Investigation and Study of Dry Erosion Behavior Using Dry 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 dry erosion behavior of AISI304 Steel under different condition such, velocity, impact angle and concentration. Dry erosion testing was carried out for the duration of 45 min. 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 dry 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 Dry Erosion, Erosive wear, Material, Rig, Statistical Technique.

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. Some of the particle parameters of erosion are given below:

* Particle shape
* Particle Size
* Particle hardness
* Particle velocity

This type of wear is common in many industrial devices including boilers .The combustion products of coal contain fly ash particle as ,which impinges boiler tube or fan blades and erode them. Fly ash erosion is the second most important cause for the boiler tube failure. At the highest rate of erosion, tube failures may occur after 16,000 hours in service.[4] In the present study, the diagnostics of AISI 304 were carried out in developed test rig to calculate the weight loss under various changing parameters. Testing and weight loss study were carried out by changing one parameter and keep constant other parameters.

2. Experiment procedure

2.1 Material

AISI 304 stainless steel is used for testing because it is widely used in thermal power plants due to their good corrosion properties and acceptable resistance to solid particle erosion.

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 specimen holder and nozzle can be increased or decreased. A 1.5p and 8 bar compressor is used for compressed air. The output of compressor pipe is connected with angle valve Sand is mixed in compressed air with the help of angle valve by which feed rate of sand can be varied. For different velocity of air pressure gauge was used. By increase or decrease the pressure velocity of air can be varied. Before start the experiment note down the weight of the specimen. Fit the specimen in the holder and turned on the electricity supply of the compressor for the 2 bar pressure. Testing was carried out of the material for 20 min and turned off the supply of the compressor. After 20 min of testing note down the weight of specimen. In second and third time testing were carried out for 4 and 6 bar for 20 min. In these cases feed rate of sand was 100gm/min and impact angle was 90^0. For different feed rate of sand, firstly note down the weight of specimen and fit the specimen in holder. Set the position of valve for the feed rate of 100 gm/min of sand and turn on the electric supply of compressor. Test the material for 20 minutes and turn off air compressor supply. Note down the specimen weight. Test the material for 200 gm/min and 300 gm/min of sand for 20 minutes respectively. In these cases impact angle was 90^o and pressure was 6 bar. 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 90^o. Test the specimen for 20 minutes and note down the weight. Do the same experiment for 30^o and 60^o for 20 minutes. In these cases pressure was 6 bar and the feed rate of sand in compressed air was 300 gm/min

3. Result and discussions

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

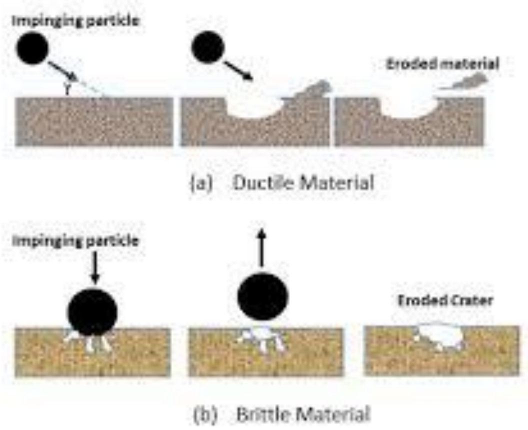

Figure 1: Erosion Mechanism: a) Ductile Material; b) Brittle Material.

Figure -2 pictorial view of dry 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 pressure with the time interval of 20 minutes. Table-2 represents the observations which are based on the change in feed rate of sand in 20 minutes. Table-3 shows the erosion rate according to change in impact angle in time interval of 20 minutes.

Table-1

Pressure	2 bar	4 bar	6 bar
Initial Weight	83.970gm	83.965gm	83.957gm
Final weight	83.965gm	83.957gm	83.942gm
Weight loss	0.005gm	0.008gm	0.015gm

Impact angle = 90^o, feed rate = 100gm/min, Time Interval = 20 minutes

Table-2

Feed rate of sand	100gm/min	200gm/min	300gm/min
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, pressure =6 bar, Time interval = 20 minutes

Table-3

Impact angle	30^o	60^o	90^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

Feed rate of sand = 100gm, pressure = 6 bar, Time interval = 20 minutes

Fig. – 3Erosion rate wrt Dry erosion

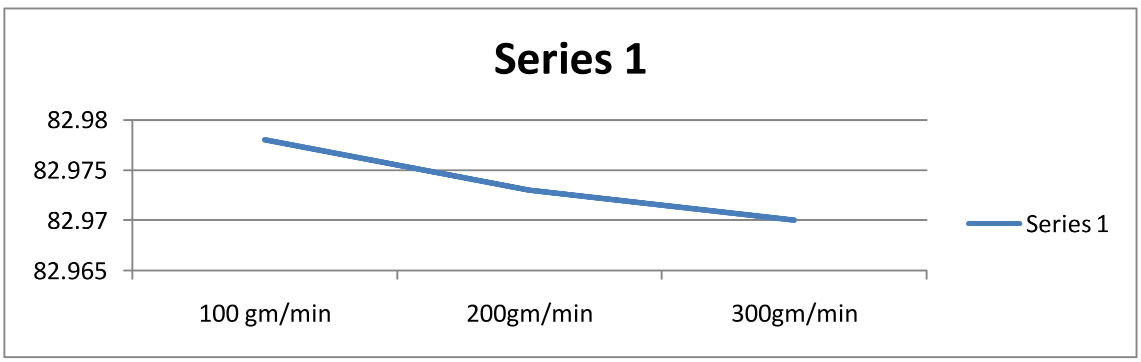

Figure-4

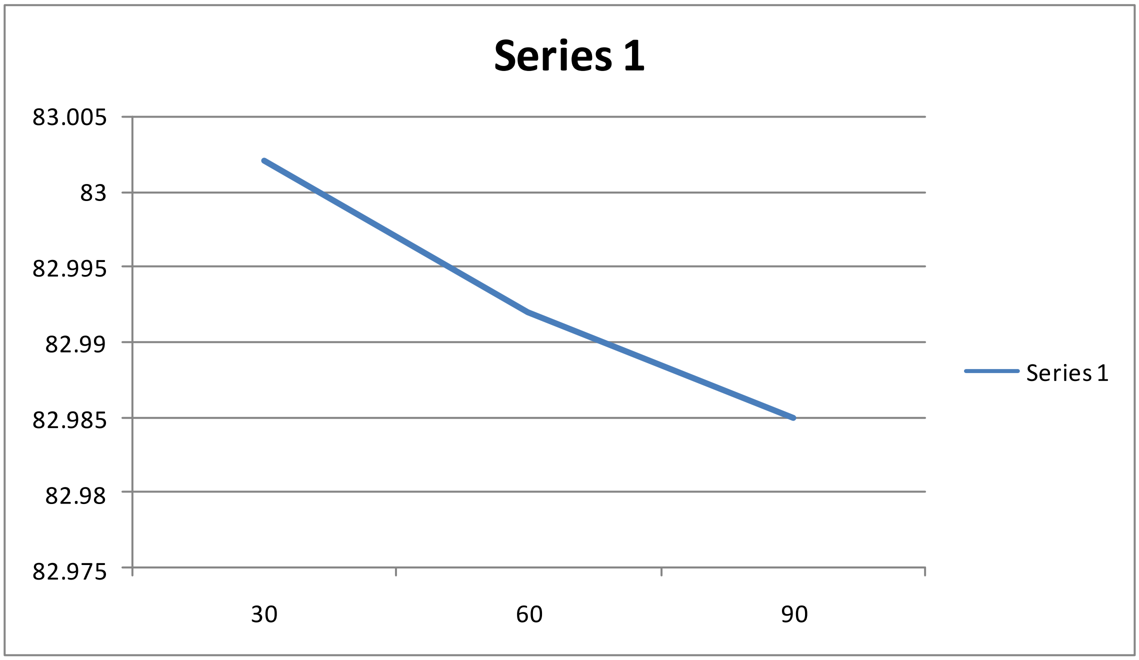

Figure-5

CONCLUSION

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

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REFERENCES

1. Thakur Lalit, Arora Navneet, Introduction, A comparative study on slurry and dry erosion behavior of HVOF sprayed Wc-Co coatings
2. https://en.wikipedia.org/wiki/Erosion_corrosion

3. Sharma Mithlesh, Goyal D.K, Kumar naresh & Sharma Raman , Introduction, Effect of Velocity on Erosion Performance of 13Cr4Ni and H.V.O.F. Coatings
4. https://www.slideshare.net/.../hard-rock-tribology-seminar-slurry-and-dry-erosion