Wear Characteristics of Thermally Sprayed Nickel Coatings

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Abstract: In present research work Nickel based alloy was deposited on Stainless Steel SS-316L using HVOF technique. Deposited coating has a thickness of 250 µm. The developed layer on the substrate was analyzed through several testing techniques include mechanical characterization by Vickers hardness test and wear resistance test on Pin-on disc apparatus according to ASTM -G99 standard. Further micro structural characterization was made using Scanning Electron Microscopy technique and it has shown proper bonding between powder and substrate. Coating showed excellent results in terms of hardness and wear resistance as compared to base material SS-316L.

Index Terms: Minimum Nickel, Thermal spray, Microhardness, Abrasive wear.

1. INTRODUCTION

The mechanical failure of construction elements in high-temperature applications can be due to interaction of the environment with the material, resulting in loss of protection and subsequent accelerated degradation, or to accidental overheating due to poor process control[1-2]. That’s why the materials used for high temperature applications need to be protected from corrosion and other forms of high temperature degradations such as erosion-corrosion[3-4]. Although there are several countermeasures to combat these high temperature problems, yet thermal spraying is one of the promising and industrial viable solutions to such problems[5-6]. The need for today and tomorrow is to gain a fundamental understanding of the phenomenon which governs the complex thermal spray techniques. Now the things have changed, and it is important to note that there is a worldwide excitement about the future possibilities of thermal sprays. These wear and corrosion related problems can be minimized mostly by following two methods: - The use of costly materials instead of low carbon steels. The increase in corrosion properties.

2. EXPERIMENTAL PROCEDURE

In this study, cast iron was selected as a substrate material. This material was purchased from Rukmani Ferrous Industries Limited, Coimbatore, Tamil Nadu. The main reason for the selection of this material is its use in engineering applications especially like machine tools such as lathe machine, palner, drilling machines etc. The material was obtained after cutting on Wire-cut EDM (Electro Discharge Machining). The substrate size was taken as 20mm x 20mm x 5mm for SEM analysis and micro hardness whereas for wear test pins were taken of 10 mm in diameter with 30 mm length as shown in figure 1.

Substrate was properly cleaned using acetone to ensure its surface free from any dust particles present on the surface before coating process. The specimen required for hardness testing was properly polished to get the hardness measurements. The chemical composition of the powder used include elements as Nickel+Cobalt-55%, Iron-19%, Chromium-19%, Niobium-3 % and Titanium-3% and Molybdenum-3%. On the other hand the pins were ground and polished before coating process. Composition of the substrate is shown in table 1. X-Ray Diffraction (XRD) of coating powder is shown in figure 1 which indicates the presence of nickel and chromium as a major element in the coating powder along with cobalt and iron.

3. DEPOSITION OF POWDER HIGH VELOCITY OXY-FUEL COATING

In this study coating powder was deposited using HVOF at M/S Mettalurizing Technology Limited, Jodhpur, India. Samples were initially prepared by cutting with Wire cut EDM process and pins were prepared in lathe machine for wear test.

After this process, the samples were ground using different emery papers grade followed by shot blasting process for some roughness around 5 microns. This was to confirm the mechanical bonding of powder to the substrate. Table 2 showing the various process parameters for depositing the powder by HVOF gun.

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<th>Table 2. Process parameters of coating</th>
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4. RESULTS AND ANALYSIS

4.1. MICRO HARDNESS ANALYSIS
A micro hardness test was performed for coated and uncoated substrates. Vickers hardness with load of 50g load for a dwell period of 20 seconds was used and average reading of 10 indentations was recorded. Each indentation was taken at a distance of 50 microns. The hardness of substrate was found to be 210 Hv and for the coat it was 378 Hv which is significantly high compared to substrate as shown in figure 2.

![Micro hardness of substrate and coated SS-316L](image)

4.2. SLIDING WEAR STUDY ON PIN-ON DISC APPARATUS
Wear analysis was done using Pin-on disc test according to ASTM-G99 standard. Substrates having 10mm diameter and 30 mm length were selected for wear study. These substrates were initially ground and polished before wear testing. Weight loss was calculated for both coated and uncoated substrates after 6 intervals consisted of 90 minutes cycle. It was calculated from the weight loss analysis that coated samples lost 0.2 grams material whereas the uncoated samples lost 0.6 grams material after complete cycle of 90 minutes. Therefore, the as sprayed samples showed high wear resistance as compared to substrate. The wear resistance resulted due to presence of nickel and chromium in the powder as a major element which forms some hard phases after the coating process and hence provides abrasion resistance.

4.3. SEM ANALYSIS
It can be clearly seen from the SEM micrograph shown in figure 4 that the powder is well bonded to the substrate material and is free from any crack and semi melted particles. Due to splats molten state coating formed has a lamellar structure and plastically deformed on the surface of the substrate. Proper bonding of the powder is due to the high velocity of the HVOF thermal spray coating process and resulted in coating free from any pores and cracks and during the high velocity oxy-fuel coating process the powder particles accelerated towards the workpiece with very high velocity of 900 m/sec and it approaches to even more than this velocity value and another factor is high temperature of powder particles due to combustion processing inside the combustion chamber of this apparatus. Both the high velocity and high temperature when carries a powder particle towards workpiece forms a layer by layer coating which is having good adhesion strength with each other and mechanical bonding.

The average particle of the powder is 45 microns showing in figure .3 the shape of the coating powder is spherical.

5. CONCLUSIONS
The powder was successfully deposited using High Velocity Oxy-fuel process on the substrate material and showed good mechanical bonding between powder and substrate. Mechanical characterization by micro hardness showed significant increase in high hardness of 378 Hv which resulted in less material loss in wear test due to presence of nickel and chromium as major elements in the coating powder. Pin-on disc sliding wear test showed the less weight loss of as sprayed substrates hence improved wear resistance for substrate material.

![SEM micrograph of coating powder](image)

![SEM micrograph of sprayed sample](image)

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REFERENCES


