ABSTRACT

Large numbers of industrial process reactions are involved in the simultaneous contacting of gas, liquid and solid. These operations are carried out in the multiphase reactors. The industrial reactors are broadly classified into agitated vessels and column reactors. The column reactors are widely used in the fermentation and other biological applications because of its good mixing. The applications of the column reactor in the process field are enormous and it can be divided based on either the presence or the absence of the third phase such as solid.

In the three phase operations, the solid particles are added either as a catalyst or an inert material to increase the mixing characteristics of liquid phase reactants and gaseous phase reactants. The complexity increases when a solid is added as a third phase to the system either as an inert material or as a catalyst material. Recently live cells have been immobilized on inert packing materials for wastewater treatment and in other biochemical applications where mass transfer phenomena are accompanied with biochemical reactions. Pneumatically agitated column reactors are classified based on position of solid phase such as packed bed reactor and fluidized bed reactor.

Recently the airlift fluidized bed reactors have been widely used in the chemical industries, environmental remediation technologies, biochemical industries etc., because of their significant advantages such as simple hermetic structure, total absence of moving parts, lower investment, lower gas requirement for the complete solid fluidization, very fine gas dispersion, definitely directed circulation flow, high mixing and mass transfer performance, rapid and uniform distribution of the reaction components etc. With their increasing applications to biotechnology processes, airlift fluidized
bed reactors appear to be one of the most important bioreactor configurations (Korpajarvi et al 1999, Jin et al 2006).

The airlift reactors are found to be suitable in the area of bio process and bio environmental application where partial liquid circulation is necessary (Chisti and Moo-Young 1988, Kawase and Hashimoto 1996, Yuguo et al 1999, Fretias et al 2000, Mohanthy et al 2008, Yazdian et al 2009). The airlift fluidized bed reactors are divided into two sections, the riser and the down comer, depending on the arrangement of the down comer, classified into the internal-loop or external loop airlift reactors. In the internal loop reactors, the riser and the down comer are present in the same column whereas in external loop reactors, the riser and the down comer are separate tubes placed side by side and connected at the top and at the bottom. In airlift fluidized bed reactor, the gas and liquid are passed at the bottom of the riser, and it results in a different static pressure in the two sections, leading to the circulation of the liquid.

The external loop airlift fluidized bed reactor provides an excellent contact among the various phases, easy removal or replenishment of the particles, reasonable interface mass transfer rates with low energy input and easier scale up. The attractive features of an external loop airlift fluidized bed reactor includes a good liquid phase mixing and a good temperature control owing to control over liquid circulation in the reactor. A large variety of configurations of external loop airlift fluidized bed reactors have been investigated and occasionally confused technological information are observed in the literature.

The hydrodynamic parameters such as gas holdup, liquid circulation velocity in external loop airlift reactor were investigated by many researchers (Hsu et al 1980, Verlaan et al 1986, Chisti et al 1988, Popovic and


From the literature survey, it was clear that most of the previous works were concentrated on the study of the hydrodynamics of external loop fluidized bed airlift reactors by using stagnant liquid. It was also observed that the majority of data have been obtained for air-water systems which are not the necessary representative of fermentation processes, which have non-Newtonian characteristics (Kawase et al 1996). To overcome the drawbacks there is a vital need to study the hydrodynamics characteristics of the external loop air lift fluidized bed reactor such as minimum fluidization velocity, riser
gas holdup, riser liquid holdup and liquid circulation velocity etc by using both the Newtonian and the non-Newtonian liquids for a wide range of operating conditions such as superficial liquid phase velocities, gaseous phase velocities, diameter size of the particles and shape of the particles etc.

Hence in this present study, experiments have been carried out to analyse the influence of superficial liquid phase velocity, gaseous phase velocity, dimensions of the particles and physical properties of the liquid on the above mentioned hydrodynamic parameters. Also the unified dimensionless correlations were developed to estimate the minimum fluidization velocity, riser gas holdup, riser liquid holdup and liquid circulation velocity by using both the Newtonian and the non Newtonian systems in a three-phase external loop airlift reactor. The present experimental measurements of the minimum fluidization velocity, riser gas holdup, riser liquid holdup and liquid circulation velocity on the different particles and various liquid systems were used for regression analysis for the development of the correlations.

The experimental results showed a good conformity with those predicted correlations according to the developed correlation. An error analysis of the proposed correlation for the prediction of the minimum fluidization velocity, riser gas holdup, riser liquid holdup and liquid circulation velocity were shown an AARD of ± 6.5%, ± 9.7%, ± 7.8 % and ± 10.4 % respectively. The proposed correlations for the prediction of the minimum fluidization velocity, riser gas holdup, riser liquid holdup and liquid circulation velocity in an external loop airlift reactor were found to be satisfactory for both the Newtonian and non-Newtonian systems with a wide range of variables covered in the present investigation.