INVESTIGATION OF EROSION WEAR ON WC-CO COATED GUN METAL BRONZE USING THE SLURRY POT TESTER

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Abstract

The slurry erosion wear is the major problem in the fluid machineries and the hydro turbines where the erodent particles are carried with the fluid and these particles are impacted on the target surface and due to impact volume loss of material takes place. There are several methods are available to control the slurry erosion; however the surface coating using the thermal spraying is mostly used. In the present study, the WC-CO coating is used to reduce the erosion wear and used to improve the life span of the selected material (Gun Metal Bronze). The coating is applied in the substrate material with the help of the high velocity oxy fuel coating (HVOF). The experimentation on the slurry pot tester has been carried out to test the erosion wear. It is observed that the maximum erosion wear is at 15° impact angle and the minimum erosion wear is at 90° impact angle.

Keywords: *HVOF coating, Bronze IS 318, Slurry Erosion Wear, WC-CO Coating, Slurry Pot Tester.*

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1. INTRODUCTION

The wear is nothing but progressive lossvolume of material from target material. Slurry erosion wear is occurring due to the impact of the hard abrasive particles carried by the water. The slurry erosion is difficult to understand because it depends on many factors, which act simultaneously. Fig -1 shows these factors which include flow field parameters, properties of target material and erodent particle characteristics. Among these parameters, the orientation angle and the microstructure plays crucial role on the material removal process. The turbine blades, needles and nozzles in the hydraulic machineries, have tolerated the high speed water with or without the solid particle impingement, and hence they must have the excellent strength, toughness, and erosion wear resistance [1]. Due to the erodent particles which are flowing with the water will strike on the blade surface and the surface gets eroded, and due to which the turbine efficiency reduces and the life span of the turbine also reduces [2].

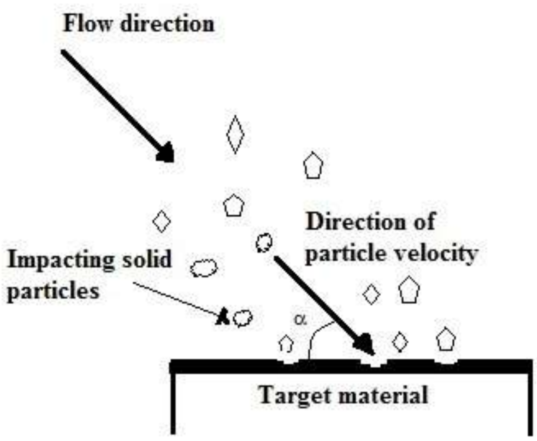

Fig -1: Erosion wear by solid particle impact.

In the present study, The Pump installed at "Dapora Pumping Station" at Village Dapora was dismantled and the impeller of the pump was examined with necked eyes to identify the probable cause of wear Fig -2. From the preliminary examination, it was observed that the impeller and casing of the pump was worm out due to impact of the solid particles. It was observed that the material from edges of the diffuser vanes of the impeller was worn out and deformed due to solid particles loading.

Fig -2: Worthington 5 Hp Vertical turbine impeller (Dapora, Jalgaon water supply station)

The thermal spaying technique is better than the other techniques. Which is most economical, desirable and useful. Hence it is good to make a choice of most suitable process. The erosion resistance of the impeller blade is used to enhance with the help of the High velocity oxy-fuel coating (HVOF). According to the various researchers it is seen that the hardness, strength and the wear resistance of WC-CO cermets is increases significantly by reducing the size of the carbide grains to nanometre scale. [3,4]. Nowadays, for various industrial applications, high velocity oxy fuel (HVOF) spray is being widely used is due to its ability to produce high quality coating with required hardness and low oxide content due to its high velocity impact inherent in the process. The porosity and hardness are the two important properties for wear and corrosion application [5,6].The WC-12CO cermet coating was more susceptible to erosion-corrosion damage than the aqueous slurry testing than was the WC-10Co-4Cr [7].The experimental results shows that the NiCrBSi sprayed coating exhibits a much better slurry erosion resistance than the SUS 304 stainless steel. With the help of the preliminary experiments the NiCrBSi can improve the service life of the needle and nozzles 3-4 times [1]. The Cr3C2-NiCr and the WC-Ni are widely used in the wear applications. It is noted that, Cr_3C_2-NiCr will give the better erosion- corrosion resistance than the WC-Ni [8].

2. EXPERIMENTAL PROGRAM

2.1 Experimental setup

The slurry pot tester used in the present work, was developed by the Desale (2005), the schematic diagram of slurry pot tester with dimensional details is presented in Fig-3. The pot of size [240 mm diameter and 155 mm height] made from AISI SS304 material. The vortex motion produced due to the rotation of the propeller is break with the help of 25 mm x 155 mm wall cylindrical pot. The hole of 20 mm diameter is provided at the bottom side of the pot in order to drain the slurry after each experiment. The acrylic sheet of 12 mm thickness is used for the visual observations. The AC motor shaft is coupled with the main shaft with the help of the love jaw coupling. The oil-seal of 10 mm diameter is provided at the bottom for the rotation of the propeller shaft. The 4 blade propeller is fixed on the shaft at the distance of 24 mm above the bottom and rotated with the help of DC motor. The wear specimens are rotated at desired speeds by AC motor. At the bottom end of the shaft the 30 mm x 25 mm brass sleeve is provided for fixing the two horizontal arms to hold the two text fixtures at diametrically opposite ends.

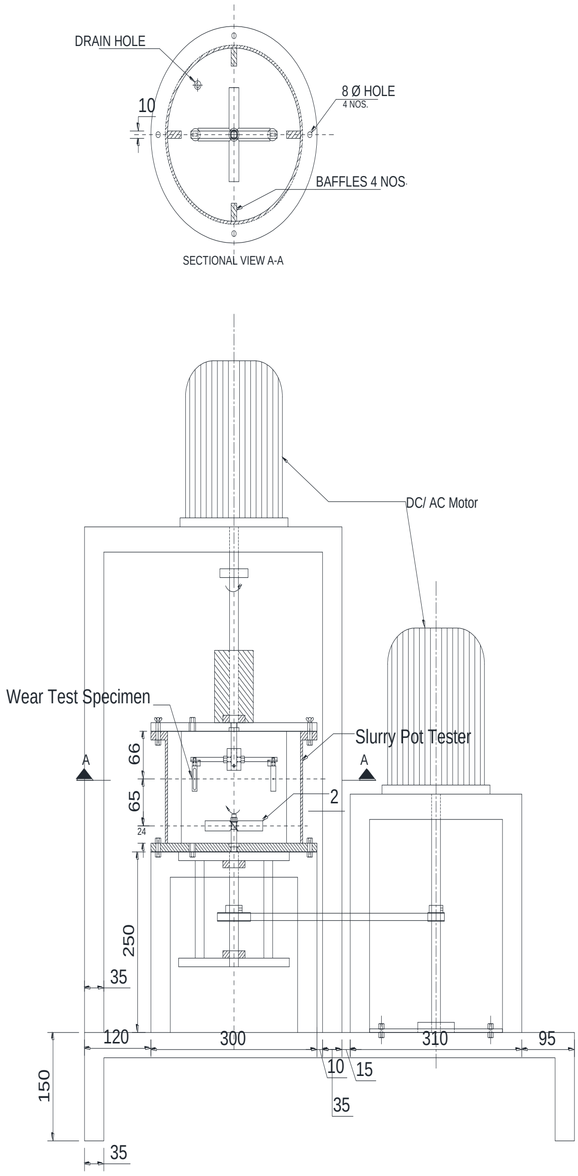

Fig -3:Schematic diagram of Slurry pot tester.

2.2 Properties of materials used

In the present study, Worthington 5 Hp Vertical turbine impeller made of the gun metal bronze is used as a substrate material. The WC-CO powder is used for HVOF coating on the substrate. The erosion wear experiments were conducted using the solid-liquid mixture of Quartz (IS Sand) with tap water.

2.2.1 Properties of targetmaterial

In the present study, Worthington 5 Hp Vertical turbine impeller made of the gun metal bronze is used as a substrate material. Fig.4 shows the vanes of the impeller which are cutting and the specimens were prepared from that material with the help of water jet cutting. The chemical composition of the material has been determined by using the optical emission spectrometer. The elemental composition of the target material is given in Table -1.

Fig -4: Bronze impeller blade

Table -1: Target Material Elemental Composition

Target Material	Elemental composition (wt. %)							
	Cu	Sn	Pb	Zn	Al	Ni	Sb	Fe
Bronze IS 318	85.50	5.25	4.26	4.25	0.003	0.43	0.15	0.10

2.2.2 Coating Deposition

In the present studycommercially available WC-CO powder was studied with regard to its slurry erosion resistance. The coating powder was deposited on the gun metal bronze sample at RMS Engineering Pune, India. Using a commercial HVOF thermal spray system. The compressed air jets is used to coolspecimens during and after spraying, before coating deposition; the specimens were sand blasted to enhance the surface roughness so as to obtain a good coating adhesion. The coating powder SEM image is shown in Fig -5. It is seen that the powder has the spherical in shape.

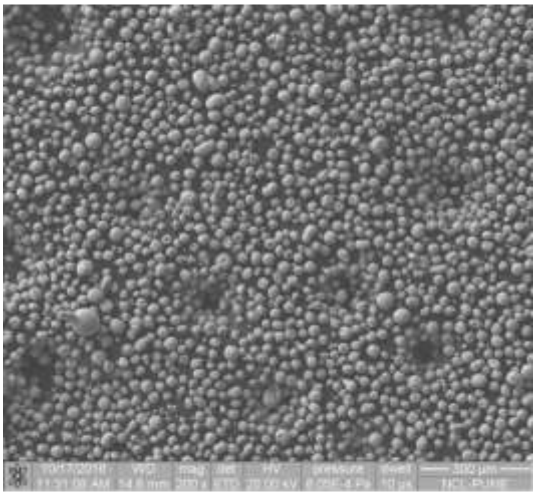

Fig -5: SEM image of WC-CO powder

2.2.3 Slurry

In the present study, quartz is used as the erodent particle, and this will be used with the water to become slurry. The mean particle size is 256 μm which is retained between the two sieves of 300 μm and 212 μm sizes. The Fig -6 shows the SEM micrograph of the erodent particle and the physical properties of the erodent is given in the Table -2.

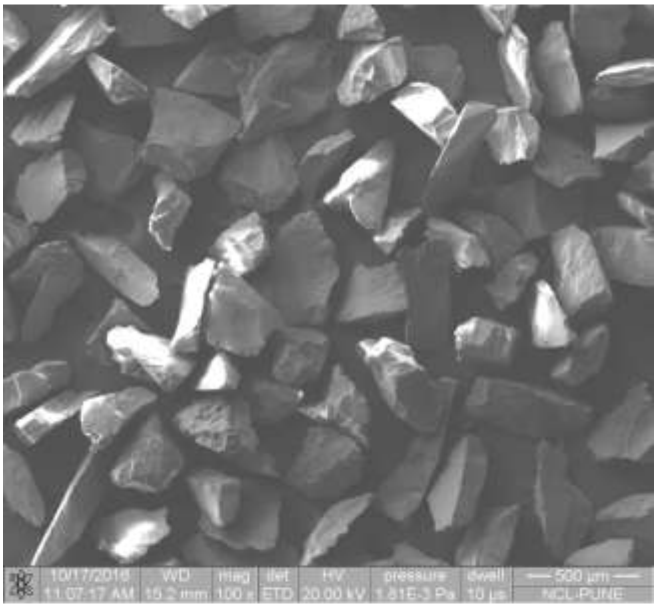

Fig -6: SEM micrograph of the erodent particle

Table -2: Erodent material Physical Properties

Solid particle	Chemical Formula	Colour	Sp. Gravity Kg/m^3	Hardness VHN	Particle Shape
Quartz (IS Sand)	SiO_2	Whitish	2652	1100	Blocky

3. CONTRIBUTION DUE TO DEFORMATION AND CUTTING WEAR

The theory proposed by the Bitter wassuggested that, the striking particle velocity components (Perpendicular and parallel) are responsible for cutting and deformation wear. Thus the deformation wear is calculated with the help of following relationship [10].

$$E_{D(\alpha)} = E_{D90}(\sin\alpha)^3 \quad (1)$$

Where, $E_{D(\alpha)}$ is the deformation wear at any impact angle and the E_{D90} is the deformation wear at the 90° impact angle at the similar experimental conditions. The cutting wear is nothing but the difference between the total wear and the deformation wear and this is presented in equation 2,

$$E_c = E_w – E_D \quad (2)$$

The variation of the deformation and the cutting wear due to the erodent particles is represented graphically in Fig -7. We generally assumed that the zero degree impact angles no wear is takes place [11, 12]. But the researcher Gandhi B.K [13] is explain that at zero degree impact angle some wear takes place due to the random impact of the particles.

From Fig-7 it is seen that cutting wear is decreases with the increase in orientation angle at reaching zero at 90° impact angle and the deformation wear is increases with increasing the orientation angle.

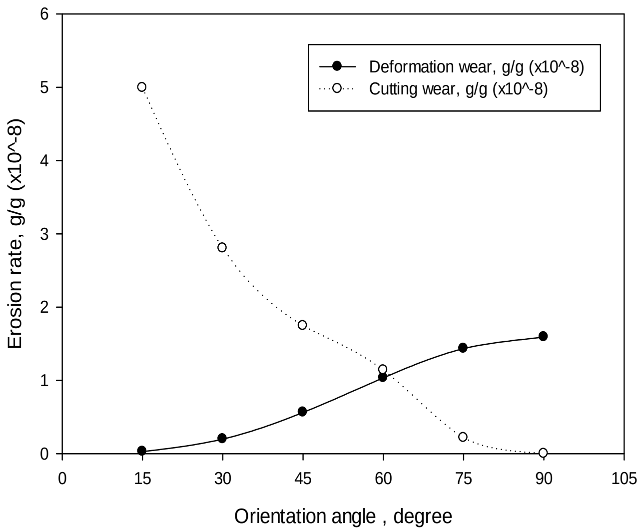

Fig -7: Variation in cutting and deformation wear of WC-COcoated substrate

4. RESULT AND DISCUSSION

In the present work, the erosion of the WC-CO coated gun metal bronze is to be studied. The slurry pot test rig is used for the experimentation. Further, Scanning Electron Microscope (SEM) is used to examine the eroded specimens in order to know material removal mechanism.

The erosion rate of WC-CO coated substrate material at the different impact angle in the slurry (quartz-water mixture) is shown in Fig -8. The experimental conditions at which the erosion rate is calculated are velocity(4.5 m/s), particle size (256µm) and weight concentration(10%). It is observed that, the erosion rate is maximum at the 15° orientation angle and goes decreasing as the impact angle decreases till 90°.

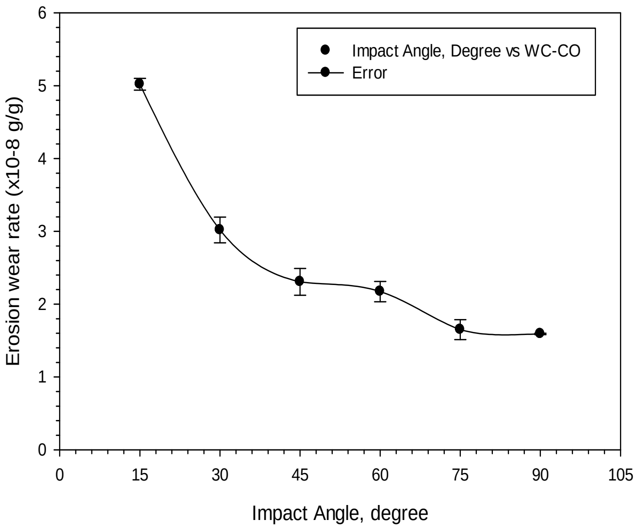

Fig -8: Erosion wear rate of WC-CO coating

5. CONCLUSION

In the present paper, we are generally concentrated on the erosion of the WC-CO coated gun metal bronze. The erosion is generally depends on the many factors i.e. impact angle, particle size, velocity, concentration etc. From the experimental data, it is concludes that the erosion is maximum at the 15° i.e. 5.02 x 10^{-8} and minimum at the normal impact angle (90°) i.e. 1.591 x 10^{-8}.

Further, the Cutting and deformation wear at different impact angles is calculated using the co-relations developed for the ductile materials. It is noted that the cutting wear is decreases with increasing the orientation angle and the deformation wear is increases with increasing the orientation angle.

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BIOGRAPHIES

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