Abrasive wear behaviour of thermal spray coatings

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ABSTRACT

In the current study, the thermal spray coated cast iron was analysed for the property and structure correlation. The high velocity oxy-fuel process was utilised for depositing the alloy poder on the cast iron. The mechanical properties of the coatings was characterised in order to have ides about the hardness and wear rate. The coatings deposited on the cast iron have a thickness of 250 microns. The Vickers hardness tester was utilised for having the hardness values and the deposited coating showed the hardness of 378 $Hv_{0.2}$. The hardness of the base material was founf to be 210 $Hv_{0.2}$. The abrasive wear test was used as per standard of ASTM-G99. The SEM analysis was used to have the microstrutural and property correlations.The microstructural study includes the structure of the powder used, coating and XRD analysis as well. The deposited coating showed th excellent adherence to the base material, thereby showed the good bond strength.

KEYWORDS *Nickel based alloy, Wear resistance and HVOF.*

I.INTRODUCTION

In many cases, a scale is created from corrosion products during exposure to high temperature resistant materials that protect the underlying metal from further attack[1-2]. If blistering, shear cracking or scale flaking impairs the integrity[3-4].That's why the materials used for high temperature applications need to protected from corrosion and other forms of high temperature degradations such as erosion-corrosion. 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 problem of wear is extensively found in the applications where the contact of one part of the component is with the other component exists. The sliding of the components resulted in the formation of craters and pits on the surface of theb materials under operation. The soft material like nickel ad chromium are used for the resisting the corrosion only. It even retains the required properties at higher temperatures. The use of these materials are restricted only for the corrosion applications. Other than the Ni and Cr as corrosion resistors, these elements can be utilised for resisting the wear in the mechanical components. Therefore, some hard particles in the form of reinforcement may be added to increase the capability of the material at the functional surface. The functional surface of the material thereby resists the wear due to embedment of the hard particles in the ductile material i.e the soft matrix. Other than the composite cotings, there are fewer other combinations available in the form of alloys, which significantly increases the wear resistance. The alloys can be beneficial in resisting the erosion and corrosion even at high temperatures as reported by many authors[7-8].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 [9-12].

II. 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-India*. 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. Initially the specimen were cast by using sand casting process, wherein the cast material was very rough from the surface. In order to reduce the surface roughness of the casts, the machining on the lathe machine was performed. The machined substarte then made thin with the help of shaper, where the required thickness of the material was achieved. The flat were obtained after the final step of the machining. The thickness of the casts were 5mm. 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 Molybedenum- 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.

Table 1. Chemical composition of the substrate

GRADE	C	Si	Mn	S	P	Fe
GREY CAST IRON	3.0-3.3	1.4-1.7	0.9	0.11	0.13	Bal.

III. 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.

IV.RESULTS AND ANALYSIS

IV. I 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 s compared to substrate as shown in figure 2.

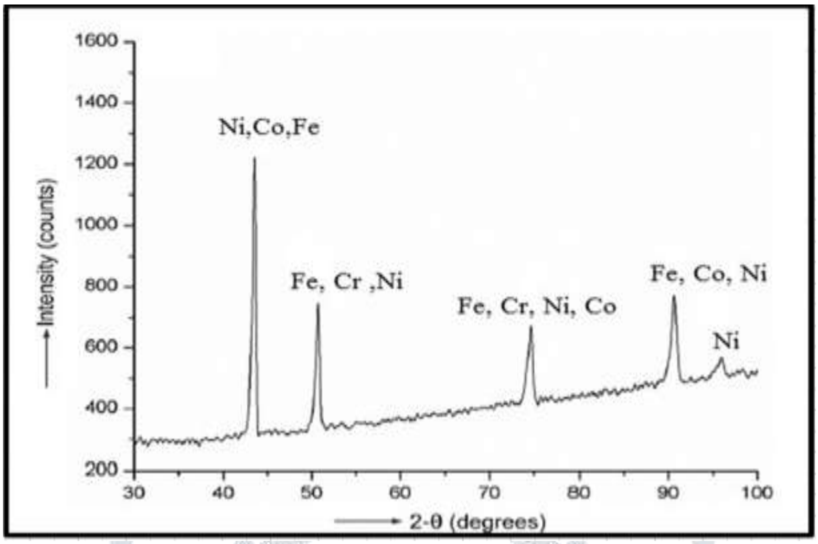

Fig.1. XRD image of Nickel based alloy powder showing various peaks

Table 2. Process parameters of coating

	Process Parametres	Values
1.	Spraying distance	250 mm
2.	Pressure of fuel	8.5 kg/cm^2
3.	Pressure of air	4.5 kg/cm^2
4.	Oxygen flow rate	300 LPM
5.	Oxygen pressure	7.0 kg/cm^2
6.	Air flow rate	800 LPM
7.	Powder feed rate	26 gm/min

V. SLIDING WEAR STUDY ON PIN-ON DISC APPARATUS

Wear analysis was done using 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 elements which forms some hard phases after the coating process and hence provides abrasion resistance.

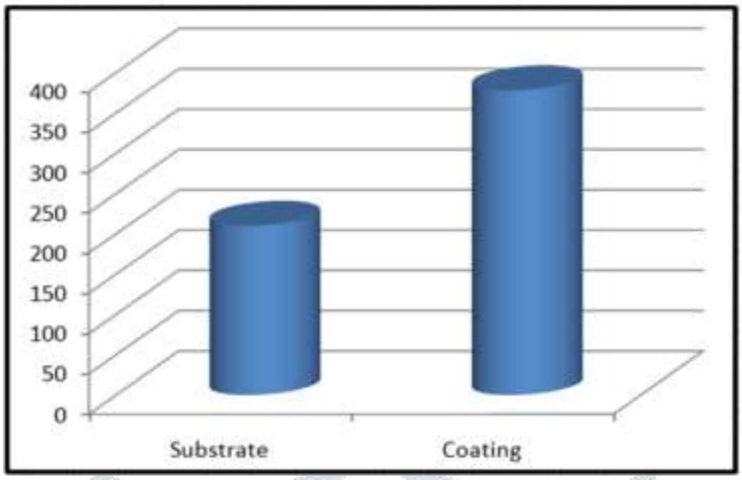

Fig.2. Micro hardness of substrate and coatded SS-316L

VI. 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 plasticslly 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 coting 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 . The average particle of the powder is 45 microns showing in figure .3 and it is clearly seen in this figure that the shape of the coating powder is spherical.

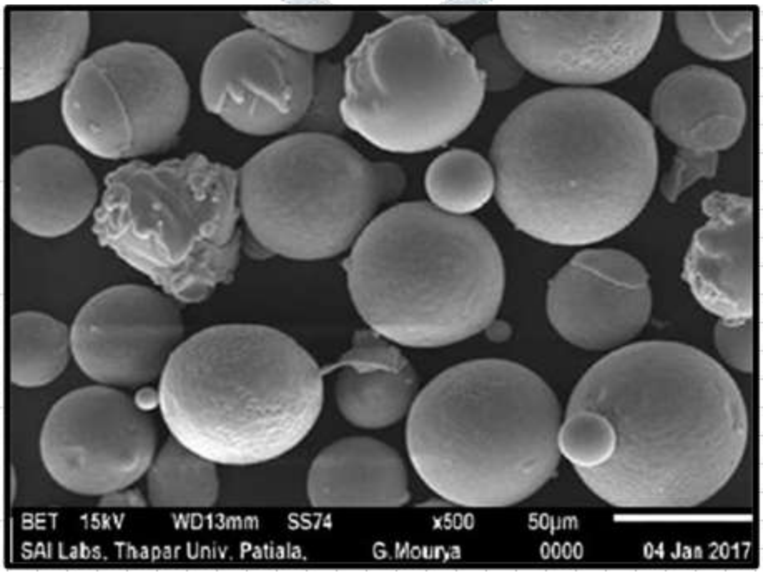

Fig.3 . SEM micrograph of coating powder

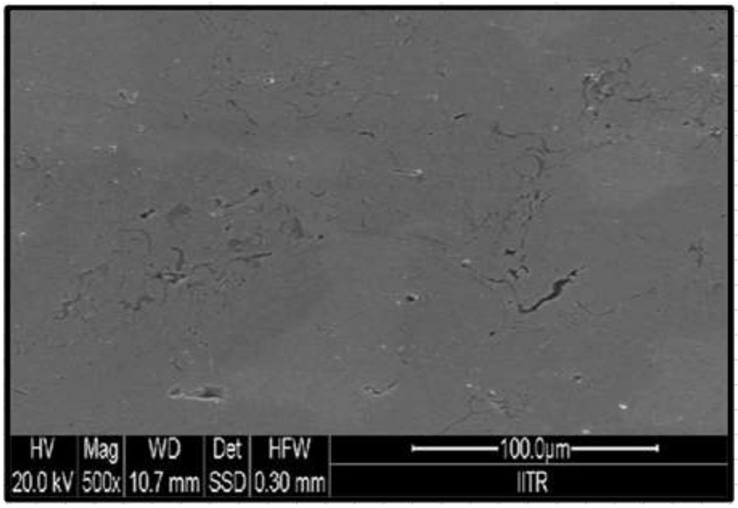

Fig.4 . SEM micrograph of sprayed sample

VII. CONCLUSIONS

- The powder was successfully deposited using HVOF process on the base material and showed good mechanical bonding between powder and substarte .
- Mechanical characterization by micro hardness showed significant increase in high hardness of 378Hv 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 micrographs showed well bonded interface and free from any semi melted particles and cracks and also less porosity is seen in the SEM micrograph.

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