# ABSTRACT

Circulating Fluidised Beds (CFB) have been in industrial use for nearly half a century but rigorous studies on high velocity beds in a circulating system have been published only recently (not exceeding one and half decade). A CFB system is unique in its operational characteristics and pressure balances. The riser inlet geometry and exit configuration as well as solid re-entry lines influence the hydrodynamic features of the riser considerably. The bed material characteristics, namely its size, density and distribution also affect the performance. Sufficient attention has, however, not been paid to studies relating to the effect of coarse particles on the character of the bed. While the earlier investigations report on the overall hydrodynamics (axial pressure profile, voidage distribution etc.), the present trend is towards a better understanding of meso- and microscale structure (clustering nature of gas-solid suspension, local gas and slip velocities, voidage etc.) of the bed.

In the present work, the hydrodynamics of co-current gas-solid flow in the riser of a CFB system has been investigated using a 10.16 cm ID X 5.62 m height riser of a 'N' type CFB system and employing both fines (FCC catalyst - Geldart Group A type) and coarse (sand - Geldart Group B type) bed materials. Comprehensive data on the riser and loop pressure profiles were obtained. Detailed studies on gas mixing were undertaken using $CO_2$ as a tracer. Transient measurements on static pressure were also made at the walls of the riser. The hydrodynamics of the bed was investigated in depth and theoretical analysis presented to support the findings (along with correlations). Chapter I details the literature review on the subject and points out to the gap in present-day knowledge. Chapter II discusses the apparatus used and procedure adopted for the experimental work.

Data on gross hydrodynamics of the bed have been presented in Chapters III and IV. Based on gas-solid momentum balance in the riser, a distinction between apparent and real voidages has been made. The effects of acceleration and friction on the real voidage have been estimated. Correlations for dense and dilute phase voidages as well as accelerating lengths have been proposed. A theoretical analysis has been made to predict the loop pressure profile in a CFB system and a comparison given between the predicted values with those measured. Detailed analysis of loop pressure indicates that the riser pressure profile is mainly dependent on the pressure recovery in the standpipe and pressure

drop in the transfer line. Therefore, the height of the dense phase and the state of flow of particles in the standpipe must be studied carefully to ensure stable operation while designing the CFB system. An attempt has also been made to predict the clustering behaviour of the FFB by incorporating the effects of acceleration and friction into the homogeneous gas-solid suspension model of Yerushalmi.

Detailed studies on gas mixing have been carried out and presented in Chapter V. A few measurements on radial solids concentration profiles indicate the existence of core-annulus structure in the FFB. Some studies on gas mixing in the core area of FFB, using $CO_2$ as a tracer, have been made. Klinkenberg's model on single phase homogeneous flow has been used to obtain the gas-solid radial dispersion coefficient in the riser. The effects of riser gas velocity and solids circulation rate on the gas dispersion coefficient have been studied. Data on gas mixing reveal that single phase homogeneous model is not sufficient to explain the gas-solid contacting process in the core region of a riser.

Based on the pressure profile data presented in Chapter III, the velocity regime, within which a FFB is likely to be operable, has been delineated and correlations for regime transition velocities proposed in Chapter VI. Accordingly, phase diagrams for the systems studied were presented. The static pressure fluctuations at various positions on the wall of the riser were measured. The data have been analysed statistically to find the microstructural characteristics of the bed.

## KEY WORDS

**Hydrodynamics; Fast fluidised bed (FFB); Circulating fluidised bed (CFB); Riser; Downcomer; 'N' type transfer line; Cluster; Pressure profile; Bottom dense phase; Dilute phase; Voidage; Accelerating length; Core-annulus structure; Dispersion coefficient; Slip velocity; Radial solids flux profile; Phase diagram; Pressure fluctuations; Probability density function; Auto-correlation function.**