

Evaluation of Air Jet Erosion Profiles in Metal Oxide Based Selective Catalytic Reduction Catalyst Materials

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Abstract- To achieve the new environmental norms to control the NO_x emission, retrofitting of existing thermal power plant with SCR catalyst materials are very much necessary. A reduction in the amount of nitrogen oxides being discharged into the atmosphere as combustion gases can be achieved by SCR catalysts. To confirm the mechanical strength and other required properties, erosion tests need to be carried to predict the life of the catalyst material in the specific application. Our results reveal that, the erosion of catalyst sample is minimum for lower angles of impact of abrasives and vice versa, the mass loss in catalysts increases with increase in velocity of impacts, catalyst mass loss is found to be maximum when lower sized particles hit the catalyst material and vice versa.

Keywords: Air jet erosion, Impact angle, Catalyst

I. INTRODUCTION

SCR (selective catalytic reduction) technology is used for, after combustion treatments for hazardous gases in the thermal power plants, and Indian coal contains high ash, results in higher exposure to the dust (fly ash) condition. High fly ash content will erode the catalyst and it will reduce the life of catalyst. The catalyst will facilitate to convert NO_x into H₂O and N₂ with the help of NH₃ which is injected. The SCR catalyst material is 50% porous and it is very smooth compared to other ceramic materials. In this study, the damage caused due to the impact of solid particles which erodes the catalyst is studied by experimentation using air jet erosion test instrument.

Q Fange, H Xu [1] has developed erosion test rig for study of four different ceramic materials, namely alumina, reaction bonded silica, silica and PSZ zirconia. They studied the effect of concentration of abrasion particles, duration of exposure of particle, velocity of the particle and different impact angles. Investigation of erosion mechanisms involved both deformation and brittle fracture.

Iain Finnie [2] investigated that the wear of the surface of the sample mainly depends on the solid particle motion with carrying fluid above the surface as well as the properties and behavior of the target samples. The influence of erosion by particle velocity and angles are different for both brittle and ductile materials.

P J Shayler[3] studied the erosion using two different coal ash as the abrasion particles for experiments, also developed two different test setup like (a) sand blasting erosion test facility and (b) wind tunnel erosion test facility. They justified that the erosion of the sample mainly depends on the aerodynamic flow field around the target sample.

B F Levin[4] investigated that erosion occurs in the power plants equipment's is due to repeated impact of the fly ash to the component surface and it will create the mass loss of the equipment. They generated mathematical model for erosion of alloys by experiments with considering the variables like temperature, particle concentration, velocity and impact angle of the stream.

Guruprasad kulkarni [5] studied erosion of two different samples namely UNS N06625 and UNS S32750 by using sand as abrasive particles and air as carrier medium. They have conducted test with different variables like velocity, particle size, different impact angles of the particles and compared with existing models and also created CFD model for same.

R.D. Aponte [6] used computational dynamic tool for the study the behaviors in erosion profiles for Grant model ASTM A743 grade CA6NM martensitic stainless steel samples, also studied the effect of particle size on the erosion wear properties. They conducted experiments for different impact angles of particles stream and they found that the erosion is maximum for higher angles of impact also states that the erosion is maximum for lower size particles in particular angles of incidence due to increase in surface area of the particle..

II. METHODS

Erosion tests are conducted based on ASTM G76 standards, the air jet erosion test rig was used for this analysis. The test rig contains abrasive feeder, dry compressed air supply, and sample holder with impact angles varying arrangement, air flow controller, digital timer and nozzle. Samples for testing is prepared from one

of the walls of extruded monolithic honeycomb and dimensions of the sample is 30mm×30mm with thickness of 1mm. The above said samples are cleaned using dry air. The tests are carried out for the duration of 1min for different velocities and for different angles of impact say 15°,30°,45°,60°,75°and 90°. Also the tests are carried for different abrasive particle sizes by maintaining constant air velocity of 30m/s and angle of impact considered is 90°. The distance between the sample and the nozzle is maintained as 10mm for the tests carried at every angle of impacts which is known as standoff distance. The schematic figure1 shows the air jet erosion test rig.

The testing procedure is as follows, set the standoff distance as 10mm and angle of impacts is 90°, place the sample on sample holder and switch ON the abrasive feeder to feed the sand particles required for erosion of catalyst material and simultaneously release the air valve to carry the sand particles at required velocities to the sample. Set air velocity as 30m/s and sand abrasives feed rate as 2g/min and these parameters are constant throughout the trial. Multiple experiments has been carried with different incident angles by maintaining the constant velocity of air as 30m/s and abrasive mass flow rates as 2g/min. Similar method is used for the study on the effect of different particle sizes used for erosion test namely 425,325,275,213.5 and 163µm, by maintaining other variables as constant.



Fig 2. Actual image of air jet erosion testing rig

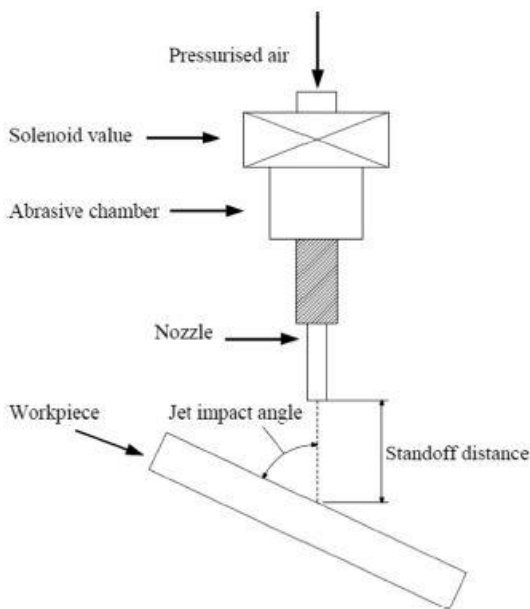


Figure 1. Schematic diagram of the air jet erosion testing rig



Fig 3. Image of the sample before air jet erosion test



Fig 4. Image of sample after air jet erosion test

Table 1. The testing conditions and specifications of the air jet erosion test rig.

Sample size	30×30×1mm
Impingement angle	15° up to 90°
Stand of distance	10mm
Air velocity	30m/s
Abrasion particle	sand
Nozzle diameter	5mm
Nozzle length	125mm
Mass flow rate of abrasive	2g/min
Testing temperature	Room temperature

III. RESULTS

Test results obtained from the air jet erosion experiments on SCR samples for 90° impact angle and for different velocities like 16m/s, 20m/s, 25m/s,30m/s and 35m/s are plotted in the figure 5. In the displayed results, the mass loss considered is the relative mass loss, which means that the amount of catalyst material lost in kg due to the mass of the sand causing the erosion in kg. The plot clearly explains the mass loss, which increases exponentially with respect to the velocity of the particle and their relation is directly proportional.

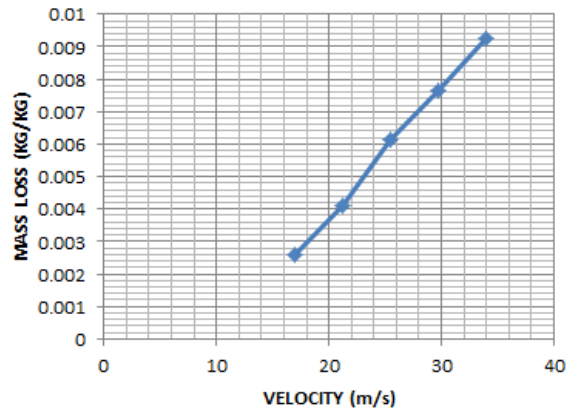


Fig 5. Mass loss vs. velocity of particle

Figure 6 shows that the erosion of sample is minimum for lower angles of impact and erosion of sample is maximum for the higher angles of impact. The experiments are carried with different impact angles like 15°, 30°, 45°, 60°, 75° and 90°, by maintaining the constant sand mass flow rate as 2g/min, velocity of carrier medium (air) as 30m/s and average abrasive sand particle diameter of 300µm.

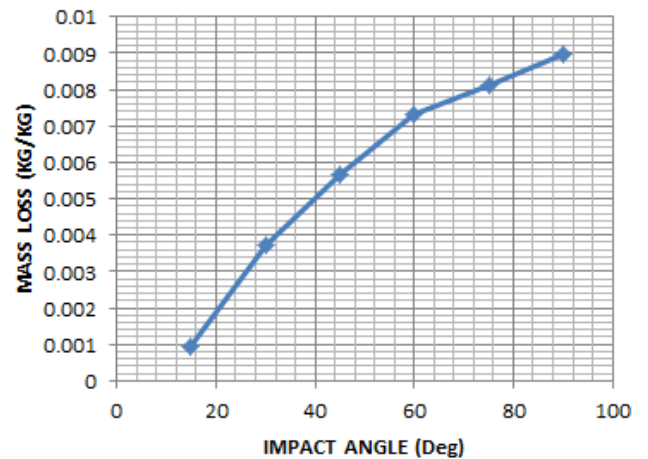


Fig 6. Mass loss vs. impact angle

Figure 7 explains about the effect of the particle diameter of sand abrasives on the catalyst mass loss, the plot clearly explains that the catalyst mass loss found to be maximum when lower particle sizes are used and catalyst mass loss is comparatively minimum for higher particle size of abrasives. The test is conducted by using the various average particle diameters like 425,325,275,213.5 and 163µm for multiple experiments. The various parameters of experiment like velocity of particle (30m/s), particle mass flow rate (2g/min) and impact angle (90°) should be constant.

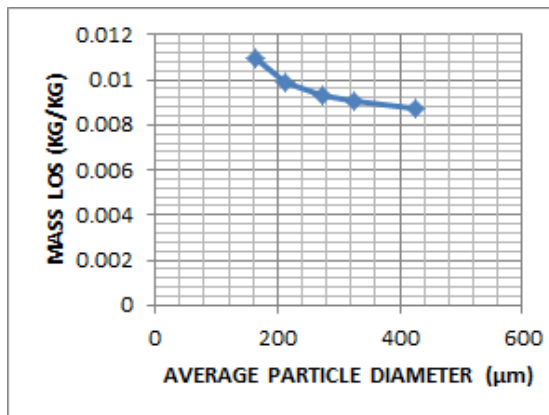


Fig 7. Mass loss vs. average particle diameter

IV. CONCLUSIONS

The erosion study is very much important for SCR catalyst material for confirmation of usage of the same in high dust applications in thermal power plants. The mass loss due to the erosion will be more in case of high impact angles and mass loss will be lower for the low impact angles. From the above experiments, one can clearly conclude that the mass loss exponentially increases with respect to the increase in the velocity of the particles eroding them in actual application.

V. REFERENCE

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