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Fluidized Bed Separators – A Comprehensive Review

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Extended Abstract

Mineral processing industries are using hydraulic separators throughout history for classification and gravity concentration of various minerals as well as coal. More commonly referred to as hindered-bed or fluidized-bed separators, these units make use of differential particle settling velocities to segregate particles according to shape, size, and/or density.

The traditional design consists of an open top vessel into which elutriation water is introduced through a series of distribution pipes evenly spaced across the base of the device. During operation, feed solids are injected into the upper section of the separator and are allowed to settle. The upward flow of elutriation water creates a fluidized bed of suspended particles within the separator that is automatically controlled using a simple PID control loop. The control loop includes a pressure sensor mounted on the side of the separator to measure the relative bed pressure. A motorized pinch valve is also used to control the underflow discharge and to maintain the desired bed pressure.

The bed thus formed hinders the downward flow of relatively slower settling particles. As a result, smaller and lighter particles accumulate in the upper section of the separator and are eventually carried over the top of the device into a collection launder. Larger and heavier particles eventually pass through the fluidized bed and are discharged through one or more restricted ports through the bottom of the separator.

Although fundamentally these separators seem to be quite efficient but there are inherent inefficiencies associated with this design. The main problems associated with traditional hydraulic separators include: (i) turbulent feed distribution which can result in unwanted misplaced particles, (ii) limited throughput capacity due to the detrimental impact of feed water on separator performance, (iii) introduction of dead zones within the fluidization chamber caused by frequent blockage/plugging of the lateral pipes located in the base of the separation zone containing the elutriation water and (iv) maintenance of the blocked elutriation water pipes.

Most of the above-mentioned problems may be solved if fundamental understanding of particle fluidization and the hindered settling behaviour of particles in fluid are properly understood. Appropriate mathematical models may then be developed to solve most of the afore-mentioned design specific problems. Literature related to particle fluidization and hindered settling are plenty but selection of the most appropriate model for a given task sometimes become difficult. Therefore, an attempt has been made in this article to review the various features of the popular models dealing with those two areas of importance. A few mathematical models on specific fluidized bed separators have also been developed and a comprehensive review of these models has also been presented. Finally, a few encouraging experimental data generated at our laboratory on a fluidized bed separator treating an Indian coal has also been given. The strategy of modeling these types of separators adopted at our laboratory is also briefly discussed.