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Comparison of Microstructural Characteristics of Plasma and HVOF Sprayed Ni-Cr/WC Coating

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Abstract: In this work, Ni-Cr/WC-Co composite coating was made on SS304 substrate using Plasma and HVOF thermal spray techniques. The main objective of this work is to compare the microstructural characteristics of Ni-Cr/WC-Co coating by both the techniques, since it combines the properties, *viz.* hardness and toughness. The microstructure & composition of powder and coatings were characterized using Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD). The coating characteristics like, micro-hardness, surface roughness and porosity were evaluated.The results show that HVOF coated samples having improved hardness over Plasma by 15% and a minimum porosity of 0.2%.
Keywords: Microstructural Characteristics,Plasma/ HVOF Sprayed Ni-Cr/WC Coating.

1. Introduction

Worldwide researches are going on in the field of protective coatings for applications like power plants, automobile, aerospace. Nickel-based alloys are more suitable for these applications alloys due to properties like hardness, porosity, adhesive and toughness. Specifically, Nickel-based alloys coatings, with high bonding strength, a better corrosion behavior, and excellent resistance to adhesive and abrasive wear, have promising applications in engineering [3]. Also carbide-based ceramic coatings are widely used for applications requiring abrasion, sliding, fretting and erosion resistance. These coatings have very high wear resistant due to their high hardness [4]. In particular tungsten carbide coatings show higher wear resistance at high temperatures [5].Development in the field of composites leads to the combination of Ni &WC.From the research results it indicates that Ni60 + 60%WC increasewear resistance from 5% to 10% than Ni45 + 45% WC when prepared under plasmathermal spray technique [6]. At high temperature Plain Ni-Cr coatings can form oxides. With addition of suitable carbide components like WC (40%) which improved the abrasive wear of the coating.

In the present work 60%Ni-Cr and 40%WC-Co by weight are blended and sprayed over the substrate material (SS304) usingHVOF and Plasma spray techniques. HVOF employs a high velocity spraying process for deposition of coating at high impact velocity ensuring pore free coating. Series of microstructural studies and particle distribution studies are carried out usingoptical microscope, SEM/EDS and XRD. Microstructure properties like Porosity, Hardness, surface roughness and residual stresses evaluated.

2. Experimental setup

2.1 Substrate Preparation

In this study, SS304 material with approximate dimensions of 25mm x 25mm x 5mm was used. The samples were polished using emery paper and subsequently grid blasted using alumina grit having grit size of 60 in order to improve the adhesion between substrate and coating. The average surface roughness was found to be approximately 6 microns.

2.2 Coating powder preparation

Commercially available powder Ni-Cr of particle size -53 to 20 µmwith chemicalcomposition of Ni-71.91,Cr-15.56, Fe-4.07, B-3.1, Si-4.16 and WC-Co of particle size -53 to 20 µm with chemical composition of W-82.7, Co-11.8, C-5.48, Fe-0.02 were supplied by Spray-Met Bangalore. These powders were blended for 1h with a mixer in the ratio of 60% wt. Ni-Cr and 40% wt. WC-Co.

2.3 Coating Procedure

Both the coatings viz. HVOF and Plasma were made at Spray-Met Bangalore with the industrial standard spray guns. The parameters for both Plasma and HVOF coatings are shown in Table 1 and 2.

Table1. Plasma Parameters

Gun	3MB	
Nozzle	GH	
	Pressure (psi)	Flow (LPM)
Argon	100-120	80-90
Hydrogen	100	20-25
Current&Volt	490A& 60-70V	
Powder feed	30-40 gms/min	
Spray distance	2"-3"	

Table 2 HVOF Parameters

	Pressure (psi)	Flow (LPM)
Oxygen	160	30
Hydrogen	120	55
Powder feed	20 gms/min	
Spray distance	200 mm	

The coated samples of SS304 is then checked for the composition using XRD and the samples were characterized by microstructural study to evaluate porosity, micro-hardness,surface roughness, and residual stresses.

2.4 Characterization and morphology study

The particle sizes of the raw materials used for coating are characterized using Laser particle size analyzer (Make: Malvern Instruments). The morphology of the coating powder was evaluated using the scanning electron microscopy (Make: JEOL Model: 6701F). For cross section examination the samples were cut by using Abrasive wheel cutter and mounted in resin by using hot mounting press. Porosity (% area) was determined from micrographs with the aid of an image analyser (Make: Getner and Model: Inverto plan). The micro-hardness measurement were performed by (Make: LEITZ MINILOAD 2 Model: LEITZ WETZLAR) without the addition of etchant. The surfaceroughness of as- spayed sample was determined using stylus type surface roughness tester (Make: Mitutoyo, Model: SJ 201).

3. Results and Discussion

3.1 Phase constitution of Powder and Coatings

The X ray diffraction pattern for the surfaces of the HVOF and Plasma sprayed Ni-Cr/WC-Co coating shown in Fig.1.Surface of the HVOF coating (SEM / EDAX) shows the presence of weak intensity peaks indexed to W_2C phase regarded as a product of decarburization. However, the diffraction peaks of WC are relatively weaker in the case of plasma sprayed coating, which may be attributed to the incomplete coating of Ni.

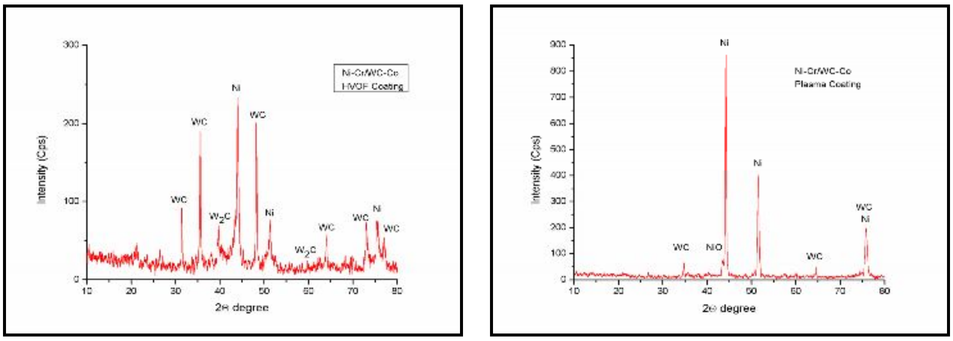

Fig1. XRD:- (a) HVOF (b) Plasma

3.2 Coating structure and Properties

The porosity measured along the cross sectional area using the image analyzing technique was found to be 0.2% in the case of HVOF. In plasma coating the obtained porosity value is 0.7%. The lower value of porosity obtained for HVOF is attributed to the higher flame velocity and lower flame temperature. The micro hardness value of the substrate was around 120-150 HV. The average hardness value of the HVOF coating was found to be 515 HV0.2 whereas for plasma coating, the hardness value was around 425 HV0.2. The improved hardness in HVOF technique is due to low porosity in the coating. The average surface roughness values of 7.9µ (HVOF) and 9.2µ (Plasma) are obtained. The reduced surface roughness in HVOF coated samples are due to the high velocity employed in the coating technique.

4. Conclusion

60Ni-Cr/40WC-Co composite coatings were produced by HVOF and Plasma thermal spraying techniques, Superior quality coatings were produced using HVOF technique compared to plasma due to the high velocity and low flame temperature employed. The hardness was improved by 15% in HVOF coatings compared to Plasma with a minimum porosity of 0.2%.

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