INVESTIGATION OF HYDRODYNAMIC AND MASS TRANSFER OF SIEVE TRAY BY DISTILLATION

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ABSTRACT

The distillation is one of the methods for separating liquid mixtures based on different distribution between the liquid and vapour phases of the components in the mixture. Vapor and liquid flow are passed countercurrent, repeatedly interacting with one another through special apparatuses (rectification columns), in which part of the vapor (or liquid) leaving the column is recovered after condensation (in the case of the vapour) or evaporation (in the case of the liquid). The contact between the two phases takes place on the contact devices (trays) horizontally located along the height of the column.

The purpose of this work was to study the influence of load on steam phase on hydraulic resistances, the height of entities vapour-liquid layer and the efficiency of separation of sieve tray.

Key words: *rectification, glass column, mass transfer, efficiency, sieve tray*

INTRODUCTION

During the course of teaching of engineering staff as well as in research work, for the chemical industry are used many and varied instrumentation. The renovation, the modernization and the visualization of research and practical equipment requires large capital investment. The mass transfer processes as one of the most common and most important in this industry are carried out in sophisticated apparatus.

The distillation is among those processes that require sophisticated, modern and research teaching facilities. Any investment in the form of research in this area is restored in the form of qualified professionals and a competitive production.

MATERIAL AND METHOD

Physicochemical properties of pure components (liquid and steam phase) [1] are shown in Table 1.

Table 1 *Physicochemical characteristics of pure methanol and water components*

№	characteristics	component methanol		component water	
		liquid	vapour	liquid	vapour
1	Molecular weight kg/kmol	32,04	32,04	18,02	18,02
2	Boiling point, ^{o}C	64,7		100	
3	Density of the liquid phase at 64 ^{o}C , kg/ m^{3}	752	1,16	980,8	0,652
4	Density of the liquid phase at 100 ^{o}C, kg/m^{3}	711	1,05	958	0,589
5	Heat of vaporization at 64^{o}C ,kJ/kg	1100,75		2348,94	
6	Heat of vaporization at 100^{o}C, kJ/kg	1013,9		2258,4	
7	Refractive index at 20^{o}C	1,3282		1,3300	

In the present work is exposed study of the effectiveness and hydrodynamic characteristics of overflow sieve tray. Experiments were conducted on the installation shown in fig.1. The column is made entirely of quartz glass. The column has a diameter of 0,1 m and is equipped with three

overflow trays with a clear section 4.66%. The number of holes in the plate is 52 with a diameter of 3mm, as the overflow limit of each plate is 15mm.

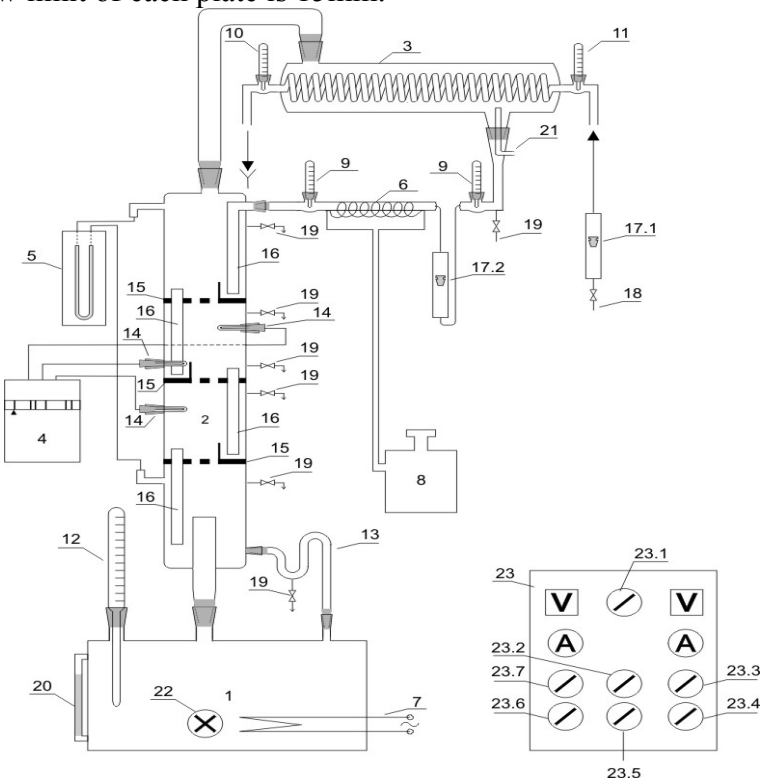

Fig.1 Scheme of the experimental equipment

1-bottom; 2-distillation column; 3-condenser; 4-potentiometer; 5- U-tube manometer; 6,7-heater; 8-LPS; 9,10,11,12-termometers; 13-level regulator; 14-termocouple; 15-trays; 16-merged tube; 17-rotameters; 18-adjustable valve; 19-samples; 20-gauge level; 21-connection to atmosphere; 22-drain valve; 23-control unit; 23.1-master switch; 23.2-regulator switch; 23.3-LPS switch; 23.4,23.5,23.6,23.7-heater switch.

The installation is equipped with registering and regulating technics, permitting precise experiment. The installed electrical capacity allows survey in a wide operating range. Studies were conducted on mixture methanol-water, operation - full reflux.

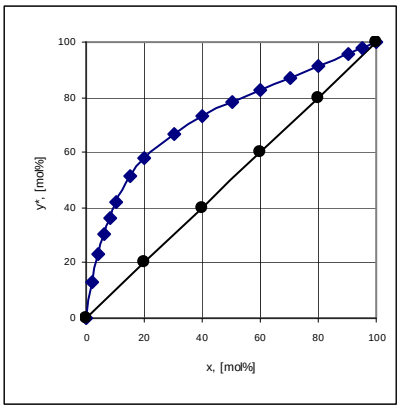

Fig.2. $y-x$ diagram of the mixture

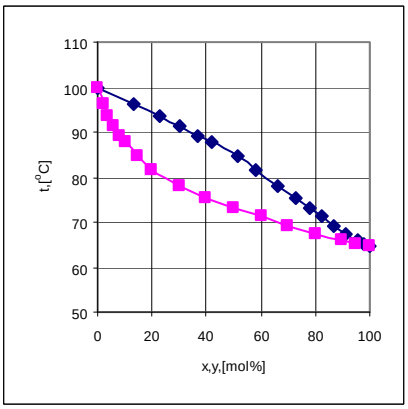

Fig.3. $t-x,y$ diagram of the mixture

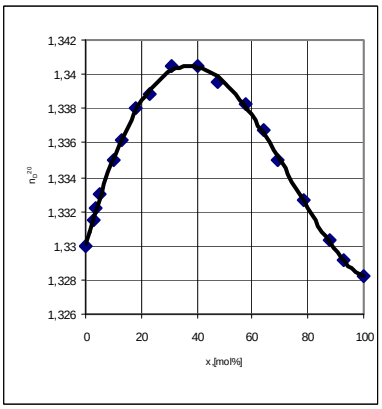

Fig.4. $n_D^{20}-x$ diagram of the mixture

In Fig.2, 3 and 4 are shown respectively y-x; t-x,y diagram of a mixture model [2] and the dependence of the refractive index of the composition of the mixture model [3].

RESULTS AND DISCUSSION

The efficiency of work, of overflow sieve trays was evaluated through etc. Efficiency of Marfri [4, 5]:

$$\eta_M = \frac{y_2 - y_1}{y^* - y_1} 100, \%$$

Where: y_1 - average composition of the incoming vapors into the tray, mol / mol;

y_2 - average composition of the outgoing vapors out of the tray, mol / mol;

y^* - composition of the vapors in equilibrium with the outgoing liquid of the plate with composition x, mol / mol.

The height of the gas-liquid layer on the plate is determined visually, the hydraulic resistance of the plate through the U - tube manometer.

For this purpose samples were taken from the middle tray as a liquid and vapor before and after the tray.

The analyses were carried out refractivily by a refractometer of Abbé. The accuracy of counting is ± 0,0002 divisions. For each regime were held in several experiments. The visual observation and the constancy of parameters ensure that the installation is in regime. Because the installation is fully bared, performance and the speed of the vapours were determined by a flow of reflux, measured by rotameter and recalculated the relevant conditions. This special feature allows a comprehensive monitoring process of the installation, which makes it particularly valuable for work with students. The investigation was conducted in the range of speeds - home of formation of the foam layer to the point of choking. The resistance of the tray was measured with U - tube manometer, in mm water. Part of the hydrodynamic studies are shown graphically in Fig.5 and Fig.6. In the investigated range of speed from 0,1 to 0,4 m / s the hydraulic resistance of the plate increases from 3 to 16 mm water. The height of the vapor-liquid layer is changing from 15-25 to 40-50 mm, as with increasing the concentration of the low-boiling component in the parent compound, also increases and the height of vapor-liquid layer.

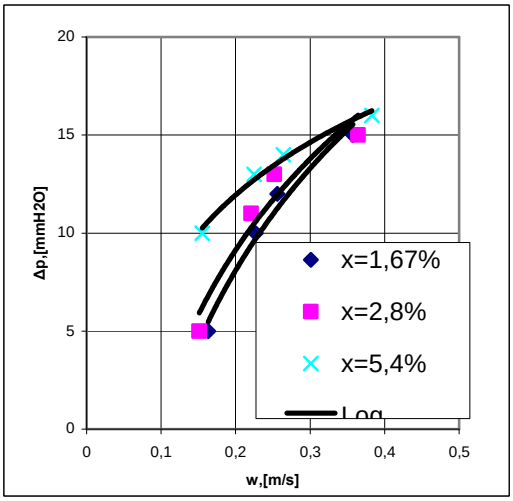

Fig.5. Dependence on Δp of the velocity of vapor in different compositions of the mixture

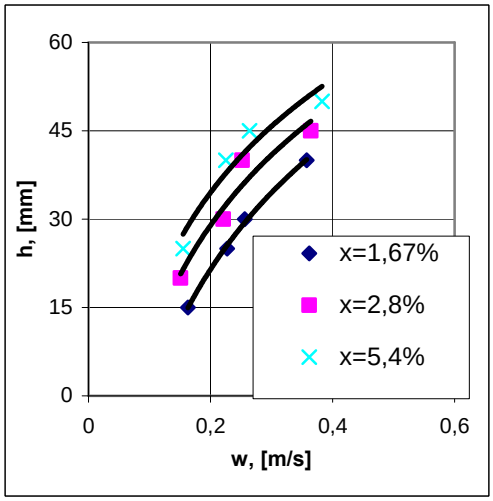

Fig.6. Dependence on the height of the gas-liquid layer by the velocity of vapor

While the resistance of the column is affected by the velocity of vapor, then the change of the concentration of low volatile component in the cube of the column visibly does not affect on Δp. The resistance of the column and the height of the layer are measured to the nearest 1 mm.

The concentration in the cube of the column was changing in the range of $1,67 \div 5,4 mol\%$. For each speed were taken samples of liquid and steam phases, enabling the calculation of the tray`s efficiency. Some of the results are shown in Fig.7. The graph shows that the efficiency of the plate decreases with the increasing velocity of vapor in the column.

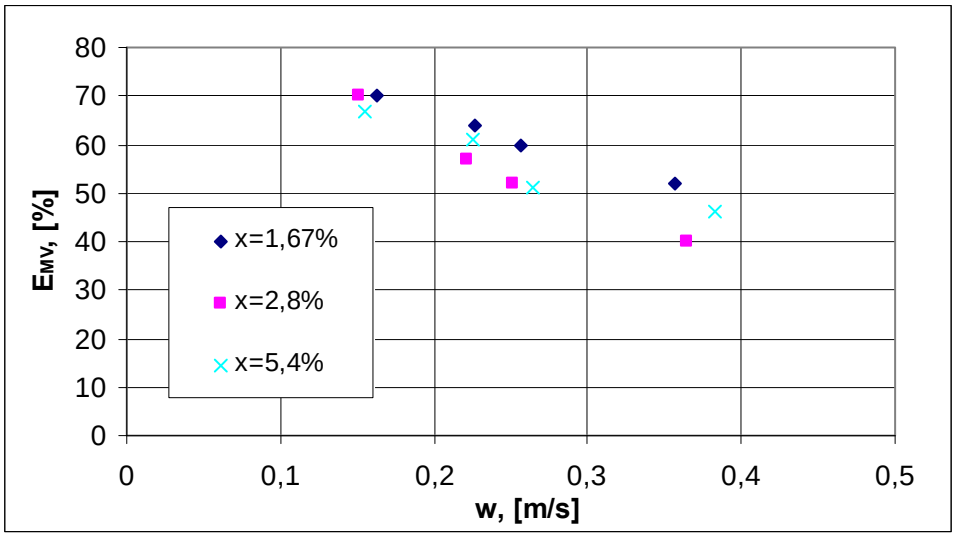

Fig.7. Dependence on efficiency of Marfri by the speed of the steam phase

The efficiency of the plate for the investigated model mixture methanol - water was changing in the range of 40 to 70%.

CONCLUSIONS

1. In glass laboratory column with three overflow sieve trays with diameter 0,01 m are obtained experimental data on hydraulic resistance of the plate, the height of gas-liquid layer and the efficiency of separation by distillation of a binary mixture methanol-water within the concentration range of $1,67 \div 5,4 mol\%$.

2. It has been shown that with increasing velocity of the steam phase, the resistance increases continuously, grows and the height of the gas-liquid layer.

3. The effectiveness of the plate with increasing velocity of vapor in the column decreased, varying in the range of 40 to 70%.

4. The resistance of the plate and its effectiveness are influenced less by the changes in concentration in the cube of the column.

5. The height of the gas-liquid layer increases with the rise of the concentration of low volatile component in the cube of the column.

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REFERENCES

1. Плановский, А. Н., В. М. Рамм, С. З. Каган, 1968, Процессы и аппараты химической технологии, Химия, Москва.

2. Gmehling, J., U. Onken, 1986, Vapor-liquid equilibrium data collection, Chemistry Data Series, Vol. I, Part 2a.

3. Stefanov Zh., M. Karaivanova, 2011, "Surface tension effects in sieve plate distillation column**"**, Int. sci. conf., Stara Zagora.

4. Касаткин, А. Г., 1973, Основы процессы и аппараты химической технологии, Хими,, москва.

5. Fairq J. R., H. R. Null, W. L. Bolles, 1983, “Scale-ap of Plate Efficiency from Laboratory Oldershaw Data”, Ind. Eng. Chem. Proc. Des. Devel., v. 22, 53-59.