. Evaluation of Coating Deposition Efficiency,

Deposition efficiency can be defined as the ratio of the weight of coating deposited on the substrate to the weight of the expended feedstock. Weighing method is used to measure this. Specimen weighing was done by using a precision electronic balance with ±0.1 mg accuracy. Each specimen has been weighted before and after coating deposition. Gc known as the difference is the weight of coating deposited on the substrate.
Gp is the weight of expended feedstock which can be calculated from the powder feed rate and time of deposition. The deposition efficiency is then calculated using the equation

$$\eta=(Gc/GP) \times 100\ \%$$

3.3.3 Coating Thickness Measurement

To measure the thickness of coated material on the substrate, specimen cross section will be measured using an elco meter. We will take five readings on each specimen and the average value is report as the coating thickness.

3.3.4. Hardness Measurement

After coating has been done samples were transversally sliced to form small specimens which containing coating deposition. Coating cross-sections were mounted and polished. Vickers hardness tester with a load of 5 Kg and a loading time of 20 seconds will be carried out.

We will take about four or more readings on each sample and the average value is report as the data point.

3.4. Erosion Wear Behaviour of Coatings

Solid particle erosion is usually carried by following methods: one is “sand blast” process where particles impacted onto a stationary target and are carried in an air flow and the second one is “whirling arm” process where through a chamber of falling particles in which the target is spun.

In the present investigation we will use sand blast type erosion apparatus with angular erodent (Fig 2). The test will be conducted as per ASTM. Erosion Test will be carried out with varying particle sizes, velocities, incidence angles, and particles fluxes in order to generate quantitative data on materials and to study the mechanisms of damage.

Fig-2 General Erosion Test Rig Set Up.

In this work, the jet erosion test rig we will be use whose schematic diagram shown in Fig.3 employs a 350 mm long nozzle and 3 mm bore. The mass flow rate will be measure by conventional method. Particles will be feed from a simple hopper under gravity into the groove. The measurement of velocity of impact will be carried out using double disc method. The wide range of particle types can be used in the testing, allowing better simulations of real erosion conditions.

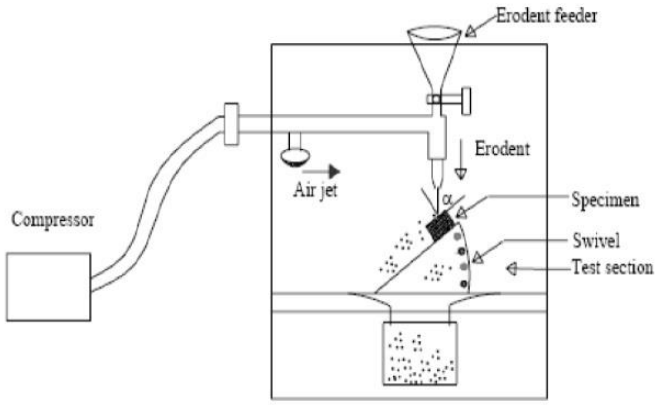

Fig- 3 Schematic Diagram Of Erosion Test Rig.

Some of the type of this test set up is:

1. Different nozzles may be accommodated: provide stability to change the particle plume dimensions and velocity range.
2. Vertical traverse for the nozzle: provide nozzle with variable to target stand-off-distance, hence influencing the size of the eroded area.

The angle of impact of the particles of the material can be changed in the range of 0°-90° and this will influence the erosion process. The erosion wear test will be carried out by varying angles (i.e. at 45°, 60°, 90°), standoff distance (100 mm t0 140 mm), pressure (3 bar to 5 bar), time (60 sec to 180 sec). The erosion wear rates will be obtained with silicon carbide erodent of 130 µm size. Erosion rate defined as the coating mass loss per unit erodent mass was calculated.

4. ADVANTAGES

1. Better technique for coating of any shape.
2. It increases life-time of wearing part by 6-7 years.
3. We can use various type of materials (metal or ceramic).
4. Improves upon the materials inherent susceptibility to wear and oxidation.
5. Improve wear resistance capacity.
6. Increase life of material.
7. Increase tribological properties of materials.

5. SUMMARY

1. The main aim or objective of this research is to increase the tribological properties of the substrate material i.e. Mild steel. M. S. is a commercially low cost and widely used material.
2. This material was chosen because of the attractive properties it exhibits and because this grade of M.S. is very cheap compared to the other grades of steel.
1. Chrome oxide may be eminently coatable on M.S. samples when mixed with quartz and illmenite, the low grade mineral ore, employing atmospheric plasma spraying technique.
2. Such coatings possess potential coating characteristics such as good hardness, adhesion strength, etc.
3. If the properties of Mild steel can be improved adequately then it can be used as a replacement for the more expensive grades that are currently widely used.
4. The main task of this study is to develop Mild steel substrate materials. It's very difficult due to plasma coating introduced in this process. It's also difficult due to difference in melting points of base material and coating material.
5. This process will improve wear resistance and corrosion resistance properties capacity of material against external effects

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BIOGRAPHIES

Mr.LachakeHarshad Sanjay.
harshadlachake18@gmail.com
BE Mechanical
Sandip foundation's SIEM, Nasik (PUNE)
ME Design
SND COE & RC Yeola (PUNE)

Prof. Bhamre V.G.
PhD
G.H. Raisoni institute, Nagpur

Asso. Prof. Londhe B.C.
PhD "Thermal Engineering"
KL University, Vijaywada.

Asst. Prof. Ghodake A.P.
BE Mechanical & ME Design
SND COE & RC Yeola (PUNE)