ICMIEE18-328

Wear behavior of Different Impeller Materials for Pumping Various Slurry

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ABSTRACT
Slurry erosion tester is ordinarily used to study the comparative erosion behavior of different materials at moderate solid concentrations which are used in our civilization life. In the present work, a pin mill type slurry-pot wear tester has been made. Flat type and impeller type sample material has been tested by this tester. By this testing apparatus different types of material can be tested at various speed and concentration. Total four types of material such as Aluminum, Brass, Mild Steel and Cast Iron has been tested by taking different types of slurries to find out the wear characteristics of the material by measuring the rate of mass loss with respect to various parameters like slurry concentration, speed of rotation, distance traversed, impact angle and time. The machine has been tested by taking slurry of silica sand in a GI container to find the rate of mass loss of aluminum, brass, mild steel, cast iron sample.

Keywords: slurry-pot, pin mill, slurry-erosion, silica sand and speed control box.

1. Introduction

Slurry erosion can be broadly defined as the process whereby the material is lost from a surface in contact with a moving particle-laden liquid by mechanical interaction [1]. It is an extremely serious problem for the performance, reliability and operation life of the slurry handling equipment in which solid liquid mixture is transported through pumps and pipes, used in many industrial applications like thermal power plants, hydropower plants, mining industries, food processing industries, construction and civil works, oil field mechanical equipment, solid-liquid hydro transportation systems, coal liquefaction plants, and industrial boilers where coal is carried directly as a fuel in water or oil [2]. In Bangladesh, different types of pump and piping are used in many industrial applications like thermal and hydro power plant, construction works, Gas Field, Water treatment plant, Sewage water system, Sugar Industry etc. This large number of pumps and piping materials erode frequently due to wrong choice of materials. The consequences are the loss of material, loss of equipment reliability, increasing operational cost [3]. Therefore, use of right material for specific industrial application can save large number of money.

For slurry pumping system, wear occurs mainly due to erosion and the mechanism of erosion is greatly dependent on the processes parameters involved. The constraint that affect the erosion wear in case of pumping different type of slurry are pump impeller materials quality, materials of target surface, slurry concentration, impact velocity, impact angle, size and shape of solid particle containing in the slurry, slurry viscosity, and environment [4]. But due to difficulty to find out common causes and remedy of erosion, researcher all over the world have been trying to reduce the slurry erosion by taking various techniques such as uses right materials, impact angle, target materials surface coating ,optimizing pumping velocity [5].

Pin mill type slurry-pot wear tester has very simple design. A slurry pot was introduced by Tsai et al. [6] and similar one was designed and fabricated in 1995 by Gupta et al. [7]. The pot tester of approximately 3.8 l capacity consists of aluminum cylindrical container, rotating arms, specimen holders, shaft, motor, stirrer and bearings is shown in Fig.1.

In this study, a pin mill type slurry-pot wear tester has been developed and different types of impeller material with various types of slurry has been tested to evaluate the erosion wear rate of different impeller material to decide suitable pump impeller material for pumping different slurry.

This machine can be used for carrying out experiments on various samples of different materials which are subjected to slurry erosion. By this apparatus slurry wear rate of different material can be measured and can make decision which materials is suitable for which application.

2. Pin Mil Slurry Erosion Tester

The slurry erosion tester is shown in below Fig.2. This apparatus is a box type arrangement. The major components are structure, motor, slurry pot, shaft, pulley, belt and control box. Main shaft are fixed by pillow type bearing housing. One end of the shaft is fixed with pulley and other end is connected with sample via slurry pot bearing housing. Sample is connected with shaft and fixed by nut bolt. Shaft pulley is connected with motor pulley via a v-belt as a result when the motor starts rotating the shaft holding the samples will also rotate. The frame is made by 1.5 inch V type GI angle. The main structure dimension is 2.5 feet length, 2.5 feet wide and 3 feet height.

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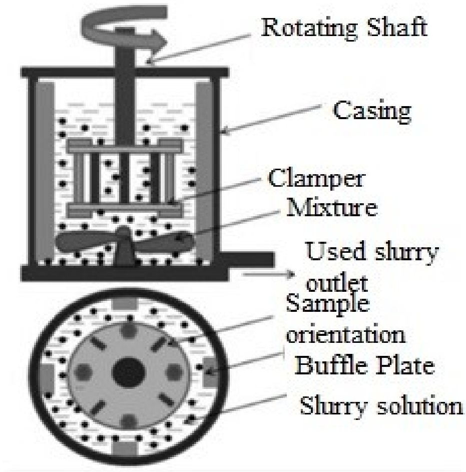

Fig.1 Slurry pot test device [6]

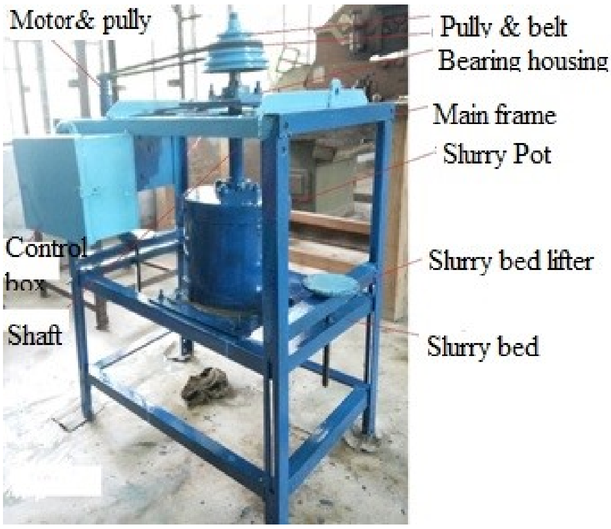

Fig.2 Erosion pot tester (experimental setup)

The shaft was made from a piece of 35 mm diameter mild steel rod having total length 650 mm. This shaft has two bearing holding groves and one pulley holding groves which was made by turning it in a lathe machine.

A slurry pot with led has been made for this testing apparatus. The size of slurry pot is 28 mm diameter and 25 mm height is shown in Fig.3. Slurry pot was made by 4 mm thickness GI plate. Main shaft is connected with slurry pot via pot lid by pillow type bearing housing. Slurry pot is fixed with an adjustable height bench and bench height can be adjusted by two screw.

A control box with dimension 8-inch X 6-inch X 6 inch was made for fixing control switch, protection circuit breaker and motor speed controller.

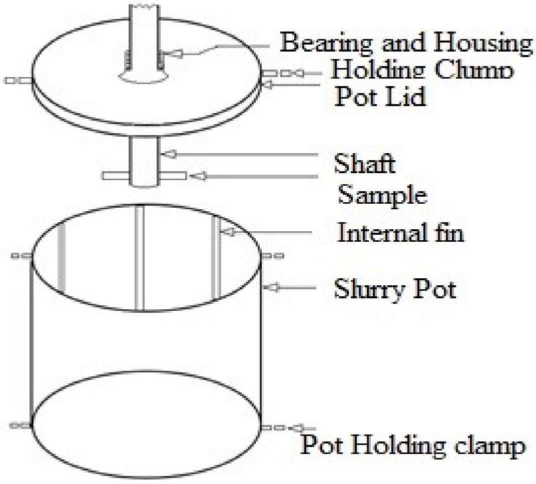

Fig.3 Slurry erosion tester pot with lid

In these experiment two types of sample was used. One was impeller shape and another flat bar shape, that are shown in below Fig.4.

A solid metal having width 28 mm, thickness of 12 mm and length 190 mm was made for experiment that is shown in fig.4. One holes of diameter 16 mm was drilled on the metal strip, one at the center by a universal drilling machine for fitting the spindle with it using a nut.

On the other hand, a solid impeller shape sample was prepared for test having impeller width 30 mm, thickness 10 mm and length 190 mm that is shown in fig.4. One hole of diameter 16 mm were drilled on the metal strip, one at the center by a universal drilling machine for fitting the spindle with it using a nut.

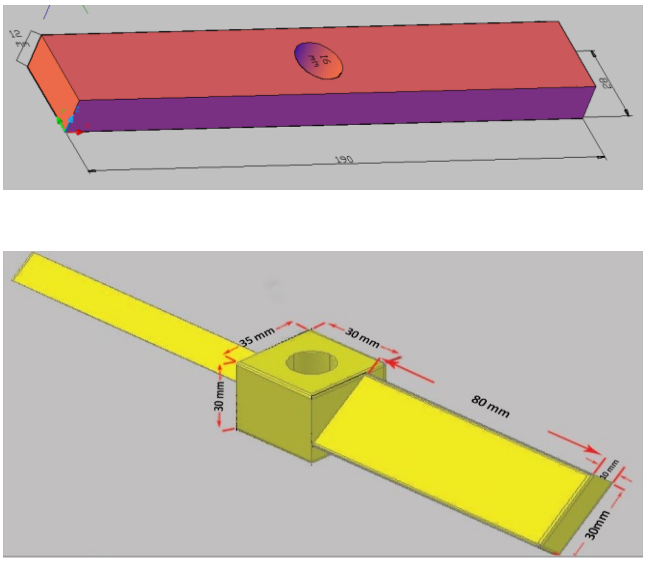

Fig.4 flat bar and impeller type samples

Main characteristics of the slurry-pot equipment is given in Table-1 and Table -2

Table 1 Main characteristics of the slurry-pot equipment.

Main structure	2.5 feet x 2.5 feet x 3 feet
Shaft	Diameter 35 mm and length 650 mm.
Pulley	4 stage pulley with different diameter (4,5,6,7 inch)
Slurry pot	Diameter 28 mm and height 25 mm
Motor	2 HP, single phase, 1450 rpm
Belt	V- Belt, size-B
Samples	
Flat bar type	190mm X 28mm X 12 mm
Impeller type	190mm X 30mm X 10 mm

Table 2 Composition of the slurry.

Natural water P^H	7.4
Coarse sand	0.25 mm - 0.5 mm

3. Results and discussion

The self-made slurry erosion tester was used for testing the samples. Two different type sample of different material such as aluminum, brass, mild steel, cast iron were made in work shop. All sample has been cleaned by cleaning agent and recorded initial weight. Samples has been fixed with tester and test by this developed apparatus. After completing testing period sample was removed from sample holder and cleaned by cleaning agent WT-40. After cleaning final weight has been taken. The difference between two weights is the required erosion.

In this experiment, total four types of impeller material with two geometries were used for testing at different operating condition such as impact angle, velocity, density and time. Among of the four samples (45-degree impact angle) material Brass was more erosive in constant density for both type of geometries (Flat bar and Impeller) which was shown in table 3.

On the other hand, cast iron was less erosive at constant density for impeller type geometry but for flat bar (0-degree impact angle) type geometry mild steel was less erosive. From the bellow Table 4, it was cleared that erosion is increased with respect to impact angle. If impact angle is increased, erosion will be increased for all types of materials and geometries. Fig.5 and fig.6 depicts the erosion at different impact angle, speed and various density.

It clearly shows that as the density is increased, erosion is also increased for all types of materials and geometries. From the Fig. 7 and 8, it is cleared that erosion is increased with respect to impact velocity. As the impact velocity is increased, erosion is increased for all types of materials and geometries. All slurry were chemically inert and PH value of those slurry was 7.4.

Table 3 Impeller type different samples erosion at constant speed.

Speed (rpm)	Time (hour)	Slurry density (kg/L)	Average Erosion (mg)			
			AL	Brass	MS	CI
530	1	0.475	710	1008	480	401
		0.51	750	1038	487	410
		0.625	808	1096	498	421

Table 4 Flat bar type different samples erosion at constant speed.

Speed (rpm)	Time (hour)	Slurry density (kg/L)	Average Erosion (mg)			
			AL	Brass	MS	CI
530	1	0.475	512	613	160	390
		0.51	522	642	169	415
		0.625	540	673	175	428

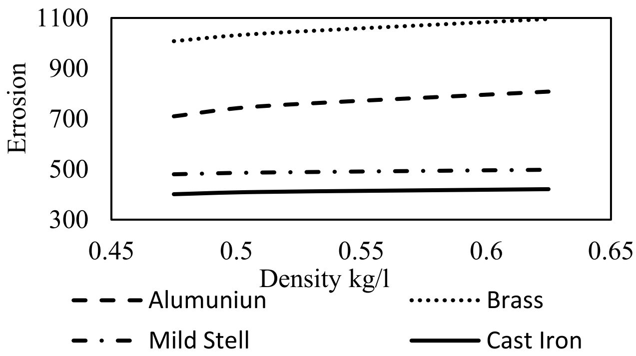

Fig.5 Erosion at 45-degree impact angle, constant speed and various density.

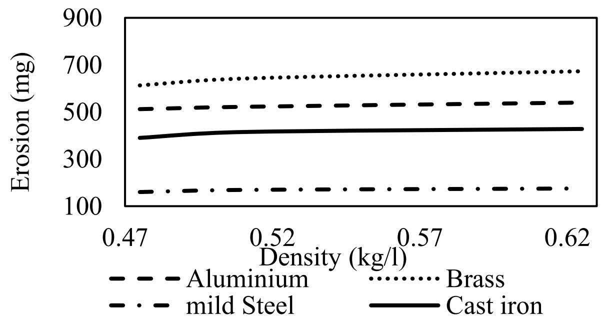

Fig.6 Erosion at 0-degree impact angle, constant speed and various density.

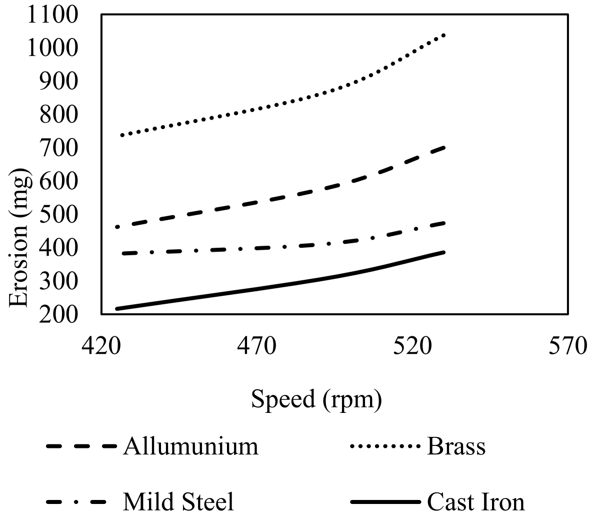

Fig.7 Erosion at 45-degree impact angle, different speed and constant density.

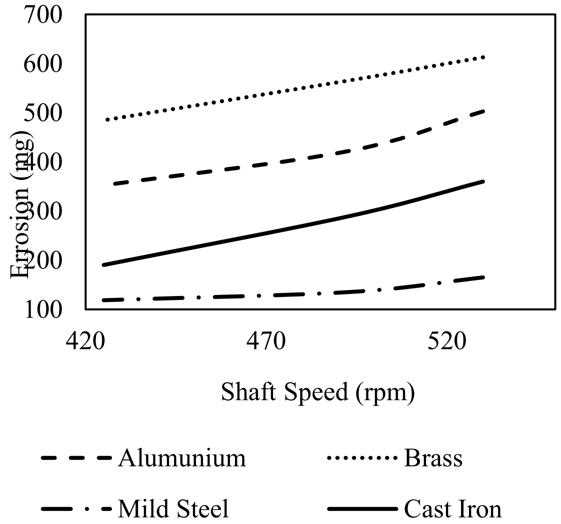

Fig.8 Erosion at 0-degree impact angle, different speed and constant density.

4. Conclusion

The use of pump for pumping slurry has increased vastly day by day in our civilized life. Therefore, it is very important to reduce erosion from the related machinery or equipment so that performance, reliability, and operation life. In this current study, four types of slurries material such has been tested by measuring the rate of mass loss with respect to various parameters like slurry concentration, speed of rotation, distance traversed, impact angle and time. From the obtained results, it is shown that by this testing apparatus different types of material can be tested and suitable pump impeller materials for different application can be find out. In this experiment, total four types of impeller material such as mild steel, cast iron, brass, aluminum were tested for different geometries, impact angle, velocity, density and time. Among of the four samples cast iron was less erosive at 45-degree impact angle and mild steel was less erosive at 0-degree impact angle. If impact angle is increased, erosion will be increased for all types of materials and geometries.

5. Reference

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