Study the Effect of Sample Holding Arrangement Height on Slurry Erosion Behavior of Brass using Slurry Pot Test Rig Under the Solid-Liquid Slurry

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Abstract: **Material loss due to erosion wear is a serious problem associated with flow of solid-liquid mixtures. Slurry erosion limits the useful life of equipment and is therefore a critical parameter for design, selection and operation of the hydraulic transportation system. Engineering interest is to estimate the service life of equipment / components subjected to slurry erosion and to investigate the possibilities of enhancement of their life. Various researchers have put their efforts to study the wear mechanism of Brass material. In the present work, erosion wear tests have been carried out in a slurry pot tester for brass material to find out the optimum position of wear sample holding arrangement with reference to bottom propeller. This is necessary because erosion wear rate and material removal mechanism change according to the position of test sample. For that it is necessary to develop different extra attachment with sample holding arrangement. The Experiments are conducted at a constant velocity, particle size and solid concentration of particles with varying impact angle ranging from 15º to 90º with different height of sample holding arrangement. The experimental result shows the rate of erosion wear at different impact angle for the different condition with varying sample holding arrangement height.. So above work is help to find the optimum position of sample in sample holding arrangement with respect to bottom propeller to improve the erosion wear and material removal mechanism.**

Keywords: wear, maximum erosion wear, Brass material, Surface Roughness

1. INTRODUCTION

Pump is an important device which is used for many purposes and plays a key role in various process industry, irrigation and liquid handling process. Pump impeller in pump is an important part which directly affects the efficiency of pump. The life of impeller is most important parameter for the pump efficiency. The life of impeller is affected due to erosion wear occurs on the pump impeller material. The solid particle or impurity present in slurry (water sand mixture) due to erosion wear is responsible for decrease the equipment life, Performance and reliability [1-2].

In slurry transportation system mainly slurry erosion is occurs. The pump impeller subjected to slurry undergoes for both cutting and deformation type of wear due to present of solid particle suspended in liquid. The wear in impeller mainly depends on the size of solid particle, impact angle, solid particle concentration and solid particle velocity. The life of the impeller is depends upon the above parameter, so it is necessary to study the all parameters for improving the life of impeller. If the life of pump is known then it is possible to change the impeller before damage the pump during the maintenances schedule. Because the cost of the breakdown pumps is more than the cost of changing the impeller during regular maintenance schedule [3-4].

Throughout the past the different researchers developed various types of bench scale test rigs to simulate the erosion wear mechanism and rate of erosion wear at the laboratory scale such as jet impingement tester, pot tester, Coriolis erosion tester, Falling Jet test Apparatus. The above mentioned test apparatus have some advantage and limitations and also simulates different operating conditions and applications [5-6].

In the present study a slurry pot tester is used for the comparative study of brass material. The experiments were carried out on brass specimen to establish the effect of solid particle size, solid concentration, velocity and height of sample holding arrangement on erosion wear of pump impeller.

2. EXPERIMENTAL SETUP

For the present experimental work a 7 liters capacity slurry pot test rig has been used as shown in fig. 1. The above photographic view of experimental test setup shows some details of wear sample fixing arrangement along with slurry pot, PTB propeller. Fig. 2 shows the sample holding shaft arrangement with different position of sample height. One drill machine and two electric motor of 1.5 HP with variable frequency drive (VFD) are used as an accessory for the present experimental setup. One VFD is attached to drill machine motor to control the speed of sample holding shaft which is at the top side of the pot, another VFD and motor attached to the PTB propeller shaft which is at bottom side of the pot. All the parts are made of SS 304 material. To break the vortex flow motion developed due to bottom propeller four baffles are located at inner side of pot. For remove the slurry after experiment a hole of 20 mm diameter size is provided.

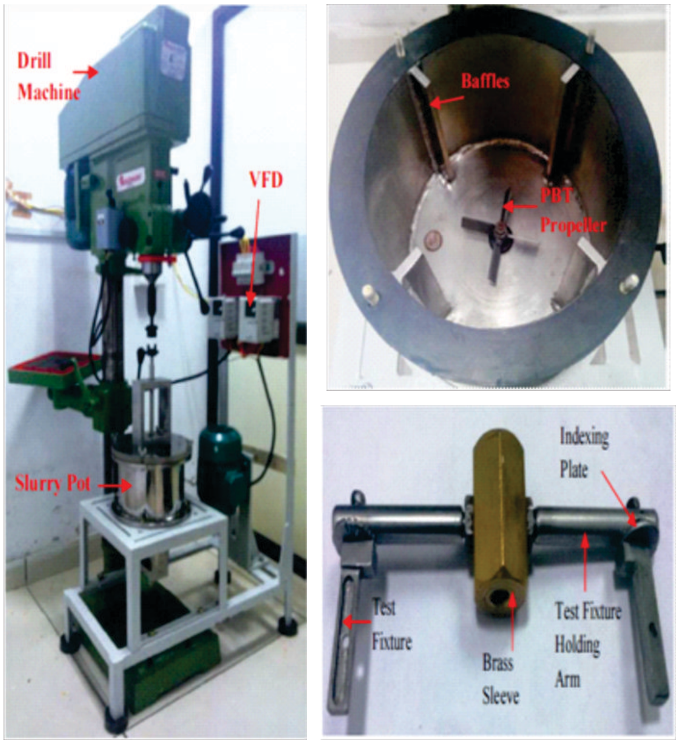


Fig.1 Photograph of (a) Slurry pot test rig, (b) Fixing arrangement of wear sample and (c) Details of Pot with PTB Propeller

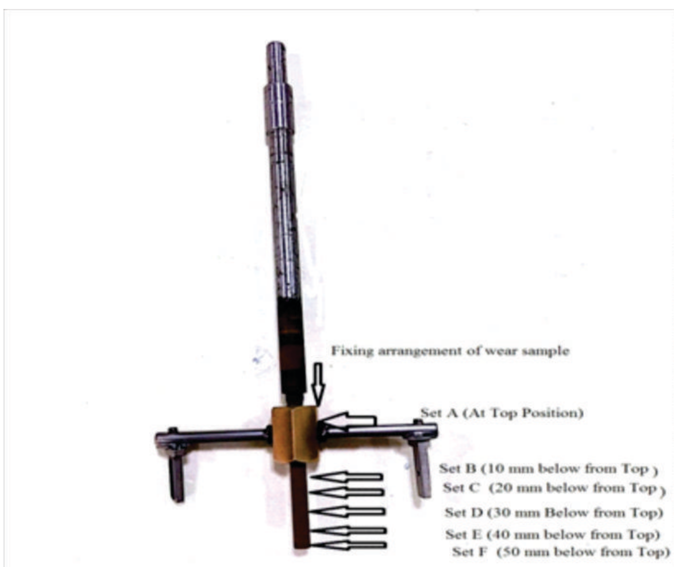


Fig.2 Fabricated shaft and different position of the sample on sample holding arrangement

The test fixture is held with two horizontal arms which are attached to brass sleeve of size 25 mm diameters and 30 mm length at the different variable position of top shaft. Fig. 1 shows the photographic view of fabricated test rig with all accessories. A slot of size 30 mm × 5 mm × 2 mm, rounded at both ends was provided at the test fixture to fix the test specimen inside it as shown in Fig. 1. A rectangular tooth of 1 mm thickness and 2.5 mm width is provided on each fixture to place it at the required 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. The swept volume of wear sample and holding arm is negligible.

3. EXPERIMENTAL METHODOLOGY AND DATA ANALYSIS

Before starting the experimental work the wear sample is cut with dimension of 30 mm× 5 mm along thickness of 2 mm. After that each sample are polished with #600, #1000 and #1200 emery paper for the mirror finish, and for each experiment fresh wear sample is used. The mirror finish samples are clean with tap water and acetone and then dried using hot air dryer. The process of cleaning and drying is repeated before and after the experiment. The weight of each sample is measure before and after the experiment by using electronic weight balance having least count of 0.1 mg.

The correlation proposed by Bree et. al. [7] is used to compare the erosion wear rate for that average mass loss of two wear sample is considered.

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

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

Cv - Solid concentration by volume in fraction; Cw - Solid concentration by weight in fraction; $_S$ - Solid particle mass density in kg/m^3; Ew - Total erosion wear rate in g/g; A_{SP} - Surface area of the wear sample subjected to erosion in m^2; T - Time over which mass loss has been measured in sec; V_{SP} - Peripheral velocity of wear specimen in m/s; W_L-Measured mass loss in kg; - Orientation angle of wear specimen in degree.

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

4.EROSION BEHAVIOR WITH ORIENTATION ANGLE

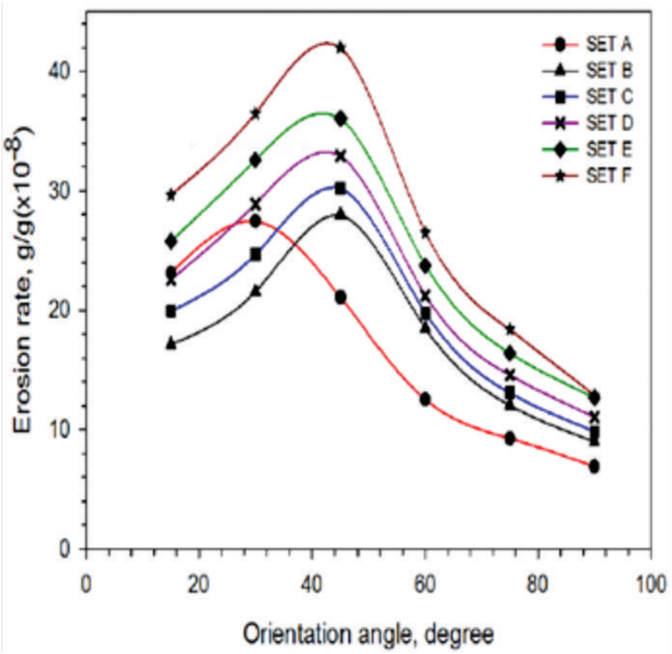


Fig. 3. Particle size = 655 μm, Target Material = Brass, Velocity= 5 m/s, Propeller Speed= 360 rpm, Solid Concentration= 10% by wt., I S Sand.

Impact angle	At 10 mm below from top (Set B)	At 20 mm below from top (Set B)	At 30 mm below from top (Set B)	At 40 mm below from top (Set B)	At 50 mm below from top (Set B)
At 15°	25.9% (↓)	13.85% (↓)	2.4% (↓)	11.44% (↑)	28.31% (↑)
At 30°	21.52% (↓)	10.23% (↓)	5.25% (↑)	18.64% (↑)	32.8% (↑)
At 45°	32.61% (↑)	43.24% (↑)	56.03% (↑)	70.77% (↑)	99% (↑)
At 60°	47.5% (↑)	57.8% (↑)	69.43% (↑)	89.7% (↑)	111.63% (↑)
At 75°	30.24% (↑)	41.53% (↑)	57.66% (↑)	77.42% (↑)	98.79% (↑)
At 90°	29.68% (↑)	42.18% (↑)	59.37% (↑)	82.81% (↑)	85.94% (↑)

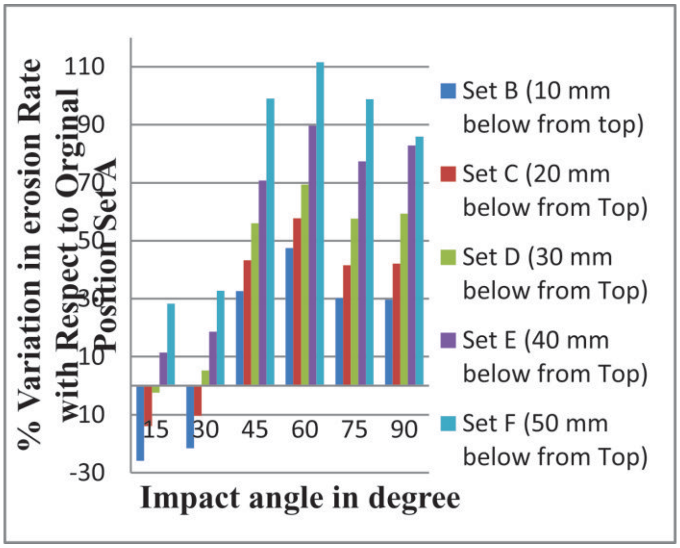


Fig.4 Percentage Variation in erosion wear Rate with respect to Original Position Set A

Fig. 3 show the erosion wear behavior of all six set i.e. Set A to Set F and was evaluated using slurry pot test rig. Table 1 shows the percentage (%) Variation in erosion wear rate with respect to top position or original position (Set A). The erosion rate of Brass is evaluated by using the equation no. (1).For the experimental conditions as 5 m/s impact velocity, solid particle size 655 μm and solid concentration 10% by weight with orientation angle varies from 15º to 90º. The variation of erosion wear behavior of all six set of experiment with various position of sample holding arrangement is shown in fig. 2. From fig. 3 it is clearly observed that for the set A the maximum erosion rate is at 30º orientation angle and then wear rate decreases continuously with increasing orientation angle till 90º [9]. Similarly for set B to F the maximum erosion rate at 45º orientation angle and then wear rate decrease continuously with increasing orientation angle till 90º[6] this is due to the change in height of sample holding arrangement. The erosion wears rate increase when the height of the sample holding arrangement is decrease with respect to the bottom propeller which is clearly observed from the fig. 3 (Set A to F on different height).

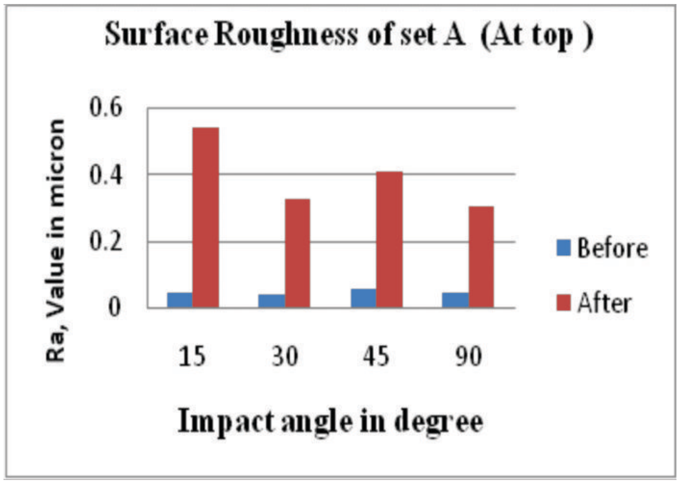
The table no. 1 & Fig.4 shows the change in percentage of wear rate at 15 º, 30 º, 45 º and 90 º impact angle. At 15º it shows there is decrease in erosion rate with percentage value 25.9 %, 13.85% and 2.4% for decrease the height of sample holding arrangement to 10 mm, 20mm and 30 mm respectively and then increase when below the sample height up to 50mm with 11.44% and 28.31%.

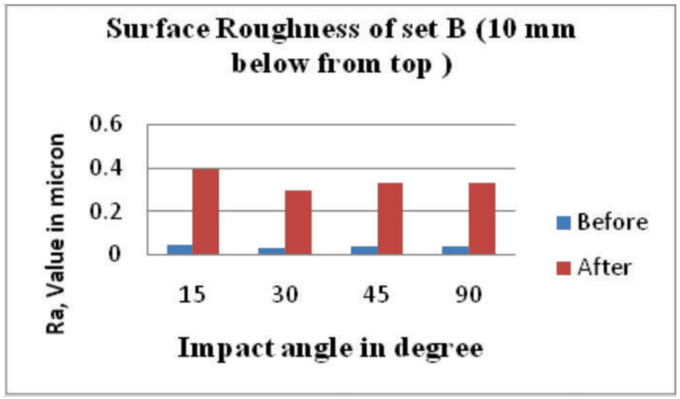
Similarly at impact angle 30º % changes in erosion rate with respect to original position first decrease with below the sample height up to 20 mm with % value 21.52% and 10.23% and then increases with below the sample height up to 50 mm with % value 5.24%, 18.63% and 32.8%. At impact angle 45º, 60º, 75º and 90º it is clearly observed from the fig. 3 and table no. 1 the % of erosion rate with respect to original position (Set A) increased continuously with below the height of sample holding arrangement.

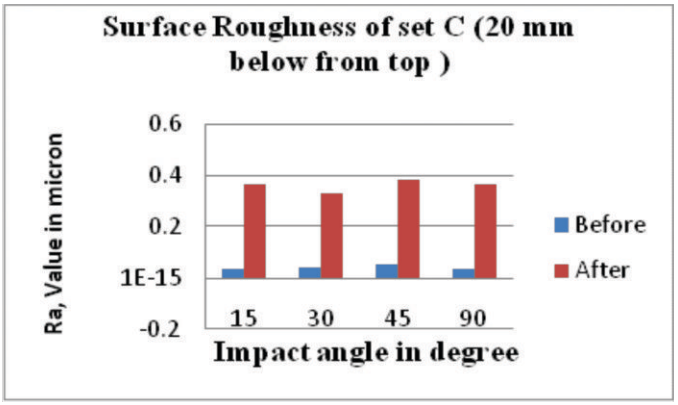
Desale et. al. [8] observed the same trend for erosion wear with maximum wear rate at 15º orientation angle for quartz-water as slurry and AA 6063 as erodent sample. Abbade et. al. [9] was observed maximum erosion angle at 30º under the similar slurry and API 5L X65 steel as a target material. Lin and Shao et. al. [10] conducted an experiment on pure aluminium and hot-rolled 1020 steel with quartz-water slurry, the result shows maximum erosion rate at around 20º orientation angle.

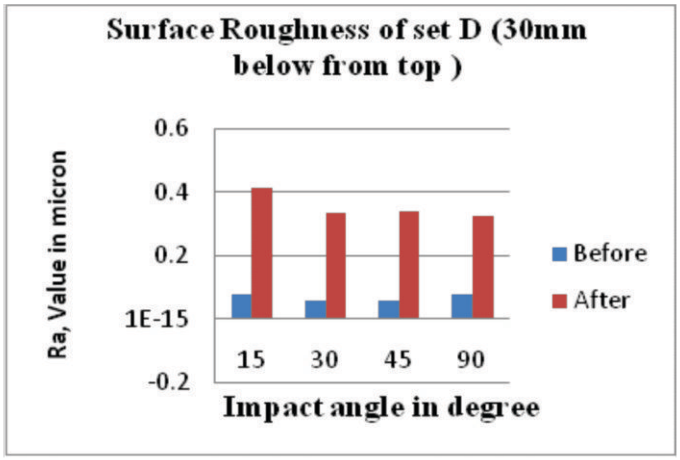
5. SURFACE ROUGHNESS ANALYSIS

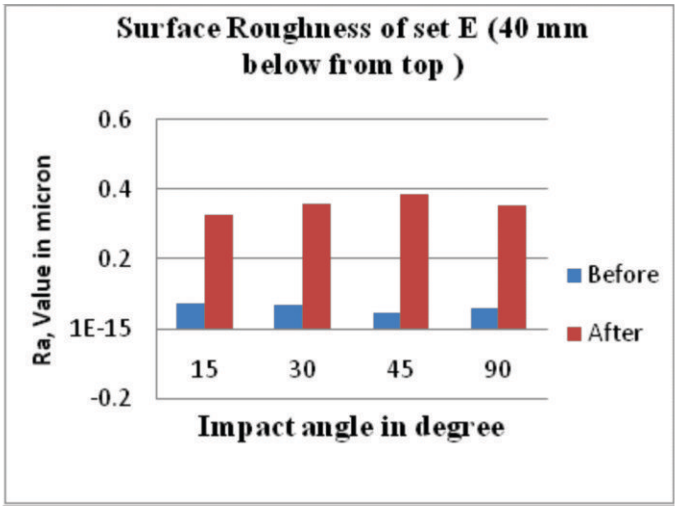
Fig. 5 shows the roughness values of wear sample surface at 15º, 30º, 45º and 90º impact angle before and after the experiment of the set A to F. From the Fig. it is clearly observed that the surface roughness values Ra increase after the experiment as compare with before the experiment. Fig. 4 Set A shows maximum surface roughness value for all impact angle as compare to other set i.e. set B to F. No significant improvement in surface roughness is shown between set B to F, so it conclude the sample holding arrangement gives the maximum surface roughness value at original position (Set A). When the sample holding arrangement changes its position from Set B to F it gives minor change in surface roughness value as compare to set A.











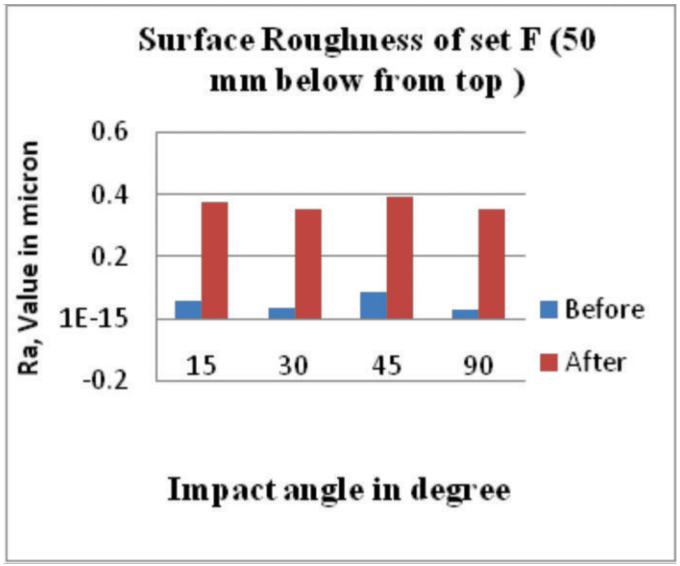


Fig.5. Surface roughness of wear sample before and after experiment at 15º, 30º, 45º & 90º impact angle for the set A to F

6. CONCLUSION

The maximum erosion rate for brass as a target material in a slurry pot tester observed at 30º impact angle for set A i.e. when sample is at top position. For set B to F the maximum erosion rate is observed at 45º impact angle due to decrease in height of sample holding arrangement from bottom propeller.

As the decrease in height of sample holding arrangement from bottom propeller the impact energy and velocity of erodent particle is increased because the solid particle travel less distance with a parabolic path. Due to less distance travels by the erodent particles the impact kinetic energy is high with higher material removal rate.

The erosion wear rate decreases at 15º and 30º impact angle when the sample holding arrangement is at 10mm and 20mm below from top. Similarly erosion rate increases continuously from 15º to 90º for the entire position height sample holding arrangement.

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