Chapter 17
A Future Trend on Research Scope of Numerical Simulation on Conical Fluidized Bed

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ABSTRACT

Fluidized bed technology is a well-established environment friendly technology, by which energy can be generated through combustion and gasification techniques. It is widely prevalent today owing to its excellent heat transfer, mixing characteristics and compactness. The design and scale-up of the fluidized beds are vital to the enhancement of heat transfer and mixing characteristics. However, heat transfer characteristics play a key role in determining the combustion and gasification characteristics. CFD is a technique which helps to optimize the design and operation of fluidized bed combustor and gasifiers. Enhancement of computing speed and numerical techniques has led to CFD being used as a widely implemented tool to provide a bridge between laboratory scale and industrial study. In this chapter, a comprehensive review of CFD modelling and experimental study on the conical fluidized bed has been carried out. Primarily this chapter demonstrates probable future accomplishments and identifies trends and regions where further research is required.

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INTRODUCTION

In recent times, more emphasize is given on clean coal technologies. Because of the depletion of fossil fuels, environmental security and increased pressure worldwide, there is a demand for efficient utilization of fossil fuels without emission of unburnt products. Fluidized bed combustion and gasification are such technologies, through which emissions of harmful products can be controlled (Singh, Brink, & Hupa, 2013).

The heat transfer characteristics determine the performance of fluidized bed through combustion and gasification techniques. However, the heat transfer characteristics are inevitably influenced by the hydrodynamic behaviour of a fluidized bed (Patil, Pandey, & Mahanta, 2011). The hydrodynamic behaviour of the conical fluidized bed is different from the conventional fluidized bed, which is characterized by different fluidization regimes. Hence, it is obvious to investigate the hydrodynamic behaviour and heat transfer characteristics of the conical fluidized bed riser, since, it anticipates the distribution of the species and the phases involved (Philippsen, Vilela, & Zen, 2015; Wu, 1993). The study of the hydrodynamic behaviour and heat transfer characteristics of the conical fluidized bed has received much attention from the scientific community leading to various numerical studies on it besides experimental work.

Nature of two-phase mixing plays a vital role in enhancing the heat transfer and better facilitation of the chemical reaction, which determines the performance of a fluidized bed reactor (Wu, 1993). A proper insight into complex multi-phase flow is required to advance the fluidized bed performance, leading to the improvement of multidimensional models. These multi-dimensional models form a bridge between research on a laboratory scale and activity of the fluidized bed in industries by providing the information on processes of combustion and gasification that cannot be provided by experimental data alone (Singh et al., 2013). Hence, there is a scope for the research of complex processes involved in the fluidized bed system, which are characterized by multidimensional models through numerical simulation. A proper framework of numerical simulation is required to understand the flow processes. The framework for numerical simulation is provided in Fig. 1.

The performance of the fluidized bed systems is substantially influenced by the design and scale-up. It requires a long duration to explore the impact of scale-up on fluidized bed riser performance experimentally, which leads to the high operating cost. Besides, it is challenging to attain steady-state condition fully in fluidization problems. With the changing of load or other operating parameters, its behaviour changes immensely. Therefore, the operation of the fluidized bed system in an experimental condition is very complex. Apart from that, the equations used in fluidization problems are non-linear and to obtain the exact solution of these equations is a strenuous exercise. Due to the complex non-linear equation, the accurate prediction of the numerical solution is difficult. With the rise in the computing technology and numerical tools development, computational fluid dynamics (CFD) has become a key tool for predicting the precise two-phase flow, since, the nature of the two-phase flow is complex and transient. Besides, characteristics of the fluidized bed such as design, optimization and scale-up are essential from the modelling point of view, which can easily be predicted by using CFD process (Askaripour & Dehkordi, 2016; Sau & Biswal, 2011). Hence, the above discrepancies allocated with experimental study can be shrunk with the help of numerical study so that the performance of the fluidized bed is optimized.

CFD is a numerical solution tool that includes fluid flow to solve algorithms and evaluate the issues by numerical methods. Various processes, such as physical and chemical processes are involved in the aspect of fluidized bed simulation. The models involved with physical and chemical processes along

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