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Phase holdups in three-phase fluidized beds in the presence of disc promoter

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ABSTRACT

Three-phase fluidized beds are found to have wide applications in process industries. The present investigation essentially comprises of the studies on gas holdup, liquid holdup and bed porosity in three-phase fluidized beds with coaxially placed disc promoter. Holdup data were obtained from bed expansion and pressure drop measurements. Analysis of the data was done to elucidate the effects of dynamic and geometric parameters on gas holdup, liquid holdup and bed porosity. Data were correlated and useful equations were obtained from empirical modeling.

1. Introduction

The design of equipment for any chemical process demands high heat and mass transfer rates. Compactness of the equipment and effective operation and control are the main objectives that challenge the design engineer's capability. These tasks can be achieved by employing such equipment that offer higher heat and mass transfer rates, uniform temperatures and concentrations and better controllability. Three-phase fluidized beds offer all these advantages.

In many situations, presence of internals such as draft tubes, baffles, immersed heaters and geometrical irregularities, occur inadvertently. Some times, turbulent promoters are also employed to obtain enhanced heat and mass transfer rates. Thus the presence of internal becomes inevitable on many occasions. This greatly increases the complexity of the hydrodynamic and transport phenomena.

Achievement of high heat and mass transfer rates is possible by employing suitable augmentation technique. Various augmentation techniques in use were comprehensively reviewed by Bergles [1]. He classified the augmentation techniques available into two broad categories: active and passive. The active methods require the application of external energy. In passive methods, augmentation is attained by modifying the flow passage for the advantage of increased transfer rates.

Majority of scientific investigations aimed at augmentation of heat and mass transfer rates focused mainly on passive augmentative techniques. These techniques basically modify the flow path thus intensify the turbulence which renders the resistance film thin leading to increased heat and mass transfer rates. Use of treated surfaces, rough surfaces, extended surfaces, displaced enhancement devices, swirl flow devices and coil tubes were the various techniques employed generally for enhancement of heat and mass transfer rates.

The advantages of three-phase fluidization include rapid mixing which leads to nearly isothermal conditions, hence operation can be made continuous and can be controlled simply, reliably and automatically with ease of handling, however with relatively low pressure drop across the bed. It is also possible to transport vast quantities of heat produced or required in large reactors. Heat and mass transfer rates are high when compared to the conventional methods of contacting. Therefore, it is suitable for large-scale operations. Because of high transfer rates, small surface areas are required compared to the conventional methods. The disadvantages include the difficulty in flow visualization, pulverization of solids, erosion of pipes and vessels from abrasion by particles.

Three-phase fluidized bed reactors are used in coal liquefaction, flue gas desulfurization, Fishcher–Tropsch synthesis, hydrogenation of cyclohexane, oxidation of sodium sulfite, drying of granular material, treatment of waste water containing phenol, production of ethanol by yeast cells, etc.

Venkateswarlu and Jagannadha Raju [2] investigated the effect of the geometry of disc promoter assembly on the pressure drop in the presence of homogeneous flow of liquid. It was found that the friction factor increased with increasing disc diameter and

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