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STUDY THE SLURRY EROSION WEAR BEHAVIOR OF BRASS USING SLURRY POT TEST RIG UNDER THE SOLID-LIQUID SLURRY

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Abstract- Slurry erosion wear of the centrifugal pumps is a serious issue for the pump efficiency. If the erosion rate and material removal mechanism can be estimated, the pumps impeller can be changed out before the failure i.e. during the maintenance schedule. Various researchers have put efforts to study the wear mechanism of brass material. The present work focuses on experimental study of erosion wear rate and material removal mechanism of brass in I S sand water slurry using slurry pot test rig. Experiments are conducted at a constant velocity and constant concentration of solid particles of sample slurry under the impact angle ranging from 15° to 90° with uniform increment. The result shows 30° impact angle is maximum erosion wear angle for the given condition. Wear microstructure is also studied under SEM to understand the material removal pattern at different impact angles and material removal mechanism. Also the surface roughness measured at 15°, 30° and 90° impact angle before and after the experimentations. The results are found in good agreement with the published literature.

Keywords - Slurry Erosion Wear, Slurry Pot Tester, Solid – Liquid Slurry, Brass.

I. Introduction

Pump is important equipment and it plays key role in all the cases like all industry, irrigation and liquid handling process. Pump impeller is an important part which is directly affects the efficiency of pump. So the life of impeller is most important parameter for the pump efficiency. The life of pump impeller affected due to the erosion wear of impeller. Because every liquid having some impurity and solid particle due to this erosion wear is responsible for reduce the equipment life, performance and reliability [1-2].

Mainly slurry erosion wear is occurs during slurry transportation. The pump impeller undergoes both cutting and deformation type of wear due to solid particle suspended in liquid. Impeller erosion wear mainly depends on solid particle size, impact angle, solid particle concentration and solid particle velocity. So it is necessary to study the all parameters for improving the life of impeller. So life of the impeller is finding using erosion wear responsible parameters. If the life of pump is known then it possible to change the impeller before damage the pump during the maintenances schedule. Because cost of the breakdown pump is more than the cost of changing the impeller during regular maintenances schedule [3-5].

From the beginning of erosion wear research, different researchers developed various types of bench scale test rigs to simulate the erosion wear rate and mechanism at the laboratory scale namely jet impingement tester, pot tester, Coriolis erosion tester etc. all the test rigs having some advantages and limitations. All test rigs simulate various working conditions and applications [6-7].

For the present study a pot test rig proposed by Desale et al. (2005) has been suitably modified and fabricated for the comparative study of brass target material. A systematic experiment was conducted on brass as specimen to establish the effect of solid particle size, concentration and velocity on slurry erosion wear of pump impeller. Brass is having low melting point with high malleability and machinability. The combinations of iron, aluminum, silicon and manganese make brass improves the corrosion, wear resistant properties. So it will help to reduce the slurry erosion wear.

II. Slurry Pot Test Rig

The 7 litres capacity slurry pot test rig has been used for the present experimental work. Fig. 1 shows the photographic view of experimental test setup with some details of wear sample fixing arrangement along slurry pot and PTB propeller. One drill machine and two AC electric motor (1.5 HP) with variable frequency drive (VFD) is used as accessory for the present experimental setup. One VFD is attached to drill machine motor to control the speed of sample holding shaft which is on top side of the pot. Another motor and VFD is attached to PTB propeller shaft which is at bottom side of the pot. All the parts are made with SS 304 material. The four numbers of baffles are located at inner side of pot to break the vertex flow motion developed due to bottom propeller. At a bottom of pot 20 mm diameter size hole is provided for remove the slurry.

The test fixtures are held with two horizontal arms which are attached to brass sleeve of size 25 mm diameters and 30 mm length at the position of lower end of the top shaft. Fig. 1 show the pictorial view of fabricated test rig with all accessories. For fixing the test fixture a slot of size (30x5x2 mm) with rounded at both the ends was used as shown in Fig. 1. A rectangular tooth of 1 mm thickness and 2.5 mm width is provided on each test fixture to fix

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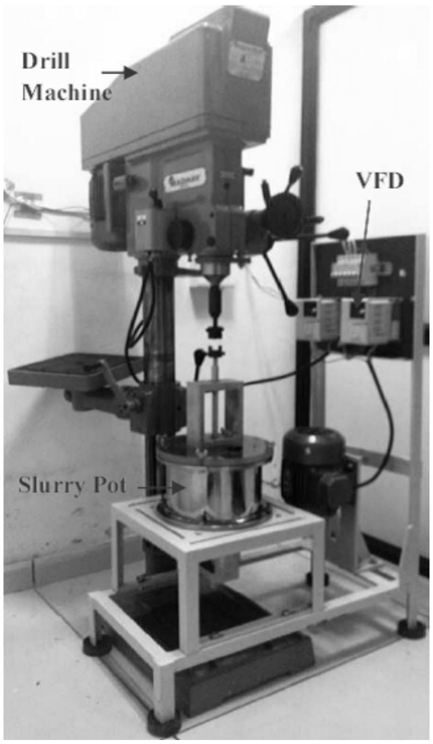
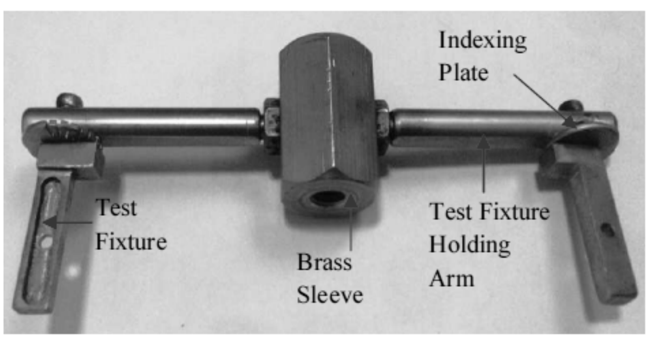
and place it at the necessary impact angle from 0° to 90° with steps of 15°, along the direction of peripheral velocity, using the slotted angular plate as shown in Fig. 1. For balancing the dynamic force and minimized wake interference effect the two test fixtures are mounted at 180° apart from each other. For controlling the rotational motion effect the test sample fixture is rotated in opposite direction to the propeller shaft at 71 mm radius. Hence the swept volume of wear sample and holding arm is negligible.



(a)



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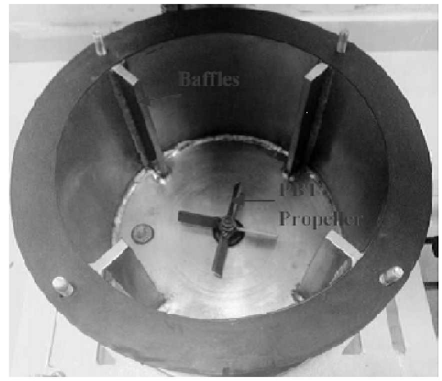


(c)

Fig.1. Photograph of (a) Slurry pot test rig, (b) Fixing arrangement of wear sample and (c) Details of Pot with PTB Propell

III. Experimental Methodology and Data Analysis

Before starting the experimental work wear sample is cut with dimensions of 30mm x5 mm along thickness of 2mm. for each experiment fresh wear sample is used, each sample are polished with #600, #1000 and #1200 emery paper for the mirror finish. After the mirror finishing samples are clean with tap water and acetone. Finally samples are dried using hot air dryer. This process of cleaning and drying repeated before and after the experiment. A high precision electronic weight balance was used to measure the sample weight before and after the experiments.

The correlation proposed by Bree et. al. [8] was used to compute the erosion wear rate for that average weight loss of two wear sample is considered.

$$Ew = \frac{W_L}{\rho_S \times A_{SP} \times Cv \times V_{SP} \times T \times Sin\alpha} \quad (1)$$

Where

$$Cv = \frac{Cw}{\rho_S - (\rho_S - 1) \times Cw} \quad (2)$$

WL -Measured mass loss in kg; ρS - Solid particle mass density in kg/m3; ASP - Surface area of the wear sample subjected to erosion in m2; Cv - Solid concentration by volume in fraction; VSP - Peripheral velocity of wear specimen in m/s; T - Time over which mass loss has been measured in sec; α - Orientation angle of wear specimen in degree. Cw - Solid concentration by weight in fraction; Ew - Total erosion wear rate in g/g;

Before starting the experiment known quantity of solid particle was poured first into the cylindrical pot and closes it with acrylic cover and nut bolt arrangement. The required volume of water was completely filled through the hole which is present on acrylic cover. For the uniform distribution of solid particle, the propeller is rotated in a down-pumping mode with desired speed. Variable frequency drive (VFD) is used to achieve the required speed and it can be monitor by using a tachometer. Another VFD is used to rotate the test fixture at a required speed which is attached to the upper shaft.

IV. Erosion Wear Behaviour With Orientation Angle

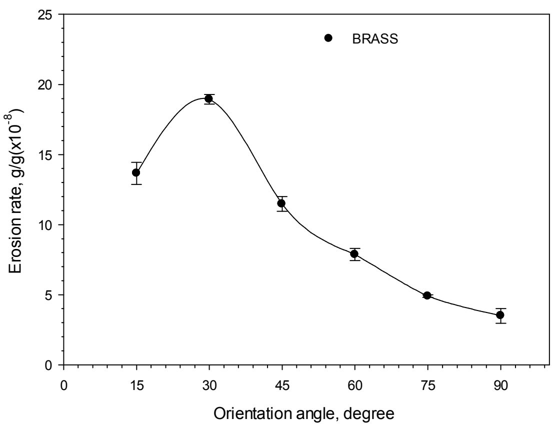


Fig. 2. Particle size= 925 µm, Target Material = Brass, Velocity= 5 m/s, Propeller Speed= 690 rpm, Solid Concentration = 10% by wt, I S Sand.

The erosion rate of Brass is evaluated by using the first equation for the experimental conditions as 5 m/s impact velocity, 925 µm solid particle size and 10% by weight solid concentration with orientation angle varies from 15° to 90°. Fig. 2 shows variation of erosion wear behaviour with different orientation angle. From fig. 2 maximum erosion wear rate is observed at 30° orientation angle and then wear rate decreases continuously with increasing orientation angle till 90°. Desale et. al. [9] was observed the same trend for the erosion wear with maximum wear rate at 15° orientation angle for quartz –water as a slurry and AA 6063 as erodent sample. Abbade et. al. [10] was observed maximum erosion angle at 30° under the similar slurry and API 5L X65 steel as a target material. Lin and Shao et. al. [11] conducted an experiment on pure aluminium and hot-rolled 1020 steel with quartz-water slurry the result shows maximum erosion rate at around 20° orientation angle. So based on the above experimental results it is found that the 90° impact angle, 5 m/sec velocity, 10% solid concentration and 925 µm particle size give optimum value for less slurry erosion wear.

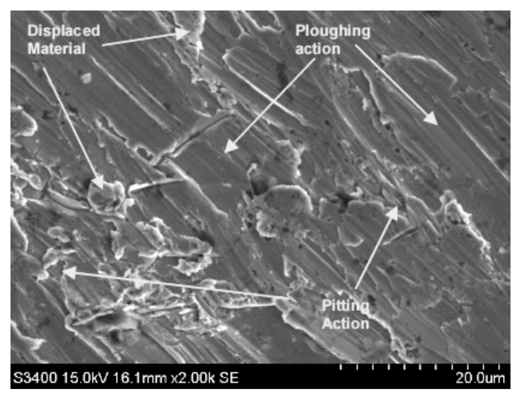
VI. SEM Analysis

The scanning electron microscope (SEM) was performed to study the material removal mechanism of erosion surface.

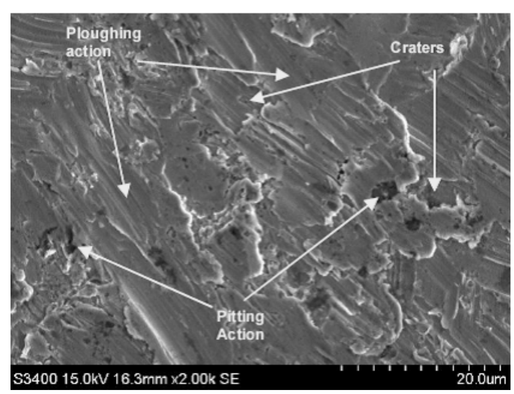
Fig.3 (a, b) shows the ploughing and pitting type of material removal mechanism with craters. The length and width of ploughing action with size of craters is large in 15º impact angle as compare to 30º. Fig. 3 (a) shows some material displaced type of mechanism which is not shown 30º. Fig. 3 (b) shows pitting type of material removal mechanism the size of pitting erosion is more in 30º impact angle as compare to 15º impact angle this is due to the intensity of vertical component of velocity is in (b) as compare to (a) [7, 11-16].

However, fig. 3 (c) shows SEM micrograph for 90° impacts angles it shows only indentation type of pattern on the wear surface. Here at this angle, the only vertical component of velocity plays an important role for removed the material so it developed indentation with the crush of the material over the adjacent crater and it flattened because of the repetitive impact of particles. So this indicates that particles are impacted with only normal impact angle surface of the target material [7, 12-16].

From discussion and SEM micrographs presenting in fig. 3 (a-c) it can be concluded that the material removal mechanism changes with respect to impact angle of the solid particle. Also, it insures that the impact of a particle on the target surface was accurate as per the orientation angle to given to the wear sample.



(a)



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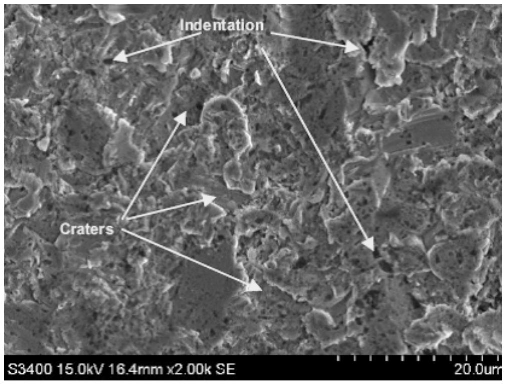

(c)

Fig. 3. SEM Micrographs of wear sample at (a) = 15°, (b) = 30° & (c) = 90° impact angle

VII. Surface Roughness Analysis

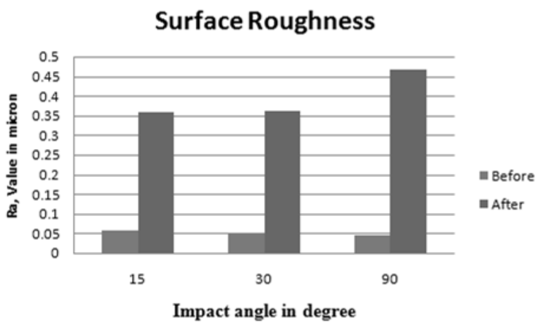

Fig. 4. Surface roughness of wear sample before and after experiment at 15°, 30° & 90° impact angle

Fig. 4 shows the some surface roughness behavior of wear sample surface at 15°, 30° and 90° impact angle before and after the experimentations. Form the Fig. 4 it is clear that the surface roughness is increases after the experimentation for all three impact angles. The surface roughness of wear sample increases due to the slurry erosion wear. Here at 90º impact angle all the values of surface roughness is higher as compare to 15º and 30º impact angle. So it is clear that indentation type of material removal mechanism gives higher surface roughness as compare other type of material removal mechanism. At 30º impact angle more surface roughness is observed as compare to 15 º impact angles because more pitting action takes place at 30º angle than the 15º.

VIII. Conclusions

For the brass as target material a slurry pot tester shows 30º impact angle is maximum erosion wear angle. The SEM analysis is useful to study the material removal mechanism at various impact angles. Ploughing and pitting action is observed at 15º and 30º impact angles. Size of ploughing and pitting mechanism are maximum at 15º impact angle as compare to 30º. Surface roughness of wear sample was change before and after erosion test. The value of surface roughness is maximum at 90º impact angle as compare to other two. Also surface roughness value is more for the indentation type of material removal mechanism as compare to other. The results obtained from the present study of erosion wear testing on brass in the present test rig are found to be reliable with the literature. This ensures practical results for the different slurry erosion wear conditions in slurry handling pump and centrifugal pump impeller and pipeline etc. The erosion wear is minimum in the range of 60º to 90º impact angle under the operating conditions, so base on above the result impeller angle of supply or feeding angle use in at the 90º impact angle for better erosion wear resistance with higher life improvement.

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