Experimental Analysis of Erosion Wear in Dense Slurry of Large Particle size in pot tester

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Abstract - Slurry erosion is caused by the interaction of solid particles suspended in a liquid and a surface which experiences loss of mass by the repeated impacts of particles. During slurry transportation the erosion phenomenon will occur. Erosion wear depends upon various parameters like solid concentration, Particle size, Impact angle and slurry velocity. In the present experimental set-up of slurry pot tester the sample are attached on the rotating wheel in sand-water slurries (solid concentration < 40% by mass) and the impact angle is 90^0. Mean particle size of sand particle is 156µm and the average velocity of slurry mixer is 3m/s. wear piece which is made of Al and Cu, is attached directly on the rotating shaft which is suspended in dense medium. The wear is calculated on the basis of average weight of material loss. The weight loss is proportionate to the speed of rotating shaft & duration of experiment and slurry concentration. Creo modeling of the experimental set up has been done.

Keywords: Dense slurry flow, Pot tester, Erosion wear , Particle size distribution

I. INTRODUCTION

Wear is such type of phenomenon in which volume loss is occurred by various surfaces due to abrasion, Erosion & corrosion. Erosion phenomenon is occurred due to removal of material from the surface. The removal of material can be occurred by impact or sliding of abrasive particle. The resultant of this slurry flow, the life of the component get reduced .Various factors are involved in studying the slurry flow Impact angle, Velocity of solid particle, hardness of surface, solid particle size & concentration.

II. LITERATURE SURVEY

Various experiments are performed to analyze the basic phenomenon of erosion wear. A pot tester is used to find the erosion wear due to slurry flow. Wide range of apparatuses has been designed to conduct laboratory-scale slurry erosion studies. Gandhi, et al.[1] has studied about the multi size particulate flow in slurry medium. The slurry pot tester is developed with variation of particle sizes ranging between 37.5 to 655µm. Mass loss is calculated which is occurred due to the erosion wear. A high speed slurry pot tester was developed by Ojala et al.[2]. In this type of pot tester sample are attached to a vertical rotating shaft on four levels in a pin mill configuration. The speed of sample tip with large abrasive size up-to 10mm. Experiment was performed of the High Speed Erosion by Singh et al.[3]. In this experiment fly ash is used as a erodent with particle size of 75 µm on cast iron impeller. Experimental analysis is also performed on lightweight aluminum alloy by HVOF thermally sprayed Inconel-titanium coating by Sekhar et al.[4]. The slurry erosion wear is calculated on different parameter by variation in impinging particle size, velocity of solid particle, hardness of material. Erosion rate of cylindrical steel specimen tested at speed 18.7 m/sec. by Lynn et al.[5] with particle diameter size in between 20 to 500 milli-micron. The result shows that increase in erosion rate with decreasing particle size.

Desale et al.[6] developed a pot tester for determining effect of various parameter in slurry flow like solid concentration, impact angle. Erosion wear increases with the increase in concentration of solid particle in multi size particulate flow of slurry medium. The slurry pot tester is developed the quartz particle with eight different sizes (varies between 37.5 to 655µm) have been used.

Desale et al.[7] has studied about erosion wear by using an experimental set up pot tester. Sand water slurry is formed and solid concentration varies from (0-30%) by mass. By using the uniform particle size of solid particle in slurry flow analysis to find out the minimum speed of rotating device in pot tester. Silica mixture slurry flow is also invested by various types of experiments performed. Dude et al[8] performed a experiment using counter rotating double disc erosion tester to analyze the erosion wear due to alumina and silica slurry in turbulent flow with solid concentration C_w <50% by mass.

III. EXPERIMENTAL SETUP

In this experimental setup wear piece is connected directly on the central shaft. The central shaft is rotated with the help of pulley which is attached on the top of the central shaft.

 DOI : 10.18231/2454-9150.2017.0010

Pulley is attached with the holding device and power is to be transmitted through belt. The belt is driven by a motor which provides the rotation to the belt.

3.1Various Views of the Model (Creo 2.0)

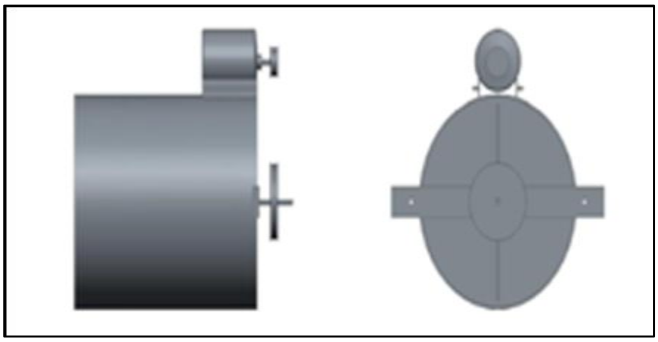

Fig 1: Side View (90' CW)& Top View

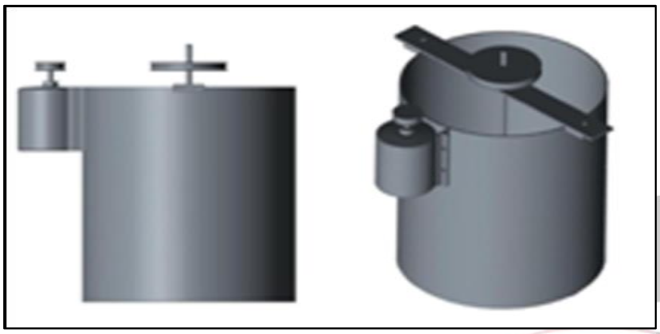

Fig 2: Side View &Isometric View

Fig 3: Actual working model

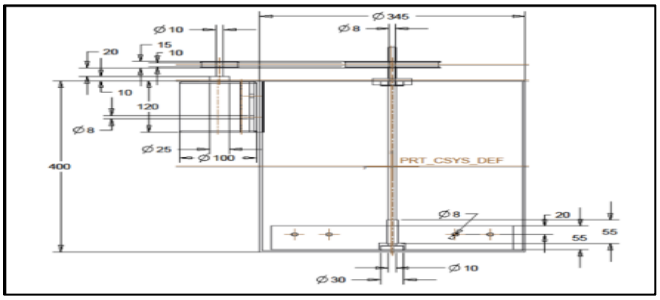

Fig 4: Creo modeling of front view

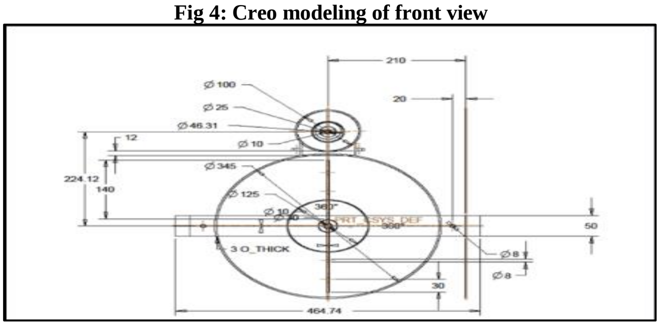

Fig 5: Creo modeling of top view

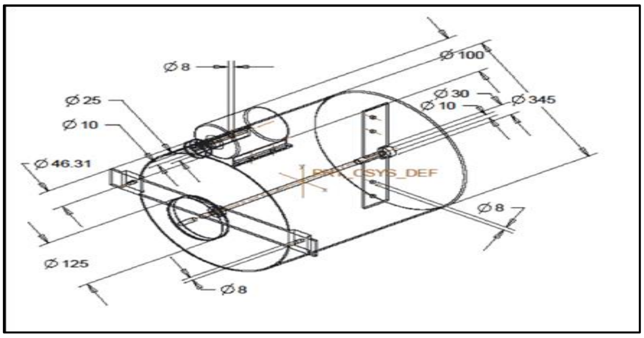

Fig.6: Creo modeling of side view

IV. MAIN PARTS OF MACHINE

1. **Cylindrical Pot**: A hollow cylinder of diameter 34.5 cm has been taken as a cylindrical vessel whose bottom end is welded with an iron plate. A fabricated bush is welded at the centre of the cylinder base and a bearing is fitted at bottom.

2. **Shaft**: A shaft is supported by bearing fixed at the centre of the cylinder base. A pair of rectangular blade is welded on GI pipe which is attached to the shaft with the help of nut and bolts. A groove is formed on the shaft for the attachment of the bolt. On the another end of the shaft a pulley is attached which, with the help of a belt (A-cross section) is connected to driving pulley mounted on an electric motor of 1 H.P. An mild steel strip is attached at the upper end of the cylindrical vessel on which a bush is fabricated facing downward. A bearing is fixed in it to support and hold the shaft on the upper end. The specimen is attached on the blades by means of nut and bolts on the span of both the blades, that are rectangular in shape. When the blades rotate, it provides tangential impact on the specimen leading to sliding wear .On the outer surface of the cylinder an iron frame is fabricated in order to hold the motor. A nut bolt arrangement is provided for the lateral shifting of electric motor for better adjustment of the belt and the pulleys.

3. **Specimen holding arrangement** In Specimen Holding Arrangement, the blades are made of cut section of C.R Iron sheet and welded to a hollow pipe which is in turn mounted on the main cylinder shaft. The specimen is mounted on the blades of the shaft using 5mm diameter bolts. This arrangement facilitates easy mounting, dismounting and changing the metal specimens.

V. SPECIMEN SPECIFICATION

1. Aluminum plate: Aluminum being a ductile material has been chosen as the wear test piece material for the present study. The specific gravity of Aluminum is 2.7g/cc. The size of the wear piece used was 50 mm x 20 mm of thickness 2 mm to fit in the slot of the blades. Each wear test piece was fixed in the blades with the help of bolts. The

 DOI : 10.18231/2454-9150.2017.0010

wear pieces were polished using 1000 number emery paper and cloth before conducting the experiment to ensure identical initial conditions for each set of data.

2. **Copper Plate:** Copper being a ductile material has been chosen as another wear test piece material for the present study. The specific gravity of Aluminum is 8.9g/cc. The size of the wear piece used was 50 mm x 20 mm of thickness 2 mm to fit in the slot of the blades. Each wear test piece was fixed in the blades with the help of bolts. The wear pieces were polished using 1000 number emery paper and cloth before conducting the experiment to ensure identical initial conditions for each set of data.

Particle size: Measurement of particle size distribution is essential to establish the variation in the particles in the solid sample and the percentage of particles present in different size ranges. For the coarser particles, sieve analysis can be used to determine the particle size distribution. This distribution has been obtained by dry sieve analysis method. A representative sample of the solid particle is taken and sieving is done with a set of sieves. Special care is taken to ensure that the sample is properly dried. The sample retained on each sieve is collected and its percentage is calculated following the standard procedure.

Table I: Sieve analysis of specimen

Grade	Element	Composition
G-40	CARBON	0.6 TO 1.25 %
	SILICON	0.2 TO 1.10 %
	MAGNESE	1.125% max
	PHOSPHORUS	0.080% max
	SULPHUR	0.080%max

GRADE	SIEVE ANALYSIS
G-40	1.000MM – ALL PASS
	1.000MM – ALL PASS
	0.425MM- 70% MIN
	0.300MM- 80% MIN

Table II : Specification of solid particle Steel GRIT(G40)

DENSITY - 7.4 gm/m^3 /minimum
HARDNESS - >700HV
MICROSTRUCTURE – Fine & Uniform Martensite

VI. EXPERIMENTAL PROCEDURE

Fresh wear specimens are taken for each experiment and are polished with #1000 emery paper before conducting any wear test to keep identical initial condition for each experiment. The wear specimens are cleaned with tap water, dried with hot air blower before and after each test. Mass loss of the wear specimen is measured by an electronic balance (Make: Contech) having least count of 0.01 g. The average mass loss of two wear specimens is evaluated. To prepare the solid-liquid mixture, a predetermined mass of solid particles was poured first in the pot and then it was closed by tightening the acrylic cover. Known quantity of water was then poured through the hole at the top of the cover to fill the pot. The mean size diameter of slurry particle is known. The propeller shaft is rotated at the desired suspension speed to achieve nearly uniform distribution of solid particles in water with the help of AC motor. The speed of each shaft is measured by using a tachometer. The assembly of the test fixture was mounted on blades of the propeller shaft, which is to be rotated at desired test speed. The test is performed by fixing the samples (rectangular, square or circular) on to a fixture attached with a shaft. The assembly is to be immersing in the container drum containing the slurry. The shaft is attached to a motor, which can be rotated at varying and predetermined speed

VII. RESULTS

Mass loss method:

The sample can be weighed prior to and after a particular interval corresponding to a particular sliding distance, to find out the corresponding weight loss. The slurry wear rate (m³/m) can be used for comparison. The graph is plotted between the time run and material loss.

The material loss primarily depends upon the ash concentration in the slurry and the rotational speed of the pump impeller. By using the average mass loss method the approximate deterioration time can be calculated. Performance of the pump can be increased by determining the work range. Erosive wear of the pump impeller would decreases with decreasing ash concentration, rotation speed and particle size. Experimental set-up show that as increases the time run the erosion wear increases. effect of metals, minerals, polymers composites, ceramics, coatings samples in the slurry flow analysis can be tested with this instrument

Table III : Results of Mass loss on Cu plate(Sample I & II)

Material	Sample Dimensions	Motor Speed(rpm)	Initial Weight(gm)	Final Weight(gm)	Time Run(min.)	Material Loss(gm)
Copper Plate Sample-I	10cmx5 cm	160 max.	41.10gm	40.95gm	30	.03
					60	0.05
					90	0.08
					120	0.11
					150	0.13
					180	0.14
					200	0.15
Copper Plate Sample-II	10cmx5 cm	160max.	39.35gm	39.21gm	30	0.025
					60	0.058
					90	0.079
					120	0.102
					150	0.120
					180	0.130
					200	0.140

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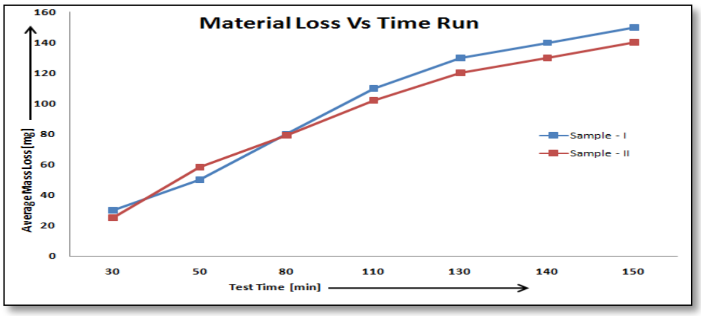

Fig 7: Variation of Mass loss on Cu plate w.r.t. Time run

Table IV: Results of Mass loss on Al plate(Sample I & II)

Material	Sample Dimensions	Motor Speed(rpm)	Initial Weight(gm)	Final Weight(gm)	Time Run(min.)	Material Loss(gm)
Aluminum Plate Sample-I	10cmx5 cm	160 max.	7.83gm	**7.62gm**	**20**	**.015**
					40	**.045**
					60	**.078**
					80	**.125**
					100	**.165**
					120	**.187**
Aluminum plate Sample-II	10cmx5 cm	160max .	7.87gm	**7.64gm**	**30**	**.018**
					60	**.074**
					90	**.132**
					120	**.172**
					140	**.198**
					150	**.23**

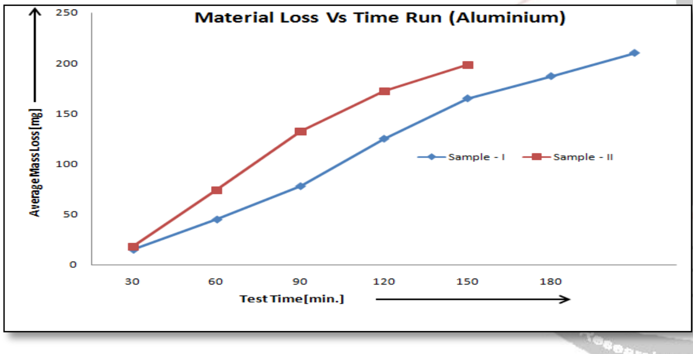

Fig 8: Variation of Mass loss on Al plate w.r.t. Time run

VIII. CONCLUSION

Impact wear is affect by the various parameter like solid particle size, % of concentration of particle size, Impact angle, settling time of solid particle and the time of run. Desale has performed the sam experiment by using the pot tester in which the wear specimen is suspended on sand water slurry for an impact angle 30^0 & 75^0 with narrow size particle of 855µm,505µm & 225µm and measured the weight loss. Gandhi[2] is also performed the experiment on pot tester with multi-sized slurries by using median diameter or weighted mean diameter for multi sized slurries. In this present experimental set up the impact angle is 90^0 , the wear piece of Cu and Al is directly suspended in the slurry medium and solid particle size of Steel grade(G-40) is large as compared with other solid particles which are used in existing pot testers.

This pot tester is designed for finding the relationship between the wear rate and rotational velocity of slurry medium and also between the wear rate and the time of run. By comparing the results with previously existing data the relationship exist that the wear rate is directly proportional to the time run & rotational speed of slurry medium with constant Slurry concentration.

IX. FUTURE SCOPE

The Computational approach can be used to simulate propeller and stir tank to study the quality of suspension and effect of dance slurry. The energy dissipation rates and the vorticity in the stir tank can also be studied using computational fluid dynamics. The wear tests in the slurry pot tester can be performed by using different blade profiles and by provision of baffle clearance at the sides and bottom of the tank.

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DOI : 10.18231/2454-9150.2017.0010