INFLUENCE OF SURFACE TENSION ON PRESSURE DROP OF SIEVE PLATES

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A new general expression is developed for the hydrodynamic design of sieve plates, namely for the calculation of total pressure drop and its components.

The division of total pressure drop into part pressure drops is theoretically based on the momentum theory and fundamental laws of fluid flow.

Applying and developing the results of Haq[3] and Davy and Haselden[8] it was established:

- **The partial pressure drops—except that of wet plate pressure drop—are practically independent of surface tension, liquid density and viscosity.**
- **The wet plate pressure drop is a parabolic function of gas velocity. It is practically independent of liquid density and viscosity in a wide range, but strongly depends on surface tension.**

In conclusion a general expression is presented for total pressure drop of sieve plates, which is theoretically established, valid in all the three foaming regimes and expresses the influence of surface tension.

INTRODUCTION

The surface tension effect on the performance of plate columns has been widely recognized since many years[1]. Among others Lockett[2] and Haq[3] deal with its effects on hydrodynamics parameters, while Dribika and Biddulph[4], Sawistowki[5] and other authors with its effect on mass transfer in different flow regimes.

In this paper, theoretically established expressions are developed, based on the momentum theory, showing the influence of surface tension.

The first part of this work deals with the momentum theory of sieve plates and develops a new division of the total pressure drop, which division follows from the physical phenomena. The results are verified by experiments with an air-water system.

The second part examines the effect of surface tension on the total pressure drop and on the components of pressure drop using our own experimental data with liquids of different surface tensions and the results of Haq[3] and Davy and Haselden[8].

PRESSURE DROP ON SIEVE PLATES

Many authors have studied the pressure drop on plates and many formulae are known for estimating it. Without mentioning the empirical formulae, it is necessary to summarise the results established theoretically.

Cervenka and Kolar[6] used the momentum theory for sieve plates. The theory is combined by the Bernoulli equation; the dynamic reactions are neglected.

Steiner and Standart[7] defined the real free cross section of plate.

Davy and Haselden[8] measured the wet plate pressure drop (Δp_w) with an air-water system. They recognized, that $\Delta p_w > \Delta p_{dry}$ because the liquid penetrates into the holes, reducing the area available for gas flow. Both are proportional to the square of the hole velocity (Table 1).

Nencetti *et al.*[9], Brambilla *et al.*[10], Koch and Koziol[11], Thomas and Ogboja[12] measured the pressure drop on the foam (Δp_f) with an air-water system, and developed equations for Δp and Δp_f (Table 1).

THEORY

For a description of the two phase flow within the column the momentum theory can be applied:

$$\iint_{(A)} \bar{v}\,\rho\,\bar{v}\,\mathrm{d}\bar{A} = -\iint_{(A)} p\,d\bar{A} + \iiint_{(V)} \rho\,\bar{g}\,\mathrm{d}V \tag{1}$$

The first term represents the change of momentum, the second one the pressure force, the third one the gravity force.

The control surface (A) of the momentum theory is drawn around the foam on the sieve plate (Figure 1). The volume of the two phase foam is V, its density is ρ_f while the foam height is H_f

If the direction upwards is chosen to be positive and the phenomenon is regarded as a turbulent steady flow, equation (1) can be written as equation (2):

$$w_G(v_a - v_r) + \Delta w_L v_L = (p_2 - p_3)A_a - H_f \rho_f g\, A_a \tag{2}$$

The first term represents the change of momentum of the gas, the second one the change of momentum of the weeping liquid. The third term is the pressure force, the last one the gravity force. In and outflow velocity of the main quantity of the liquid is basically horizontal and does not affect the momentum equation.

Adding and subtracting the pressure under the plate investigated, after rearrangement results in:

$$p_1 - p_3 = p_1 - p_2 + H_f \rho_f g - \frac{w_G}{A_a}(v_r - v_a) + \frac{\Delta w_L}{A_a} v_L \tag{3}$$

or term by term:

$$\Delta p = \Delta p_w + H_f \rho_f g - d_G + \mathrm{d}_L \tag{4}$$

As can be seen, the total pressure drop of the stage (Δp) consists of the following parts:

- pressure drop on the wet plate, Δp_w;

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