THE UPS AND DOWNS OF GAS-SOLID FLOW - A REVIEW

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ABSTRACT

The scope of this review is confined to (i) upflow of particulate solids in a tube as occurs in vertical pneumatic conveying and riser-reactors; and (ii) downflow of particulate solids in a vertical standpipe. The aims are to present a personal view on the status of knowledge of the subjects in a structured framework and to indicate areas where further work is warranted. No attempt has been made to report all works published on the subjects and to present the conflicting conclusions reached by all the workers.

The scope of the present review does not extend to horizontal gas-solid flow - a much less well understood subject. A recent review by Knowlton (1979) covers all aspects of gas-solid flow including horizontal conveying. Nor does the present paper touch on elutriation of fine particles from a fluidized bed. A comprehensive review of this subject was recently reported by Matsen (1979). This is an area with active research in progress as indicated by the papers presented at the 1979 Annual AIChE meeting in San Francisco and here at Henniker.

SECTION A. VERTICAL UPFLOW OF SOLID

A.1 INTRODUCTION

The different flow regimes in vertical upflow of granular materials may be described in terms of a flowchart (Figure 1). At a very high gas velocity, solids are conveyed in an apparently
uniform suspension in so-called lean or dilute phase flow at a voidage close to one. As the gas velocity is reduced at a fixed solid flowrate, solid concentration in the tube increases. Two different types of behaviour are possible as represented in Fig. 1. In one type of system, (right hand branch of Fig. 1) a sharp transition point will eventually be reached at which the uniform suspension collapses and the solids are then conveyed upwards in dense phase slugging flow with solids carried upwards mainly in the wakes of rising slugs (or bubbles). This sharp transition point from lean phase conveying to dense phase slugging conveying is known as the choking point and has been described in detail by Zenz and Othmer (1963), Yousfi and Gau (1974) and Yang (1975). The transition gas velocity is defined as the choking velocity for the particular solid flowrate. In dense phase slugging conveying, if

Figure 1. Possible flow patterns in vertical pneumatic conveying showing two types of systems: the choking type system (right hand branch) and the non-choking type system (left hand branch)