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Technological Scheme Development of the Azeotropic Mix Separation

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Abstract: The technological scheme of azeotropic mix separation by means of the selective water absorption with use of KA zeolite molecular gate properties is developed. It is shown that initial mix will be divided into two phases in a three-phase separator where from azeotropic mix the phase of liquid hydrocarbons and water-methanol mix separates. The following stage of water-methanol mix gets on the block of adsorbers where methanol dehydration takes place. Technological parameters of operating the block of adsorbers are also determined, on the basis the test research the cycles of adsorbents regeneration are established. Comparison of test and experimental data of liquid adsorption process on solid adsorbents is carried out. The mathematical model reflecting process of adsorption in KA brand zeolite is developed.

Key words: Three-phase separator, mathematical model, adsorption process, zeolite, water-methanol mix

INTRODUCTION

The adsorptive processes are widely used in the industry for separation of gases, receiving oxygen and nitrogen from air and also for natural gas dehydration from liquid hydrocarbons and water. But for some reason rapid development of gases adsorption on solid adsorbents was more widely used, than adsorption of solutions on solid adsorbents. And theoretically description is more devoted to describing adsorption of gases than adsorption of solutions. It is possible to note that in a case with solutions molecular gate properties of zeolites can be used which allows to adsorb certain size molecules selectively (Zhdanov *et al*., 1981).

Technological scheme description: In Fig. 1, the developed technological scheme of azeotropic system separation process with the subsequent dehydration of methanol and its return to technological chain is submitted. This scheme can be realized in the conditions of main compressor station where the dehydration gas and preparation of natural gas for transporting is carried out (Paranuk, 2012). And also it can be applied in the conditions of production on the well for dehydration of methanol which is pumped without the hydrate mode of the well (Paranuye and Kunina, 2012).

The azeotropic mix consisting of hydrocarbons liquid fractions comes to a three-phase separator of C-1 (C5 - C9) and water-methanol systems, in it occurs separation into liquid hydrocarbons and water-methanol mix, via V-1, V-2 gates by means of the pumps N-1, N-2, N-3, N-4, it gets on the block of filters F-1 where there is a purification of mix from small impurity and further on the block of adsorbers for dehydration, the drained methanol gets to E-1 reservoir. Regeneration of adsorbent is carried out by inert gas at a temperature of 250-300 (it is possible to use nitrogen, methane and air) (Paranuk *et al*., 2015; Paranuk and Saavedra, 2015). After regeneration solution gets to S-2 separator where from gas it is separatedin a liquid phase (Fig. 1).

MATERIALS AND METHODS

The mathematical model reflecting process of adsorption in KA zeolite: The volume of the adsorbed substance:

$$V_a = Vc\tau \qquad (1)$$

Where:
V = The volume of the drained solution (m^3/h)
c = Volume concentration of water in solution (%)
τ = Operating time of pumps

The adsorptive ability of adsorbent:

$$a = \frac{m_1}{m_2 \cdot M} \qquad (2)$$

Where:
m_1 = The mass of the adsorbed substance (kg)
m_2 = Mass of adsorbent (kg)
M = the molar mass of the adsorbed substance

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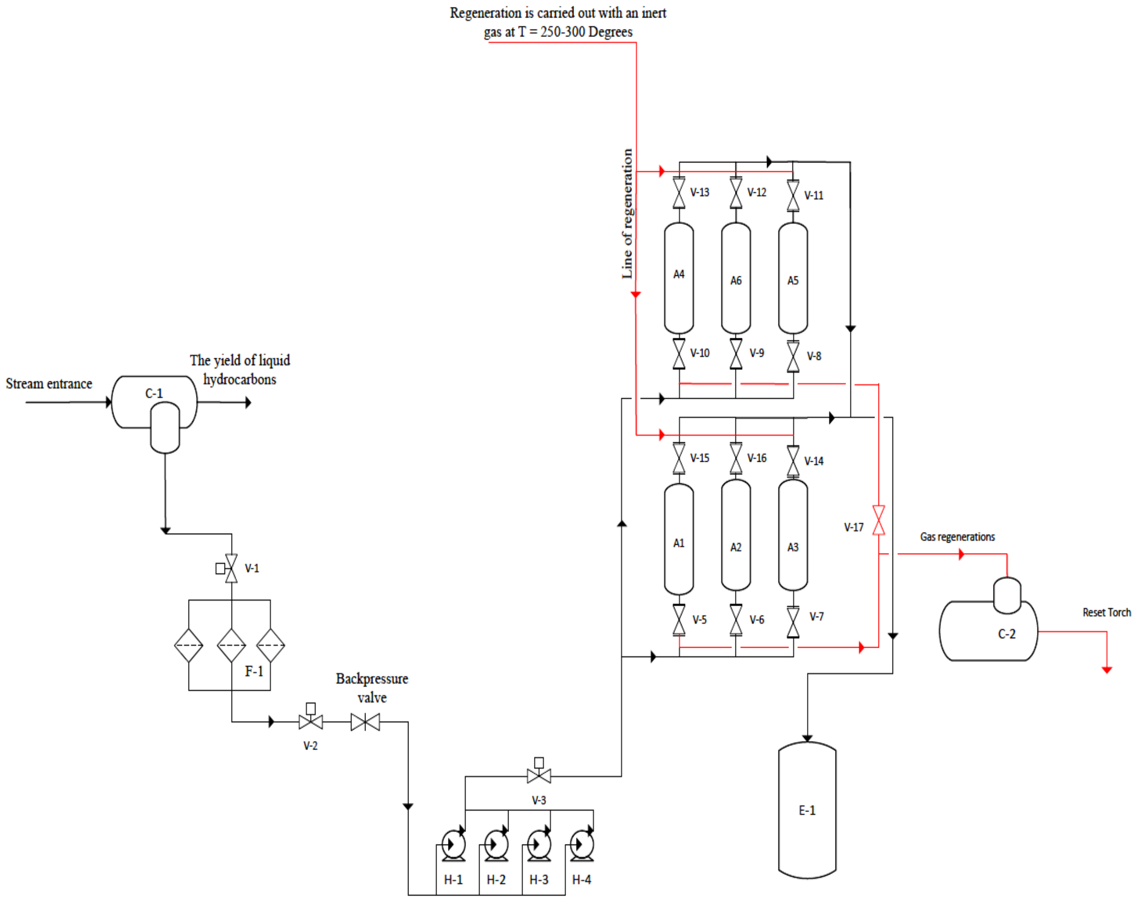

Fig. 1: Technological scheme of separation of azeotropic systems; C-1: Three-phase separator, V-1, V-2, V-3, V-4, V-5, V-6, V-8, V-9, V-10, V-11, V-12, V-13, V-14, V-15, V-16, V-17: gate with remote control, N-1, N-2, N-3, N-4: block of pumps, F-1: block of filters, A1, A2, A3, A4, A5, A6: block of adsorbers, S-2: two-phase separator, E-1: reservoir for methanol collecting

RESULTS AND DISCUSSION

Considering some volume of liquid $V_a(\tau)$ which moves through pumps with a certain speed $\vec{v}$ the scalar function according to the theorem of transfer will comply to the form (Lykov, 1987):

$$\frac{d}{d\tau}\int_{V_a(\tau)}\varphi dV = \lim_{\Delta\tau\to 0}\left[\frac{\int_{V_a(\tau+\Delta\tau)}\varphi(\tau+\Delta\tau)dV - \int_{V_a(\tau)}\varphi(\tau)dV}{\Delta\tau}\right] \quad (3)$$

Expressing volume from a Eq. 3 through the areas dS we will receive expression for the theorem of transfer:

$$\frac{d}{d\tau}\int_{V_a(\tau)}\varphi dV = \int_{V_a(\tau)}\varphi dV = \int_{V_a(\tau)}\frac{\partial\varphi}{\partial\tau}dV + \int_{S_a(\tau)}\varphi\vec{v}\vec{n}_1 dS \quad (4)$$

If $\vec{v} = 0$ then $V_a = V$.

$$\frac{d}{d\tau}\int_{V_a(\tau)}\varphi dV = \int_V\frac{\partial\varphi}{\partial\tau}dV \quad (5)$$

Considering that speed $\vec{v}$ equals to the speed of the current environment $\vec{\upsilon}(\vec{v} = \vec{\upsilon})$, then from this ratio it is possible to receive the theorem of transfer according to Reynolds (Lykov, 1987):

$$\frac{d}{d\tau}\int_{V_m(\tau)}\varphi dV = \frac{d}{d\tau}\int_{V_m(\tau)}\frac{\partial\varphi}{\partial\tau}dV + \int_{S_m(\tau)}\varphi\vec{\upsilon}\cdot\vec{n}^1 dS \quad (6)$$

where, $V_m(\tau)$ and $S_m(\tau)$, respectively are a volume and surface of moving liquid. If transferable size-vector, for example $\vec{\upsilon}$, then generally the theorem of transfer has an appearance:

$$\frac{d}{d\tau}\int_{V_a(\tau)}\vec{\upsilon}dV = \int_{V_a(\tau)}\frac{\partial\vec{\upsilon}}{\partial\tau}dV + \int_{S_a(\tau)}\vec{\upsilon}(\vec{v}\cdot\vec{n}^1)ds \quad (7)$$

The size of permeability is determined by a Eq. 8:

$$K = \frac{V_a \cdot M}{S\cdot\left(\frac{\Delta p}{l}\right)} \quad (8)$$

Where:

μ = Chemical pulp viscosity
Δp = Pressure difference (MPa) on length l (m)
S = Cross sectional area

Thus, the provided technological scheme allows to solve a problem of alcohols dehydration by methods of the selective absorption (adsorption) on KA zeolite, the mathematical model is offered; it gives the sufficient volume description of this process and allows to carry out technological calculation, using modern computing systems.

CONCLUSION

It is possible to note that the offered scheme is implemented in the conditions of production and transport of natural gas. This scheme allows to return >50% of methanol into a technological chain and also allows to receive the additional volume of hydrocarbonic raw materials. And the offered mathematical model can be used as a calculation procedure for adsorption of solutions on KA brand zeolite.

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