Investigation of Slurry Erosion Behavior using Slurry Erosion Impact Test Rig

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Abstract

In the industries, there are different types of materials used for the different kind of purposes & works. Materials are selected for various purposes according to their different kind of properties. But after long interval of time material get eroded due to erosion. Erosion is mainly caused by sliding & colliding action of solid, liquid & gaseous particles over the surface of component in service. Present work investigated the slurry erosion behavior of AISI304 Steel under different condition such, velocity, impact angle and concentration. Slurry erosion testing was carried out for the duration of 120 mins. Testing was carried out on laboratory developed apparatus. For proper interaction of various parameters and to analyze their influence statistical technique such as Taguchi l9 orthogonal array was used for Design of Experiment. Result obtained by the experimentation was further analyzed using Taguchi approach. Regression equations are modeled for modeling of the slurry erosion process of AISI 304 steel. It was found that AISI 304 Steel shown best resistance at impact angle of 90^{o}. It was found that velocity has significant effect on the erosion rate of material.

Keywords: Slurry Erosion, Material, Rig, Statistical Technique, Erosion rating.

1. Introduction

Erosion is an undesirable problem found in the power generation units like thermal power plants, hydraulic power plants, air craft engine and chemical processing equipment. Erosion is removal of material from the surface of in service component due to colliding and sliding of liquid, solid and gaseous particle on surface [1]. Erosion is degradation of material surface due mechanical action often by impinging liquid, abrasion by slurry, particles suspended in fast flowing liquid or gas, bubble or droplet, cavitation etc. [2].

It happens due to repeated impact of solid and liquid particles on pipe surface. If the surface material is ductile, repeated particle impacts will result in the formation of craters and platelets; craters will grow with subsequent particle impact and eventually platelets are easily removed into the flow, Figure 1-a. Brittle material on the other hand, will grow lateral and radial cracks under sand particle impact, which will grow and eventually form small pieces that are removed by continuous solid particle impingement, figure 1-b [3].

Erosion causes the major economical loses in the industries as well as in power plants. Flow of liquid and erosive environment are factors on which erosion rating of material depends. It is

complex phenomena that depend on many parameters [3]. The parameters on which erosion rate depends are given below:

Particle shape
Particle Size
Particle hardness
Particle velocity

In thermal power plant ash containing $SiO_2$and unburned carbon particle are cause of removal of material from heated boiler tubes. Erosion severely damages flow passages, valves and pipe fittings, leading to higher replacement costs as well as the loss of valuable production time. For example, some oil and gas fittings can fail after just 30 minutes of operation due to high erosion rates [3]. Hydraulic power plants and other fluid machineries get affected by erosion because many components are in continue contact with water containing $SiO_2$and other hard particles. This problem becomes more in rainy seasons due to increase in slurry concentration of harder particles impacting the surface [4].In these system exhaustive filtration process is not possible. Therefore slurry is a major accountable factor causes the erosion.

Slurry is a thin suspension of solid in liquid and mostly form by mixing of silicon oxide (SiO_2)in water. It is thin sloppy mud or cement, in extend use, any fluid mixture of pulverized with a liquid (usually water) often used as a convenient way of handling solid in bulk [5].

In the present research paper for testing the material a test rig named as slurry erosion test rig is developed, Figure-2. Test rig consist of a chamber in which specimen is hold inside the holder. Water impinges on the specimen with the help of jet. Water supply in jet by 0.5 HP mud pump. There is pressure gauge and the control valve is fitted by which flow of water increases and decreases. Chamber is fit on tub in which slurry & water is mixed. This water periodically used with the help of water pump. Erosion rate is test on specimen according to different parameters like impact angle, slurry concentration, velocity of water etc.

2. EXPERIMENT PROCEDURE

2.1 Material

AISI 304 stainless steel is used for testing. It is widely used in hydroelectric power plant due to their good corrosion properties and acceptable resistance to solid particle erosion. Slurry is mixed in water with various concentrations. For example if 1 liter of water is used for testing then 100 gm of slurry mixed in water, this means there is 0.1 % concentration of slurry is mixed in 1 liter water.

2.2 Erosion testing

For testing, a specimen of dimensions 25*25*5 mm of AISI 304 stainless steel material was fit inside the specimen holder. By changing the position of holder distance between specimen and jet can be increase or decrease. Specimen was test for three different parameters. Three

parameters were velocity of slurry water, concentration of slurry water and impact angle of slurry water on specimen. Tub was filled with 1 liter of water.

For different velocity of water pressure gauge was used. By increase or decrease the pressure of water in pipe velocity of water were different in jet. Set the pressure of pressure gauge at 0.3 bar. Before start the experiment note down the weight of specimen. Fit the specimen in holder and turn on the electric supply of water pump for the first position of valve. Testingwas carried out of the material for 30 minutes and turn off the water pump supply. After 30 minutes of testing note down the weight of specimen.in second and third time testing were carried out for 0.6 and 0.9 bar for 30 minutes. In these cases concentration of slurry are 0.1% and impact angle is 90^o.

For different concentration of slurry, firstly note down the weight of specimen and fit the specimen in holder. Mix 100 gm of slurry in water and turn on water pump. Test the material for 30 minutes and turn offwater pump supply. Note down the specimen weight. Test the material for 200 gm and 300 gm of slurry for 30 minutes respectively. In these cases impact angle was 90^o and volume/min wasmaximum.

Three impact angles 30^o, 60^o and 90^o are taken for testing. Note down the weight of specimen and fit it at angle of 90o. Test the specimen for 30 minutes and note down the weight. Do the same experiment for 30^o and 60^o for 30 minutes. In these cases volume/min was maximum and the concentration of slurry in water was 0.3%.

3. RESULT AND DISCUSSIONS

Figure-1 shows the erosion mechanism of ductile material and brittle material. Figure-2 presents the setup of the slurry erosion test rig.

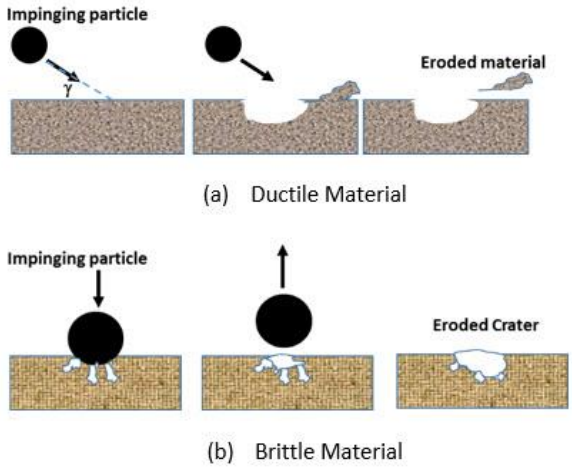


Figure 1: Erosion Mechanism: a) Ductile Material; b) Brittle Material.

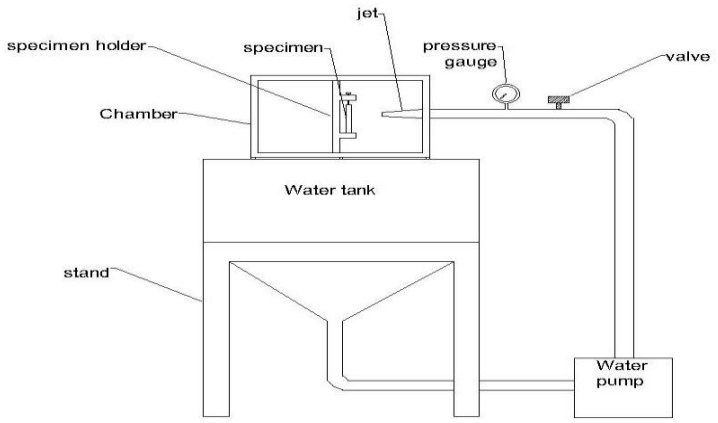


Figure -2 Block diagram of slurry erosion test rig

According to the experiment procedure testing carried out of AISI 304 stainless steel for three parameters. According to three parameters erosion rate find out in observation table and plotted in graph which are given further.Table-1 base on erosion rate according to the change in volume/min with the time interval of 30 minutes. Table-2 represents the observations which are based on the change in slurry concentration in 30 minutes. Table-3 shows the erosion rate according to change in impact angle in time interval of 30 minutes.

Table-1 – Figure-3

Volume/min	12L/min	13.5 L/min	15L/min
Initial Weight	82.970gm	83.965gm	83.957gm
Final weight	83.965gm	83.957gm	83.942gm
Weight loss	0.005gm	0.008gm	0.015gm

Impact angle = 90^{o}, Slurry Concentration = 0.1 %, Time Interval = 30 minutes

Table-2-Figure-4

Slurry concentration	0.1%	0.2%	0.3%
Initial Weight	82.985gm	82.978gm	82.973gm
Final Weight	82.978gm	82.973gm	82.970gm
Weight Loss	0.007gm	0.005gm	0.003gm

Impact angle = 90^o, Volume/min = 15 L/min, Time interval = 30 minutes

Table-3-Figure-5

Impact angle	90^o	60^o	30^o
Initial Weight	83.016gm	83.002gm	82.992gm
Final Weight	83.002gm	82.992gm	82.985gm
Weight loss	0.014gm	0.010gm	0.007gm

Slurry concentration = 0.1%, Volume/min = 15L/min, Time interval = 30 minutes

By changing above parameters 3 graphs are plotted in which result find out of erosion rate.

Figure-3

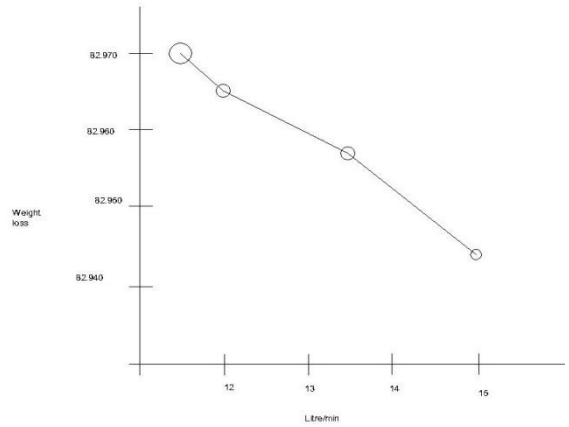


Figure-4

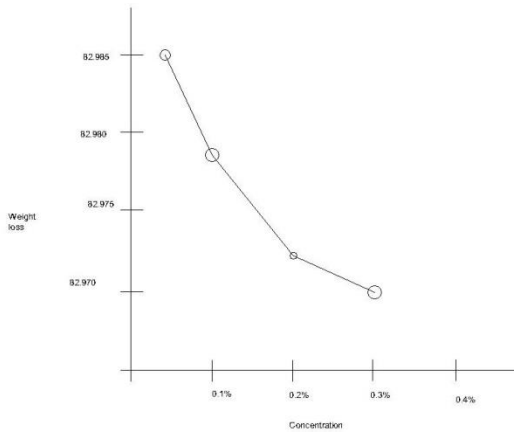
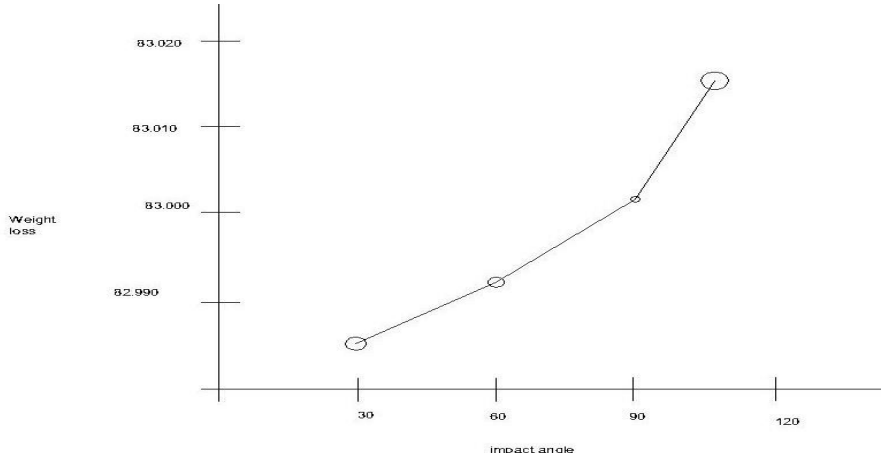


Figure-5



According to the variations of three parameters three graphs has been plotted. First graph show the variation of velocity or volume/min of water and weight loss. Second graph represents the variation of slurry concentration and weight loss. Third graph present the erosion rate by changing the parameters of impact angle. In all above changing parameters testing time was 30 minutes. There was different erosion rate according to different parameters.

CONCLUSION

Above three graphs shows that erosion rate will be maximum in the cases of velocity parameters and minimum in cases of slurry concentration. Velocity of slurry mixed water effect the mostly the specimen material. As we increase the velocity of water erosion rate increases. On the second number impact angle affect the specimen. When the impact angle was 90^o then erosion rate was maximum and when angle was 30^o then erosion rate was minimum. Last parameter was slurry concentration. When slurry concentration was minimum then erosion rate was maximum and when increase the slurry concentration was maximum then erosion rate was minimum. In case of maximum slurry concentration less number of particles impinges on specimen because there are more collision of particle with each other. Therefore erosion rate was minimum in high concentration and maximum in less concentration.

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