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Analysis/Control of In-Bed Tube Erosion
Phenomena in the Fluidized Bed
Combustion (FBC) System

to

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SUMMARY

This technical report summarizes the research work performed and progress achieved during the period of January 1, 1995 to March 31, 1995.

Using the basic principle of flow disruption as a method of preventing erosion, different types of anti-erosion tubes were designed and tested. The main function of these protective devices was to decrease the bubble momentum and form a stagnant layer of bed material on the tube surface by changing the local flow pattern.

The ball-studded tube with the in-line pattern was less effective in reducing weight loss than the ball-studded tube with the staggered pattern. The staggered, ball-studded tube had a erosion rate that was three times lower than that of a regular tube. It is believed that the flow drag of the in-line pattern was less than that of the staggered pattern, permitting a higher particle velocity and, therefore, a higher erosion. According to these results, the finned/ball-studded tube is considered a more effective protective device than either the finned tube or the ball-studded tube in terms of tube erosion in FBC.

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SECTION 1

Anti-Erosion Remedies for In-Bed Tubes of FBC

1.1 Experimental Results and Discussion of Anti-Erosion Devices on Tube Erosion

The four different types of anti-erosion tube: pinned tube, ball-studded tube, finned tube, and finned/ball studded tube, were designed [1] and tested to aid the understanding of the flow disruptive methods of preventing in-bed tube erosion. The ball-studded tube had two configurations: an in-line studding pattern and a staggered studding pattern [1].

Based upon the working principle and mechanism of anti-erosion devices, these devices were applied to break up the local flow patterns at the surfaces of eroding tubes. The pins were installed on half of the tubes as shown in Figure 1. For the bare tube of 4-hour testing time, the specific weight loss at 3 cm was 1.42 mg/cm^2 , and the specific weight loss of the pinned tube was 0.87 mg/cm^2 . This indicates that the weight loss of the pinned-tube was 40% of that of the bare tube. The specific weight loss versus excess air velocity in the diagram exhibits a characteristic jump at a threshold velocity (26 cm/s) slightly above the minimum fluidization velocity [2].

The ball-studded tube with the in-line pattern was less effective in reducing weight loss of the ball-studded tube with the staggered pattern. Figure 2 shows the measured results of specific loss for the different types of anti-erosion tubes. The staggered studding tube had a erosion rate that was three times

Figure 1 Effect of Anti-Erosion Device on In-Bed Tube Erosion at Different Fluidization Velocities

lower than that of a regular tube. It is believed that the flow drag of the in-line pattern was less than that of staggered pattern, which permitted a higher particle velocity and, therefore, a higher erosion. By using the finned and ball-studded tube, in-bed tube erosion could be reduced more than threefold. According to these results, the finned/ball-studded tube is considered to be the most effective device in terms of tube erosion in FBC.

A higher weight loss rate was observed on the bottoms of tubes in regions of upward moving bubbles relative to the tube surface. The enhanced erosion in the splash zone was considered to be the result of bed material being projected upward by erupting bubbles and striking the bottoms of the tubes [3]. Velocity and frequency of the rising bubbles change with many parameters (eg. particle size, bed height, fluidizing velocity, etc.).

Bubbles interacted with submerged tubes in many ways, depending on such parameters as bubble size, velocity, tube size, and bed material [4]. Bubbles erupt from the free surface of the fluidized bed in different ways, and each type of eruption process leads to different rates and velocities of particle projection into the freeboard region [5,6].

The main function of protective devices (pins, fins, and balls) is to decrease the bubble momentum and form a stagnant layer of bed material on the tube surface by changing the local flow pattern. Impaction is thus minimized because the protective devices impede the motion of the particles near the surface

Figure 2 Effect of Anti-Erosion Device Configuration on In-Bed Tube Erosion

of the tube. Thereby, the protective stagnant layer of solid particles withstand the incoming high velocity solid particles and prevent them from striking the actual tube surface.

SECTION 2

Research Continuation

The progress of this project has been on schedule. Using the basic principle of flow disruption method of preventing erosion, different types of anti-erosion tube were designed and tested. The measurement of material wastage using these tubes was conducted and analyzed. Protective coating and surface treatment of in-bed tube material will be discussed as the other remedies of preventing in-bed tube erosion.

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