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Failure analysis of coal bottom ash slurry pipeline in thermal power plant

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ABSTRACT

This paper presents the case study of failure analysis of coal ash slurry handling pipeline used in the thermal power plant. The failure was identified at the bottom portion of the pipeline. Cracks (Hole) and deep pits were observed at the bottom inner surface of the pipeline. Visual examination, dimensional analysis, SEM and EDS analysis of failure pipeline was done in the present failure case. Also, coal bottom ash was analysed using particle size and weight analysis, ultimate, proximate, SEM, EDS and solid concentration analysis for the present failure case. The analysis results have shown that the failure occurs due to the coal ash solid particle impact and deposited corrosion at the inner bottom surface of the pipeline i.e. solid particle slurry erosion wear. The slurry pipeline was made of mild steel.

1. Introduction and background

The coal is used as fuel in the thermal power plants for producing to run thermal power plants prime movers. 10% to 20% coal ash is producing on the daily coal consumption rate. For coal ash disposal it is mixed with water to form the slurry, because slurry is easy to handle and transport as compared to dry ash. A centrifugal slurry pump and pipelines are used for the transportation of slurry because it is easy to install, low-maintenance and simple in design. The slurry transportation finds its use in many fields such as paper & pulp industries, iron mines, copper mines, coal mines, sewage pumping, dredging industries and agricultural waste etc. [1]. The coal ash slurry flows through the system has many problems such as failure of the slurry pipeline, flow control valve, slurry pump casing and impeller due to erosion-corrosion wear. Now days, slurry transportation is the major field of research work for the engineers. Therefore, in the present investigation failure of coal bottom ash slurry pipeline case study is analysed.

Slurry erosion wear is the one of the type of wear that is progressive loss of material from the target surface due to the impact of solid particle which are suspended in liquid [2]. Now days in engineering practice, the lot of equipments/components suffer slurry erosion wear damage. Therefore, slurry erosion is a very active research topic of all the time. Slurry pipeline material degradation and failure are not only disrupting the continuity of flow but also results in loss of energy and is harmful to land because it spreads and mixes with soil and soil is losses it's the fertility. Most of the researchers highlighted that the impact of solid particles is responsible for the slurry erosion wear failure [1,2]. But in most of the failure cases, slurry erosion wear frequently appears together with corrosion.

The various types of pipeline failure and mechanical damage cases are reported by different researchers, such as failure analysis of fire water pipeline, natural gas pipeline, fuel supply pipeline and oil supply pipeline [3–9]. Subai et al. [3] studied the failure analysis of fire water pipeline. They analysed the pipeline failure by using visual examination, microscopic examination, chemical and water analysis. They reported that the bottom surface of the pipeline had suffered due to under deposit corrosion while top portion failure occurred due to the harsh oxygen corrosion attack. Rodriguez et al. [4] reported the failure analysis of natural gas pipeline. They

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concluded that failure of pipeline occurred due to the development of corrosive environment and pitting type of corrosion inside the pipeline. Tang et al. [5] carried out the investigation of pipeline failure due to the interaction between multiphase flows using CFD simulation. In their study, CFD simulation results proved that the position, rate and the mechanisms of erosion wear failures on the pipeline surfaces can be well predicted, as compared with actual instances. Shalaby et al. [6] studied the failure analysis of fuel supply pipeline and concluded that the failure of the pipeline is due to the delayed cracking as a result of a pre-existing mechanical damage, possibly aided by hydrogen-assisted cracking in the highly strained region under the damaged coating. Mohsin et al. [7] studied the erosion failure of natural gas pipes. They reported that the pipeline failure was caused due to the loss of coating and thinning of the pipe surface because of the impacting of water jet issuing from the pipe joint with surrounding soil. Yang et al. [8] carried out the failure analysis of oil supply pipeline. They concluded that the leakage of the pipeline was mainly caused by the liquid impingement erosion. Ilman et al. [9] investigated the failure analysis of subsea oil pipeline and results are reported failure due to electrochemical corrosion combined with mechanical process flow-induced corrosion.

The literature survey introduce failure of coal ash slurry handling pipeline is the routine failure for each thermal power plant. There are various parameters and conditions that are responsible for this failure. Most of the researchers try to attempt for improving the service life of the slurry handling pipeline with various testing methods and proper regular schedule maintenance. The area of working failure pipeline and coal bottom ash analysis related to slurry erosion wear failure was untouched.

Therefore, the present investigation focuses the failure analysis of working pipeline and coal bottom ash through the visual, macroscopic and microscopic observations. The leakage and failure of pipeline were found to be caused by slurry impingement erosion i.e. slurry erosion wear. The pipeline is made of low carbon steel [mild steel] with wall thickness of 10 mm. The pipeline was located in the open atmosphere. The average life of the pipeline is up to one year if proper rotation of the pipeline is done as per schedule time. The slurry flow rate was 20 m/s at the time of pipeline failure. At the time of failure pipeline age was only three month and flow rate was standard i.e. 20 m/s. The average solid concentration of coal bottom ash is used up to 30% by weight during the flow through the pipeline at time of failure.

2. Investigations

2.1. Visual examination

Fig. 1 (A and B) shows the location of leakages on the coal ash slurry pipeline in two different areas. Fig. 1B shows the cut portion of same failure pipeline considered for the present investigation. The pipeline which had failed was inspected and a large crack (hole) was observed. A small portion of the pipeline with failure region crack (hole) (Fig. 1(B)) was cut along the two cutting lines and observed with naked eyes. The external and internal surface had oxide scale over it branching at the subsurface. In addition to that several localized pitting and ploughing attacks were observed in inner top and bottom surface of the pipeline respectively as shown in Fig. 1C. This is because of large size and mass of coal ash particles which comes in contact with the bottom inner surface of the pipeline when coal slurry is flowing through the pipeline. Similarly, the top inner surface mostly comes in contact with air bubbles which have occurred due to variation in particle size, shape and temperature of ash particle flowing through the pipe.

3. Dimensional mapping

Dimensional mapping was conducted on the two half circles, where the hole is located slightly on the cutting edge as shown in Fig. 2A. The results are illustrated in Fig. 2(B–I) for two samples 1 and 2 respectively. The results obtained from dimensional mapping analysis clearly show that the length of the crack hole is up to 25 mm as shown in Fig. 2D. Also, the thickness of the metal decreases continuously closer to the failure region at the bottom half part of the pipe as shown in Fig. 2C and E. In other words, the thickness is diminishing or decreasing towards the crack (Hole) position as shown in Fig. 2E i.e. the bottom half portion of the pipeline. This is due to the continuous impact of coal ash solid particles. No significant change was observed in thickness on top half part of the pipeline because of less contact with coal ash particles during the flow through the pipe as shown in (Fig. 2F). Fig. 2 (G and H) shows the graphical view of thickness variation of bottom and top half part of pipeline along the failure region respectively. The Fig. 2I shows that the dimensional mapping close view of bottom half portion of pipe at failure region the thickness of the pipeline is zero or pipe is broken in this region this is due to the continuous impact of the coal ash solid particle. i.e. slurry erosion wear.

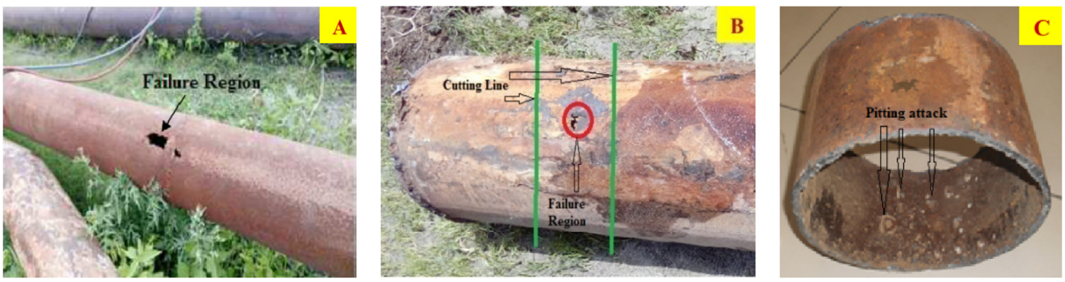

Fig. 1. Actual failure section of the coal ash slurry pipe with exact location of leakages.