Novelty Journals

ISSN 2394-7349

International Journal of Novel Research in Engineering and Science
Vol. 2, Issue 1, pp: (14-20), Month: March 2015 - August 2015, Available at: www.noveltyjournals.com

Development of Slurry Jet Erosion Tester to Simulate the Erosion Wear due to Solid-Liquid Mixture

[1]Pramod A. Thakur, [2]Hitesh S. Khairnar, [3]Dr. E.R. Deore, [4]S.R. More

[1,2,3,4] SSVPS'S B.S.D. College of Engineering, Dhule, India

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 45^0,particle size 655micron,angle and 10% solid concentration for 60 minutes and another one for authentication. The results were obtained for ductile material and are found in good arrangement with the literature.**

Keywords: **Authentication, Jet Erosion tester, Nozzle, Repeatability, Slurry erosion, Slurry.**

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 leads to 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, angled pipe bends, turbines, pipes and pipefitting, nozzles, burners etc.Thematerial 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 occurs 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 thesurface.[10]

Parameters Affecting on Erosion Wear:

Impact angle:

Impact angle is defined as the angle between the target surface and the direction of 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 occurs at 20-30degrees impact angles for 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 of 2-4 Gandhi et al (1999), evaluated the erosion rate is a function of velocity.

Erosion rate $= f(\text{velocity}^{2.6})$

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.$E_{D90} = 6.62\times K_{(HP/HT)} V^{2.02}\times d^{1.62} C_W^{-0.285}$

Particle size and shape:

Particle size and shape is also one of the prominent parameter, which affect erosion wear. Many investigators have considered solid particle size important to erosion. The erosion wear 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. Generallyroundness factor is taken into consideration. If roundness factor is onethen the particles areperfectlyspheres andalowervaluesshow the particleangularity.[14]

Solid concentration:

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 from2%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

Fig.1 Photograph of jet erosion tester

Novelty Journals

ISSN 2394-7349

International Journal of Novel Research in Engineering and Science
Vol. 2, Issue 1, pp: (14-20), Month: March 2015 - August 2015, Available at: www.noveltyjournals.com

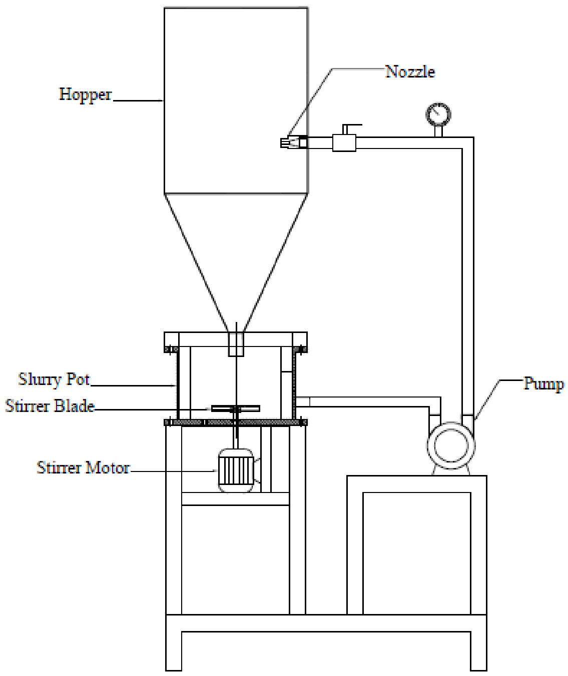

Fig.2 Schematic Diagram of Jet Erosion Tester

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.

III. 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.

International Journal of Novel Research in Engineering and Science
Vol. 2, Issue 1, pp: (14-20), Month: March 2015 - August 2015, Available at: www.noveltyjournals.com

To collect quartz particles, two grades namely, Grade II and III of Indian standard sand were used. From Grade II, the mean particle size of 655 µm was collected as the material retained between the two sieves of 600 µm and 710 µm sizes. The grade III is used to collect particle of size below 500 µm.

Fig.3 Photograph of sieves

Fig.4 Photograph of sand particle size 655µm

Fig.5 Photograph of sand particle size 450µm

International Journal of Novel Research in Engineering and Science
Vol. 2, Issue 1, pp: (14-20), Month: March 2015 - August 2015, Available at: www.noveltyjournals.com

TABLE 1PHYSICAL 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

TABLE II ELEMENTAL COMPOSITION OF TARGET MATERIAL USED

Sr.No.	Target Material	Element Composition (Wt %)						
		Si	Fe	Cu	Mn	Mg	Cr	Ti
1	Aluminium Alloy 6063	0.38	0.22	0.003	0.004	0.52	0.004-0.06	0.012

TABLE III RANGE OF PARAMETER FOR PRELIMINARY STUDY

Sr No.	Target material	Investification type	Impact angle (degree)	Particle Size (μm)	Solid particles	Solid concentration % by wt.	Time (min.)
1	Aluminium Alloy 6063	Repeatability	45˚	655	Quartz (IS Sand)	10 %	60

TABLE IV RANGE OF PARAMETERS FOR THE INVESTIGATION ON EROSION BEHAVIOUR OF DUCTILE MATERIAL AA6063

Sr No.	Target material	Investification type	Impact angle (degree)	Particle Size (μm)	Solid particles	Solid concentration % by wt.	Time (min.)
1	Aluminium Alloy 6063	Repeatability	15^0,30^0,45^0,60^0,75^0,90^0	655	Quartz (IS Sand)	10 %	60

IV. EXPERIMENTAL PROCEDURE

The procedure has to be followed on erosion tester to calculate the erosion wear of different materials is as follow:

1. Weighing the specimen (initial weight).
2. Clamp the specimen in fixture provided in test rig.
3. Setting the fixture at required angle.
4. Weight the required sand as per concentration of slurry.
5. Mixing the proper amount of waterand sand in tank.
6. Start thepump.
7. Adjust the flow rate to obtain desired value of mass flow rate and running the test for required time interval.
8. Removing the specimen from the fixture.
9. Cleaning and drying the specimen.
10. Weighing the specimen after erosion to measure the mass loss.
11. Repeat the steps from 1to 10as per requirement.

V. RESULT AND DISCUSSION

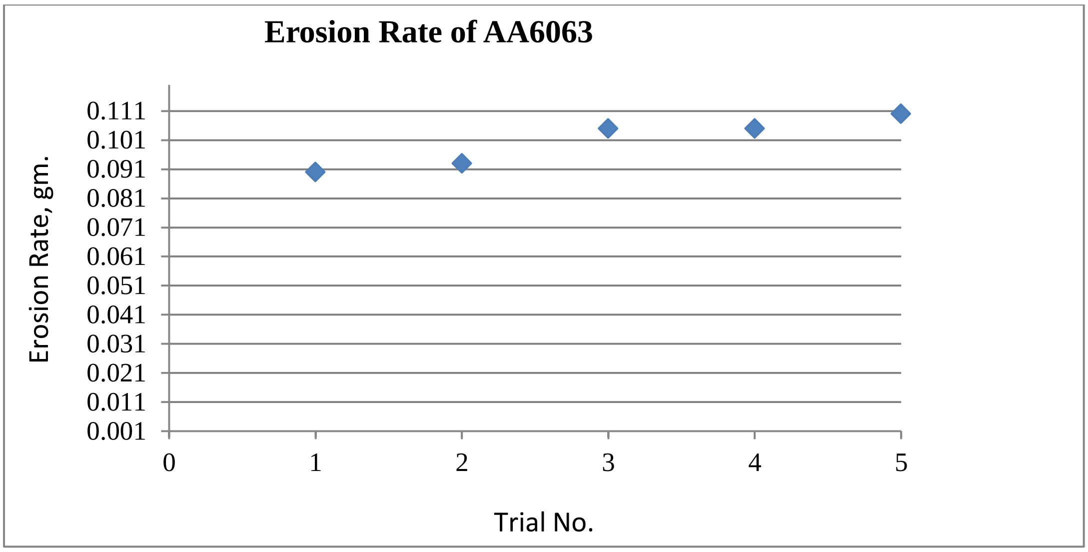

Fig.6 Repeatability of erosion wear data determined by using jet erosion tester
(Particle Size 655µm,10% concentration for 60 min at 45^0 angle)

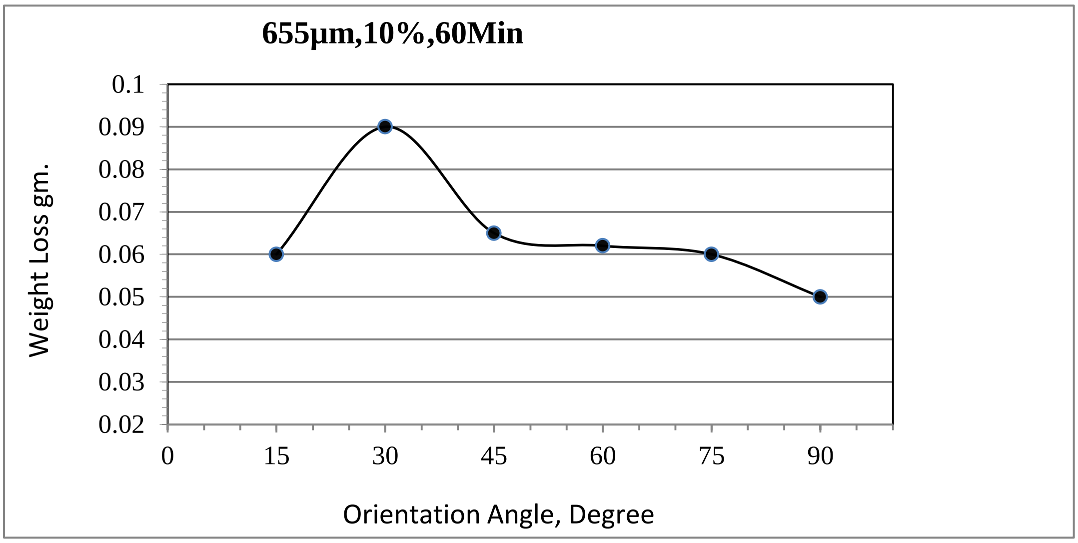

Fig.7 Variation of erosion wear at different angles
(Particle size 655µm 10% concentration for 60 min. at 15^0,30^0,45^0,60^0,75^0,90^0 angles)

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 and also for the at the same conditions like 45^0 angle , 10% solid concentration of sand for 60 minutes for ductile materials. By the observations it is found that the near about same weight loss is occurs at same working condition. For second test taken for different angular positions it is observe that the maximum weight loss is occur at 30^0 angle of impact and it decreases as angle is decreases respectively. According to literature it shows that AA6063 is ductile material.

International Journal of Novel Research in Engineering and Science
Vol. 2, Issue 1, pp: (14-20), Month: March 2015 - August 2015, Available at: www.noveltyjournals.com

REFERENCES

[1] Satish R More,Bhushan D Nandre,2014,"Development of pot tester to simulate the erosion wear due to solid-liquid mixture",IJRSD,Vol.2

[2] Al-Bukhaiti. M.A., S.M. Ahmedb, F.M.F. Badran b, K.M. Emarab, 2007, "Effect of impingement angle on slurry erosion behaviour and mechanisms of 1017 steel and high-chromium white cast iron", Wear, Vol. 262, pp. 1187-1198.

[3] Bree, S. E. M. de, Rosenbrand, W. F., and Gee, A. W. J. de, 1982, "On the erosion resistance in water-sand mixtures of steels for application in slurry pipelines", Hydrotransport 8, BHRA Fluid Engineering, Johannesburg, (S.A.), Paper C3.

[4] Desale, G. R., Gandhi, B. K., and Jain, S. C., 2005A, "Effect of physical properties of solid particle on erosion wear of ductile materials", Proceedings of 2005 ASME World Tribology Congress III, Washington, D.C., USA.

[5] Desale, G. R., Gandhi, B. K., and Jain, S. C., 2005B, "Improvement in the design of a pot tester to simulate erosion wear due to solid-liquid mixture", Wear, Vol. 259, pp. 196-202.

[6] Abbade, N. P., and Crnkovic, S. J., 2000, "Sand-water slurry erosion of API 5L X65 pipe steel as quenched from intercritical temperature", Tribology International, Vol. 33, pp. 811-816.

[7] Lin, F. Y., and Shao, H. S., 1991A, "Effect of impact velocity on slurry erosion and a new design of a slurry erosion tester", Wear, Vol. 143, pp. 231-240.

[8] Lin, F. Y., and Shao, H., 1991B, "The effect of impingement angle on slurry erosion", Wear, Vol. 141, pp. 279-289.

[9] Levy, A. V., 1981, "The solid particle erosion behavior of steel as a function of microstructure", Wear, Vol. 68, pp. 269-287.

[10] Bitter, J. G. A. 1963A and B, "A study of erosion phenomena Part I", Wear, Vol. 6, pp. 5-21, pp. 169-190.

[11] Neilson, J. H., and Gilchrist, A., 1968, "Erosion by a stream of solid particles", Wear, Vol. 11, pp. 111-122.

[12] Gandhi, B. K., Singh, S. N., and Seshadri, V., 1999, "Study of the parametric dependence of erosion wear for the parallel flow of solid-liquid mixtures", Tribology International, Vol. 32, pp. 275-282.

[13] Gupta, R., Singh, S. N. and Seshadri, V. 1995, "Prediction of uneven wear in a slurry pipeline on the basis of measurements in a pot tester", Wear, Vol. 184, pp. 169-178.

[14] Gandhi, B. K., Singh, S. N., and Seshadri, V., 1999, "Study of the parametric dependence of erosion wear for the parallel flow of solid-liquid mixtures", Tribology International, Vol. 32, pp. 275-282.

[15] Desale G.R., Paul C.P., Gandhi B.K., Jain S.C., 2009, "Erosion wear behavior of laser clad surfaces of low carbon austenitic steel", Wear, Vol. 266, pp. 975-987.

[16] Desale G.R., Paul C.P., Gandhi B. K., 2009, "Slurry Erosion Wear Properties of Laser Cladding", Kiran, Vol. 20., No. 2., pp.26-33.