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The effect of the flow direction inside the header on two-phase flow distribution in parallel vertical channels

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ABSTRACT

Uniform fluid distribution is essential for efficient operation of chemical-processing equipment such as contactors, reactors, mixers, burners and in most refrigeration equipment, where two phases are acting together. To obtain optimum distribution, proper consideration must be given to flow behaviour in the distributor, flow conditions upstream and downstream of the distributor, and the distribution requirements (fluid or phase) of the equipment. Even though the principles of single phase distribution have been well developed for more than three decades, they are frequently not taken in the right account by equipment designers when a mixture is present, and a significant fraction of process equipment consequently suffers from maldistribution. The experimental investigation presented in this paper is aimed at understanding the main mechanisms which drive the flow distribution inside a two-phase horizontal header in order to design improved distributors and to optimise the flow distribution inside compact heat exchanger. Experimentation was devoted to establish the influence of the inlet conditions and of the channel/distributor geometry on the phase/mass distribution into parallel vertical channels. The study is carried out with air–water mixtures and it is based on the measurement of component flow rates in individual channels and on pressure drops across the distributor. The effects of the operating conditions, the header geometry and the inlet port nozzle were investigated in the ranges of liquid and gas superficial velocities of 0.2–1.2 and 1.5–16.5 m/s, respectively. In order to control the main flow direction inside the header, different fitting devices were tested; the insertion of a co-axial, multi-hole distributor inside the header has confirmed the possibility of greatly improving the liquid and gas flow distribution by the proper selection of position, diameter and number of the flow openings between the supplying distributor and the system of parallel channels connected to the header.

1. Introduction

To split a stream of a single phase or mixture flow is a common need in many engineering applications, ranging from thermal to chemical processes. In such cases, the typical issue is to maintain the flow rate in each separated channel as more uniform as possible. Uneven flow (or phase) distributions is the result of a series of effects, including the pressure recovery due to kinetic energy or momentum changes inside the distributor (header), the frictional pressure drop along the length of the header, the pressure drop across the ports connecting the distributor to the system of channels downstream of it, gravitational effects on phase distribution, the channel exit conditions.

In typical turbulent flow applications, inertial effects associated with velocity changes may dominate frictional losses in determining the pressure distribution along the distributing pipe, unless the length between the openings is large. Application of the momentum or mechanical energy equations in such a case shows that the pressure inside the header increases with distance from the entrance of the pipe. If the outlet holes are uniform in size and spacing, the discharge flow will be biased toward the closed end. Disturbances upstream of the distributor, such as pipe bends or orifices, may increase or decrease the flow to the holes at the beginning of the distributor. When frictional pressure drop dominates the inertial pressure recovery, the distribution is biased toward the feed end of the distributor. An interesting discussion regarding single phase flows in manifolds and heat exchangers is offered in [1,2]. Concerning multi-phase flows, several authors have investigated two-phase flow division in T-junctions [3,4], however, the phase separation in manifolds with a number of outlets is so complicated that T-junctions' studies cannot be directly applied [5].

In spite of the importance of this subject, in the last decade only a few studies have been devoted to analyze the distribution of

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