CLEAR LIQUID HEIGHT ON SIEVE PLATES IN THE FROTH, MIXED AND SPRAY REGIMES

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The clear liquid height on sieve plates has been measured in a hydraulic simulation column. Experimental work and investigation of published data show that three different foaming regimes have to be distinguished, as Chen recognised, and the hole diameter has an influence on the clear liquid height as Dhulesia proposed.

In this work the Hofhuis-Zuiderweg correlation has been modified to describe the clear liquid height in the froth, mixed and spray regimes, respectively.

Different formulae have been developed for each of the foaming regimes.

Two new parameters have been introduced: the hole diameter and the free cross section.

INTRODUCTION

The clear liquid height on a plate and the quality and structure of the two phase foaming play an important role in the hydrodynamics and mass transfer of a plate column[1]. The quantity of liquid on the plate is expressed in terms of the clear liquid height. Its value is given by the sum of the pressure drop across the foam (Δp_f) and the dynamic effect (d_G) due to gas flow[2]:

$$h_L = (\Delta p_f + d_G)/(\rho_L g)$$

where

$$d_G = w_G/A \,.\, (v_h - v_a)$$

The structure of the foam, that is the hydrodynamic regime on the plate, changes with increasing gas and liquid loadings.

In the past thirty years many researchers have investigated the hydrodynamics of sieve plates. For quite a long time, however, it was supposed that the operating range of a plate can be hydrodynamically considered as a single regime. With improved methods of measurement, it became obvious that, e.g. from the measurements of the hydrodynamic parameters in the froth regime, no deductions can be made relating to the spray regime. Shakov *et al.*[3], de Goederen[4] and Lockett[5] have already distinguished between two different hydrodynamic regimes: at small velocities of gas cellular foaming develops on the plate, with the liquid as continuous phase and gas the disperse phase—this is the froth regime. At high velocities the gas blows up the foam and a spray layer forms, with the gas as continuous phase and the liquid as disperse phase—this is the spray regime. Lockett[5], Miyahara *et al.*[6] and Chen *et al.*[7] offer equations for calculating the transition between the froth and spray regimes.

According to recent investigations, there is a qualitatively different third regime between the froth and spray regimes, this is the mixed regime[8–10].

In 1985 Chen[9,10], on the basis of Dhulesia's[8] idea, evaluated data published in the literature measured by using the light transmission technique. He established that the froth-mixed-spray regimes are sharply differentiated on the sieve plate. At the boundary of froth and mixed regimes on sieve plate:

$$\frac{h_L}{d_0} = 3.79\, v_h \sqrt{\rho_G/\rho_L}$$

At the boundary of mixed and spray regimes:

$$\frac{h_L}{d_0} = 1.89\, v_h \sqrt{\rho_G/\rho_L}$$

The equations of Chen are valid for the ranges:

$$v = 0.4\text{–}2.8\ \mathrm{m/s};\quad L_w = (1.4\text{–}16.4) \times 10^{-3}\ \mathrm{m^3/(ms)};$$
$$w = (25\text{–}75) \times 10^{-3}\ \mathrm{m}$$

It is worth mentioning that Zuiderweg *et al.*[11] distinguished four different regimes on the sieve plate: besides those earlier mentioned they found a free bubbling regime near the boundary of weeping.

Correlations for calculating the clear liquid height on sieve plates were already published around the eighties[12–15,19,21]. However, only one part of these corrleations relates to specific foam structures[14,15,19,21].

In his summary work, Zuiderweg[12] underlines that the traditional equations containing weir height, Francis' formula, and relative froth density as parameters, are applicable to calculate the clear liquid height on a sieve plate only at small gas velocities. He proposes a new formula for calculating the clear liquid height on sieve plates in the froth + spray regimes together (Table 2). The measurements of Hofhius and the data published in literature by other authors form the basis of his equation. Dhulesia[15] shows that the correlation developed by Zuiderweg for the froth + spray regime does not define the clear liquid height in all the three foaming regimes. It is necessary to develop correlations for each regimes.

Colwell[14] collected a large number of data from literature on measurements made on substances having different physico-chemical properties. He complements the pressure drop across foam layer (Δp_f) with the dynamic effect due to gas flow (d_G) and correlates the sum for the froth regime. In his 1987 article, Chen[10] shows that Colwell marked out the froth regime wrongly

0263–8762/91/$05.00 + 0.00