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Simulate the Erosion Wear of AISI SS 304L due to Solid- Liquid Mixture

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ABSTRACT

A Jet erosion is normally used to study the relative erosion behaviour of different material at moderate solid concentration, velocity, and particle size and impact angle. A slurry pot t is then fabricated by inserting propeller from the bottom of the cylinder and is rotated at the speed required for uniform distribution. The test specimens are then mounted on test fixture which is fixed and has a provision to move in different angular position to find out the wear for different angles. Erosion of materials is occurs due to the impact of high velocity of slurry which is comes out from the nozzle and impacting on the test specimen. Two different experiments are conducted preliminarily first for repeatability test for fix parameters such as angles from 15^0 to 90^0 in six intervals of 15^0 difference,particle size 655micron, and 10% solid concentration for 120 minutes The results were obtained for ductile material and are found in good arrangement with the literature.

Keywords— Jet Erosion tester, Slurry erosion, Nozzle, Repeatability, Authentication

I. INTRODUCTION

Wear is defined as the progressive volume loss of material from a target surface. It may occur due to corrosion, abrasion or erosion. The wear due to corrosion is caused by chemical reactions, which can be prevented by adopting suitable measures; whereas the wear due to abrasion and/or erosion can only be minimized by controlling the affecting parameters. Erosion wear is a very crucial parameter for selection and design of slurry transportation systems as it affects directly to the economy of hydraulic conveyance of solids.

[1] The service life of equipment handling solid-liquid mixtures is limited due to erosion wear and therefore efforts have been made in past few decades to predict the erosion loss of materials. Erosion wear is a complex phenomenon, which depends on large number of parameters. Erosive wear is the dominant process which can be defined as the removal of material from a solid surface. It is due to mechanical interaction between the surface and the impinging particles in a liquid stream. In Erosion process there is a transfer of kinetic energy to the surface. With the increase in kinetic energy of the particles impacting at the target surface, it lead so increase in the material loss due to erosion.[4-6]It depends on the predominant impact angle of particle impingement with the material surface and it will vary from 0to90 degrees. Impact angle depend on both fluid particle and particle –particle interaction. This type of wear can be practically found in slurry pumps, angle d pipe bends, turbines, pipe sand pipe fitting, nozzles, burners etc. The material loss due to erosion increases with the increase in kinetic energy of the particles impacting at the target surface.[3]

Slurry Erosion

It is defined as that type of wear, or loss of mass, that is experienced by a material exposed to a stream of slurry. This erosion accurse it her when the material moves at a certain velocity through the slurry or when the slurry moves past the material at a certain velocity. Slurries erode by the action of abrasive particles in the liquid which results in the failure of the surface of material in one or the other mode depending upon the conditions to which the system is exposed. Slurry erosion is a serious problem for the industries, which deals with the liquids having solid particles entrained in them. When such a mixture of liquid and solid particles termed as slurry come in contact with the machine element, the removal of material takes place from the surface making the component redundant from the surface.[10]

Parameters affecting one erosion wear

Impact angle

Impact angle is defined as the angle between the target surface and the direction striking velocity of the solid particle. The rate of mass loss due to erosion is a function of impact angle of particles. The variation of erosion wear with the impact angle is different for brittle and ductile materials. The maximum erosion occur sat20-30degreesimpactanglesfor ductile materials. Whereas, the maximum erosion wear occurs at 90 degree impact angle in case of brittle materials.[15]

Velocity of solid particles

Velocity of solid particle strongly affects the erosion wear. The impact velocity has dominant effect on the material removal rate. As particle velocity increases there is significant increase in erosion rate. The erosion rate is generally related to the particle velocity using power law. Relationship in which the power index for velocity varies in the range of2-4.Gandhietal(1999), evaluated the erosion rate is a function of velocity.
Erosion rate =f(velocity2.6)

Hardness

Hardness is the characteristic of a solid material expressing its resistance to permanent deformation. Surface hardness as well as hardness of solid particles has profound effect on the erosion wear mechanism. Hardness ratio has been defined as the ratio of hardness of target material to the hardness of solid particles. Gandhi et al.(2008,)developed a correlation between hardness ratio of particleto metal K(HP/HT)and erosion rate i.e.ED90 = 6.62× K(HP/HT) V2.02×d1.62CW-0.285

Particle sizeandshape

Particle size and shape is also one of the prominent parameter, which affect erosion wear. Many investigate or shave considered solid particle size important to erosion. The erosion wears increases with increase in particle size according to power law relationship. The effect of particle shape on the erosion is not very well established due to difficulties in defining the different shape features. Generally roundness factor is taken into consideration. If roundness factor is one then the particles are perfectly spheres and a lower values show the particle angularity.[14]

Solidconcentration

Concentration is amount of solid particles by weight or by volume in the fluid. As concentration of particle increases more particles strike the surface of impeller which increase the erosion rate, the concentration of slurries can vary from 2%to50% depending upon the type of slurry. However, at very high concentrations particle interaction increases and this decreases the striking velocity of particle on the surface.[12]

II. DEVELOPMENT OF JET EROSION TESTER

Photograph of jet erosion tester

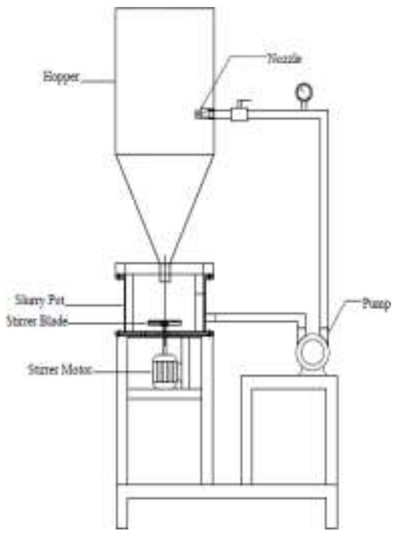

Fig.1 Schematic Diagram of Jet Erosion Tester

III. DESCRIPTION OF JETEROSION TESTER

This test rig consist of important part namely as slurry pot. This pot has 7.3 lit capacity similar to one which were developed by Desale et al (2005).the function of this pot is to prepare homogeneous mixture of Narmada sand and water for different particle sizes and different concentrations. To prepare the homogeneous mixtures of different combinations the pot has a stirrer which is to be rotated with the help of 3phase A.C. motor has

maximum capacity of 1440 rpm. Rotational speed of a motor is controlled with the help of 3 phase dimmer stat (Transformer).This test rig also contains a centrifugal pump of 0.5Hp capacity made by Kirloskar Pumps. This pump sucks the slurry from slurry pot and supply the high pressure slurry to the converging section of the nozzle having 10 mm diameter where its pressure energy is converted into the velocity of fluid.
There is one control valve also attached to control the mass flow rate of the mixture. It also has a specimen holder (Fixture), which has an arrangement to moves in different angular positions. One tin hopper is also attached to rig which is help to restrict the spreading of mixture into the work environment. This hopper collects the mixture after impacting on the specimen and drops it back into the slurry pot to recirculate the mixture. There is one acrylic plate which covers the slurry pot and gives support to the hopper or holds the hopper; it has holes on it for the hopper opening to put back the mixture in to the slurry pot. And the main part of the test rig is the frame structure which supports or holds the whole assembly and stirrer motor.

IV. PARTICLE SIZE DISTRIBUTION

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. [1]
The particles of IS sand is selected as solid material for the present investigation and its physical properties are given in Table 1. It is not possible to collect identical size particles of the solid material. The particles are, therefore, sieved using successive sieves sizes and the particles collected between two successive sieves are designated by the mean sieve size. To collect quartz particles, the mean particle size of 655 µm was collected as the material retained between the two sieves of 600 µm and 710 µm sizes.

Photograph of sieves

Photograph of sand particle size 655µm

TABLE 1
PHYSICAL PROPERTIES OF ERODENT USED

Sr.No.	Solid particle	Chemical formula	Colour	Sp. Gravity (Kg/m3)	Hardness VHN	Particle Shape
1	Quartz (IS Sand)	SiO2	Whitish	2652	1100	Sub Angular

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TABLE II
ELEMENTAL COMPOSITION OF TARGET MATERIAL USED

Sr.No.	Target Material	Element Composition (Wt %)								
		C	Mn	P	S	Si	Cr	Ni	Mo	N
1	AISI SS304L	0.030	2.00	0.045	0.030	0.75	17.50-9.50	8-12	---	0.10

TABLE III
RANGE OF PARAMETERS FOR THE INVESTIGATION ON EROSION BEHAVIOUR OF DUCTILE MATERIAL AISI SS304L

Sr No.	Target material	ification type	Impact angle (degree)	Particle Size (µm)	Solid particles	Solid concentration % by wt.	Time (min.)
1	AISI SS304L	Repeatability	$15^0, 30^0, 45^0, 60^0, 75^0, 90^0$	655	artz (IS Sand)	10 %	120

V. EXPERIMENTAL PROCEDURE

1. Theprocedurehastobefollowedonerosiontestertocalculatetheerosionwearofdifferent materials is as follow:
2. Weighingthespecimen(initial weight).
3. Clamp the specimen infixtureprovided in test rig.
4. Settingthe fixtureatrequired angle.
5. Weight the required sandas per concentration ofslurry.
6. Mixingthe proper amount of waterand sand in tank.
7. Start thepump.
8. Adjusttheflowratetoobtaindesiredvalueofmassflowrateandrunningthetestfor required time interval.
9. Removingthe specimenfromthe fixture.
10. Cleaningand dryingthespecimen.
11. Weighingthespecimenafter erosion to measurethemass loss.
12. Repeat thesteps from 1to 10as perrequirement.

VI. CONCLUSIONS

Arrangements in the Jet Erosion Tester have been made to evaluate the effect of impact angle, concentration, velocity, particle size etc. on erosion wear. This design of jet erosion tester is intend to conduct wear tests at moderate solid concentrations and actual flow of velocities to simulate the wear conditions for pipeline, bend, pump etc. and may provide more realistic results.

Finally, the contributions of jet erosion wear is find out in the form weight loss for the series of different impact angles such as 15^0,30^0,45^0,60^0,75^0,90^0at 10% solid concentration of sand for 120 minutes for ductile materials. For different angular positions it is observe that the weight loss is increases as the angle is increases from 15^0 to 30^0 the maximum weight loss is occur at 30^0 angle of impact and it decreases as angle is increases from 30^0 to 90^0respectively. According to literature it shows that AISI SS304L is ductile material.

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