A STUDY ON FLUIDIZED MOTION

CONVEYING OF FLY ASH

by

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Submitted in fulfillment of the requirements of the degree of

Doctor of Philosophy

to the

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DEDICATED TO

My Worship Goddess Maa KALI

&

My wife Anju

CERTIFICATE

This is to certify that the thesis entitled, **"A STUDY ON FLUIDIZED MOTION CONVEYING OF FLY ASH"** being submitted by **SANJAY KUMAR GUPTA** to the **INDIAN INSTITUTE OF TECHNOLOGY DELHI**, New Delhi, India for the award of the Degree of **Doctor of Philosophy** is a record of bonafide research work carried out by him under our supervision. The thesis, in our opinion, has reached the requisite standard fulfilling the requirement of the Doctor of Philosophy Degree. The research reported and results presented in the thesis have not been submitted, in part or full, to any other institute or university for the award of any degree or diploma.

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ABSTRACT

Powdered materials such as cement, alumina, plastic, detergents, soda ash, coal dust, flour, drugs, pulverized ores, and fly ash etc are handled in many industries. These powdered materials possess wide range of particle properties in terms of size and size distribution, shape, density, hardness, surface roughness; and thus their bulk behaviour such as bulk density, fluidized density, angle of repose, de-aeration rate constant etc also change. Quite often, these powdered materials need to be transported in dry state, and thus devices like belt conveyors, screw conveyors, bucket elevators, and vibratory conveyors are employed. These methods are energy intensive, noisy, waste spreader, and hazardous to the environment. However, the present increased consciousness towards the imbalance in the eco-system and related stringent government policies are forcing the industries to use environment friendly manufacturing and transporting facilities. Therefore, the gas-solid conveying occupies a prominent role among all the transportation means for powder materials. Among all modes of gas-solid conveying, dense phase mode is preferred due to its multiple inherent advantages. But, these conveying systems need an expert monitoring and high level of operational skill to avoid the system being unstable or even blocked. Thus, fluidized motion conveying system emerges as an option to transport the material in ultra dense phase mode. The major advantages of these systems are the high mass flow rate, low values of particle attrition and duct wear, low air pressure requirement, and above all the conveying through the enclosed duct makes the system eco-friendly. Literature review has revealed that despite the extensive use of airslides in industries, published literature related to the detailed parametric investigation on fluidized motion conveying system is scanty, particularly for

horizontal and upward conveying of solids. It is also found that efforts were made to develop a system for horizontal and upward conveying, but those systems were not fully successful due to the problem of manufacturing intricacies, operational difficulties, malfunctioning, high-level energy consumption, and under-developed design procedure. It has also been made clear that the up-incline transport of material without making any major change(s) to the constructional features has not been attempted. Thus, the characteristics of such kind of airslides that retain their basic simplicity and convey the dry form of particulate materials in upward incline cases are yet to be fully explored, especially for long distances. Furthermore, the present design methodology still relies on the empirical correlations. Thus, sustained detailed investigations are needed to gain insight into the functioning of the system to develop a sound design methodology to make it readily acceptable to industries. Therefore, a fluidized motion conveying system was designed and fabricated to establish its viability for industrial application. Fly ash was used as a conveyed material. It was procured from a thermal power plant, and its particle properties such as particle size distribution, median particle size and specific gravity and bulk density were determined. A permeameter was also designed and fabricated to determine the fluidized characteristics of particulate materials. This test enables to assess the flow ability of the powder and the operating condition for the same. Investigations on Permeameter have been conducted to assess the effect of material properties on the fluidized characteristics of powders. It was observed that particles size, their distribution, and specific gravity affect the fluidized characteristics of materials. Experimental investigations were carried out on the fluidized motion conveying system to examine the effect of operating superficial air velocity, material supply valve opening and conveyor inclination on the material mass flux, onset of material flow, plenum chamber pressure, and material bed thickness in the channel. The effect of conveying distance has never been reported in open literature, therefore, channel length has also been varied as a variable to cover the distances of 3.7, 5.5, and 7.5m for investigating the conveying potential of the fluidized motion conveying system. It is observed that, in addition to the downward flow, the system did show capability to transport the material on horizontal, and slight upward incline as well. The capability of upward conveying potential using a system retaining all basic simplicity was identified as a new dimension to the present state of art. However, the material carriage efficiency got reduced. It is observed that over the range of superficial velocities studied, the flow of material takes place in the form of a stratified bed. The operating superficial air velocity, channel length, and conveyor inclination have been identified as the parameters influencing the transition of flow regime in the channel. For a given set of conveyor manufacturing material and particulate solid to be transported, it was found that the conveyor at downward inclination offers the highest asymptotic mass flux with sliding flow behaviour. For a given air flow rate, full material supply valve opening gave higher material mass flux than that at half supply valve opening. Therefore, an adjustment in the supply valve opening and air-flow rate will be required to be made to obtain the highest material mass transportation efficiency. The onset of material flow occurred close to the minimum fluidization velocity. Further, it was found that the material mass flow rate reduced with increasing channel length, and despite increase in airflow rate material mass flux remained fixed at asymptotic level. It was interesting to observe that the asymptotic material mass flux is achieved at non-dimensional superficial air velocity in the range of 1.5-2 for all conveying distances; and thus the system offered the range of operating superficial air velocity for its optimum functioning.

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