

**STUDY ON THE IMPACT OF DEFOAMING AGENT ON THE EFFICIENCIES
OF SEPARATION BY DISTILLATION**

Zhelcho St.Stefanov¹, Mariana Kr. Karaivanova

Department of Technical Sciences, University "Prof. Assen Zlatarov"

Bourgas, Bulgaria, E-mail: zhstefanov@abv.bg

Abstract

The effect of a defoaming agent on the gas-liquid layer height and, respectively, the size of the interphase surface and hence on the degree of separation by distillation was studied. The experimental results obtained with a model mixture methanol-water were carried out in a laboratory sieve-plate glass column in presence of defoaming agent SIHA Silicone defoamer SE.

The comparative analysis of the model mixture studied with and without defoaming agent showed that the presence of defoaming agent gave foam height about 2 – 2.5 times smaller yet at vapor velocity in the column with defoaming agent about 1.5 times higher than that without defoaming agent. The values of the local efficiency in presence of defoaming agent were about 10% lower. This certainly confirms the fact that the lower foam height in presence of defoaming agent, i.e. the smaller interphase area, results in decreased process efficiency.

Key words: distillation, local efficiency, defoaming agent, lower boiling component (LBC), higher boiling component (HBC), surface tension

1. INTRODUCTION

Distillation is one of the methods for separation of liquid two- or multicomponent mixtures based on the different distribution of the liquid and gaseous phases of the components. Contemporary industrial distillation employs mainly plate columns and packed columns.

The variables affecting distillation plate efficiency, or any vapor-liquid contact device efficiency, can be considered in three groups: design variables, operating variables and system property variables [1].

Aiming to increase separation efficiency, surfactants are often added to binary mixtures and this method was studied by many researchers using both packed and sieve plate columns [2-6]. Zuiderweg and Harmens [2] studied the effect of surface tension on the efficiency in binary systems (organic and aqueous) in packed columns by adding surfactants. They found that the addition of surfactant had small effect on the efficiency in organic systems, unlike aqueous ones. During the experiments on the distillation of so called "negative mixtures" (where the LBC has surface tension smaller than that of the HBC, i.e. $\Delta\sigma/\Delta x > 0$), they observed the phlegm oozing off the dephlegmator in drops and streams. By the addition of surfactant to negative systems and rectification of positive systems (where the LBC of the mixture has surface tension lower than that of the HBC, i.e. $\Delta\sigma/\Delta x < 0$), thin phlegm stream was observed in column condenser. The change of column efficiency and the nature of the phlegm flow in the dephlegmator were explained [2] by the fact that the addition of surfactant changed the surface tension distribution in the flowing liquid. For this reason, Francis and Berg [3] recommended for the selection of surfactant aimed to increase of column efficiency that special attention should be paid to the relative volatility which should be close to the volatility of the main component of the mixture, so the surfactant would not accumulated neither in the cube nor in the dephlegmator. Experiments were

carried out with sieve plate distillation columns. It was found that the surfactants added to mixtures of low concentration of LBC might initiate formation of foam since they increase the stability of the thin layer. [4, 5]. An example of this phenomenon is the foaming of soap solutions. For negative systems, the addition of small amounts of surfactant might increase the efficiency coefficient (separation efficiency) of sieve plates to the levels of a positive system. [6].

The aim of the present work is to study experimentally the effects of defoaming agent on the height of the gas-liquid layer of a positive model mixture methanol-water and, hence, on the degree of separation by distillation in a laboratory column with one sieve plate.

2. MATERIALS AND METHODS

The experimental studies of the model mixture were carried out in a glass laboratory column with one sieve plate [7]. Its parameters are presented in Table 1.

Табл.1. Dimensions/Geometry of Plate

Plate diameter	32 mm
Number of openings	44
Opening diameter	1,1 mm
Column cross section area	$15,9 \cdot 10^{-4} \text{ m}^2$
Plate active area	5,6%
Weir height	12 mm

Defoaming agent SIHA Silicone defoamer SE was added to the initial mixture. The defoaming agent was white liquid emulsion containing poly-dimethylsiloxane (alpha-octadecyl-omega-hydroxy-polyglycol-ether.) with chemical name: Octadecan-1-ol, ethoxylated. The criteria for the selection of defoaming agent were to be inflammable and to contain no hazardous substances. Based on equilibrium data for the model mixture used [8], the dependence $y^*=f(x)$ was plotted. As precise enough and convenient, the method of refractometric determination of the composition was used on a refractometer of Abbe – AR4D.

On the basis of the experimental data, the local efficiency was calculated by the equation [9]:

$$E_{OG} = \frac{(y_n - y_{n-1})}{(y^* - y_{n-1})}, \text{ where:} \quad (1)$$

y_n, y_{n-1} – average compositions of the vapor flows coming to and going off the n-th plate, mol/mol

y^* - composition of the vapor in equilibrium with the liquid flowing off the plate with composition x_n , mol/mol

3. EXPERIMENTAL RESULTS

Fig.1 shows the dependence of the height of the gas-liquid layer as function of the vapor velocity in the column for the mixture studied. As can be seen for two of the concentrations studied 1,7 mol% and 2,2mol%, the height of the gas-liquid layer gradually increased from 12 to 28 mm at vapor velocities in the range $0,07 \div 0,17$ m/s. For the other two concentrations of 41,6 mol% and 47,4 mol%, the height of the gas-liquid layer sharply increased from 17 to 90 mm (Fig.2). Besides, LBC concentration had no effect at low LBC concentration while the height of the gas-liquid layer was strongly affected at high LBC concentrations. As can be seen from Fig.2, the increase of the concentration from 41,6 mol% to 47,4 mol% resulted in stronger increase of the gas-liquid layer height with the increase of velocity. This increase of gas-liquid layer height was 5 times at concentration of 41,6 mol% and about 6 times at concentration of 47,4 mol% in the range of velocities studied.

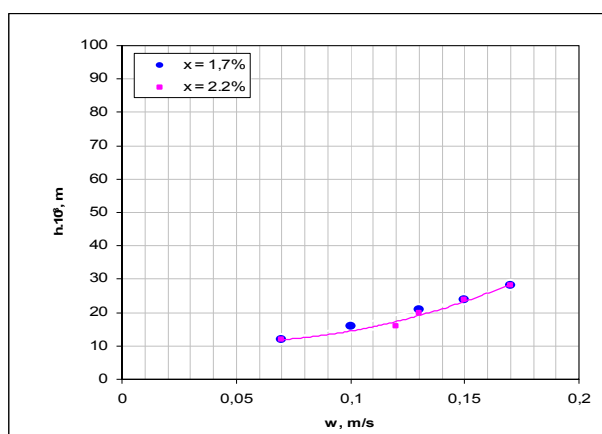


Fig. 1. Dependence of the height of the gas-liquid layer on the apparent velocity of the vapor in the column (w_n) at LBC concentrations (x_w) of LBC in the initial mixture 1,7 mol% and 2,2mol%

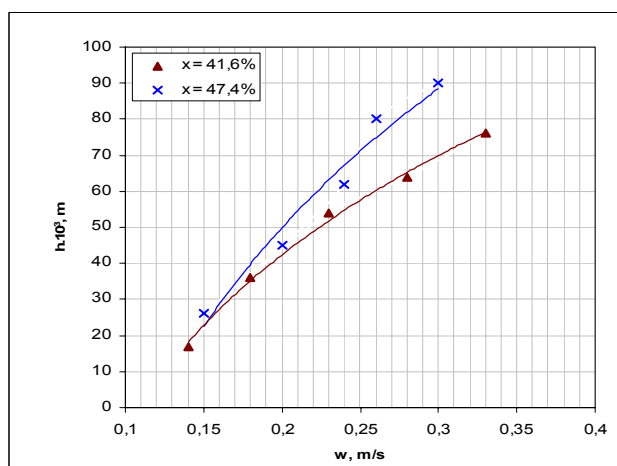


Fig.2. Dependence of the height of the gas-liquid layer on the apparent velocity of the vapor in the column (w_n) at LBC concentrations in the initial mixture (x_w) 41,6 mol% and 47,4 mol%

Fig.3 presents the comparative analysis of the gas-liquid layer height dependence on the vapor velocity in the column w_n , carried out on model mixtures with and without defoaming agent. It can be seen that the height of the gas-liquid layer changed from 17 to 76 mm in presence of defoaming agent while without defoaming agent at the same concentrations it changed from 20 to 95 mm. The presence of defoaming agent resulted in 2-2,5 times decreased height of the gas-liquid layer even at 1.5 times higher vapor velocity.

The experimental data on the influence of vapor velocity (w_n) on the local coefficient of efficiency $KПД$ (E_{OG}) are shown in Figs.4 and 5. It is obvious from Fig.4 that the local efficiency coefficient gradually increased from 65 to 86 mol% in the velocity interval from 0.07 to 0.17 m/s at LBC concentration in the initial mixture 1,7 mol% and 2,2 mol%. At LBC concentrations in the initial mixture higher than 40 mol%, however, the local efficiency coefficient changed only slightly from 83 to 86 mol% in the velocity range from 0=14 to 0=34 m/s. (Fig.5).

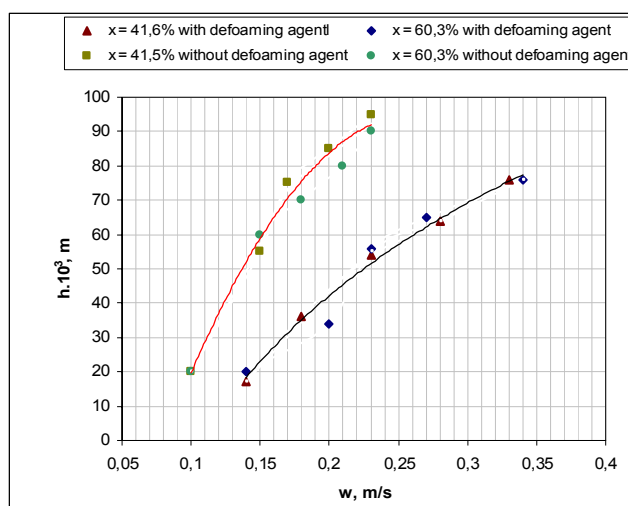


Fig.3. Dependence of the gas-liquid layer height on the apparent vapor velocity (w_n) with and without defoaming agent

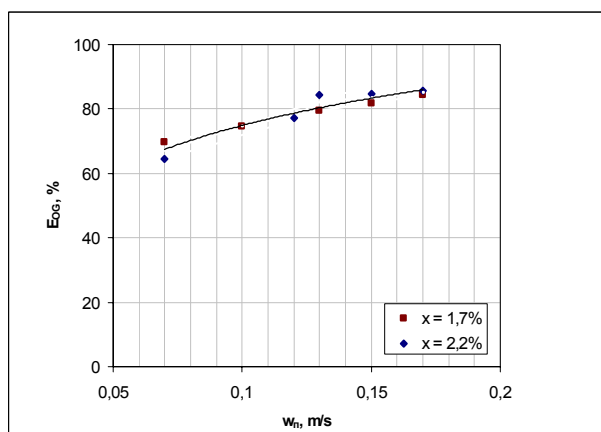


Fig.4. Dependence of the local coefficient of efficiency on vapor velocity in the column w_n at binary mixture composition in column cube $x_w=1,7$ mol/% and $x_w=2,2$ mol/%

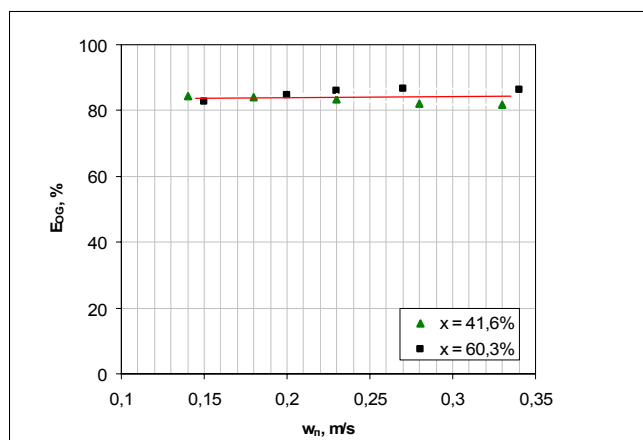


Fig.5. Dependence of the local coefficient of efficiency on vapor velocity in the column w_n at binary mixture composition in column cube $x_w=41,6 \text{ mol/\%}$ and $x_w=60,3 \text{ mol/\%}$

Fig.6 shows the dependence of the local coefficient of efficiency on the composition of the binary mixture methyl alcohol – water at different velocities of the vapor in the column. It can be seen from these dependencies that the change of LBC concentration in column cube had almost no effect on the separation efficiency in the velocity interval from 0.14 to 0.33 m/s. In the concentration interval from 1,7 mol %, 2,2 mol%, 41,6 mol%, 47,4 mol% and 60,3 mol%, the local coefficient of efficiency slightly increased with the increase of LBC concentration in the initial mixture. For the model mixture studied, the change of methyl alcohol concentration in the initial mixture from 1.7 to 60.3 mol% resulted in an increase of the local efficiency coefficient from 82 mol% to 87 mol%.

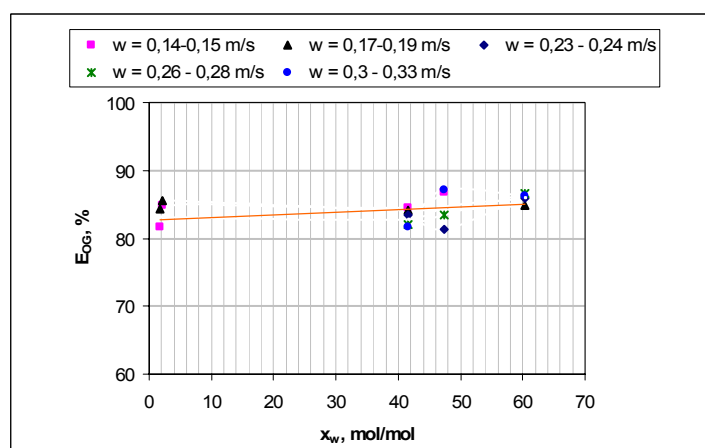


Fig.6. Dependence of the local coefficient of efficiency on the composition of the binary mixture methyl alcohol – water in column cube x_w

The experimental data on the effect of vapor velocity (w_n) on the local efficiency coefficient (E_{OG}) are presented in Fig.7 and model mixtures with and without defoaming agent are compared. Obviously, the values of the local efficiency coefficient in presence of defoaming agent were by 10% lower at LBC concentrations 41.6 and 47.7 in the initial mixture. This certainly proves that the smaller layer height in the presence of defoaming agent, i.e. the smaller area of the interphase boundary, leads to decreased efficiency of the process.

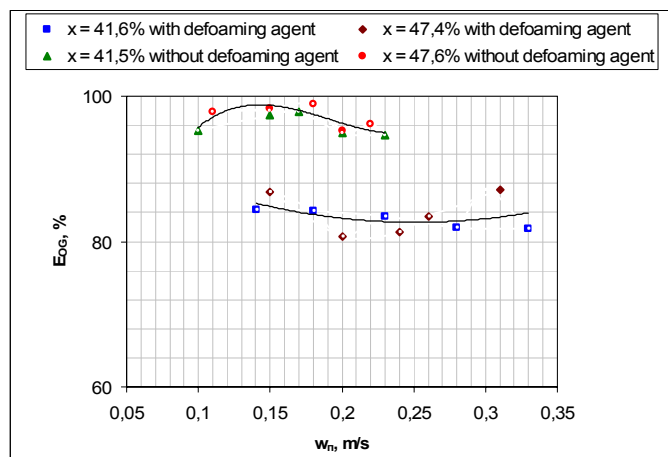


Fig.7. Dependence of the local coefficient of efficiency on vapor velocity in the column w_n at binary mixture composition in column cube:

$x_W=41,6$ mol/% and $x_W=47,4$ mol/% in presence of defoaming agent;
 $x_W=41,5$ mol/% and $x_W=47,6$ mol/% without defoaming agent [10]

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