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Reduction of Drag in Non-Newtonian Flow Through Packed Bed

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Abstract: An experimental investigation of strength of drag reduction in a bed packed was carried out in this study. The study of drag reduction performed at particle Reynolds numbers in the range 10-250 and was found to depend on the concentration of drag reducing agent and the fluid velocity. The drag reduction effectiveness increased with fluid velocity. For the systems investigated, there exists an optimum concentration of drag reducing agent that produces a maximum drag reduction. The present study may be useful for further understanding and modeling of porous multiphase reactor with non-Newtonian system in industrial applications.

Key words: Packed bed, pressure drop, drag reduction, non-Newtonian liquid, DRA, Reynolds numbers

INTRODUCTION

The non-Newtonian fluid flow through particulate bed system is important in a variety of chemical and processing applications. Various examples of applications of the particulate system have been described by many researchers (Reay and Baker, 1985; Davidson *et al*., 1985; Fan, 1989). Over the years, considerable research efforts have been expended in exploring and furthering understanding of the basic phenomena of momentum, heat and mass transfer processes with and without chemical reactions in the systems in packed bed. Recently, drag reduction of flow through packed beds and porous media has received considerable attention because of its important industrial applications for specific reactive process. Zhu and Satish (1992) studied of the flow drag decreases with a decrease in the flow behavior index and with an increase in the characteristic time. They studied of the degree of this reduction is found to be more significant at low voidages. It is found that both the second normal stress difference and the bed voidage have a great influence on the resistance of viscoelastic flow through a packed bed. Vossoughi (1999) studied the pressure drop of a porous media flow is only due to a small extent to the shear force term usually to derive the Kozeny-Darcy law and also studied the addition of small amounts of high molecular weight polymers to a solvent with Newtonian flow properties causes drastic pressure drop change if the flow rate exceeds an onset flow rate corresponding to a critical Deborah number of the porous matrix-polymer solution system. Drag Reduction (DR) has numerous applications in a variety of fields. In the chemical, oil and process industries, non-Newtonian liquids are encountered frequently through different process equipments. The drag is one of the most important factors in hydraulic transport of fluid flow depending on the physical properties and input fluxes of the phases and the size of equipments. The reduction of the drag is of practical importance from an economic viewpoint since, it may reduce the process energy of the fluid in equipments. Other applications of the drag reduction phenomenon are as: oil pipelines, oil well operations, flood water disposal, field irrigation, transport of suspensions and slurries, water heating and cooling systems (Mowla and Naderi, 2006). The reason of research in the area of drag reduction is in response to a challenge. Packed beds are widely used in industry at relatively low pressure drops. For process design purposes, it is essential that pressure drop is estimated for its proper operation. Physical design characteristics of columns-particularly packing type, size and column dimensions can greatly impact neighboring process units and the load induced upon compressors and pumps. The main advantage of using a packed column rather than just a tank or other reaction vessel is that the packing affords a larger surface area per unit volume for mass transfer. They are readily used in industry for catalytic reactions, combustion, gas absorption, distillation, drying and separation processes. Single phase drag reduction due to polymer based additives has been thoroughly studied and the mechanisms are beginning to be understood to be related to dampening of turbulent bursts and reduction of Reynolds stresses. In addition to mechanisms available to

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