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MATHEMATICAL MODEL OF TEMPERATURE'S ANOMALY AT CO-ADSORPTION BINARY MIXTURE AND NEW TYPE OF ADSORBERS – SECTIONED APPARATUS

INTRODUCTION

The gas family from oil-field is useful divided on methane, ethane, propane, butane with adsorption method taking of crude for petrochemical processing or gaseous fuel for automobile motors[*)]. As adsorption process is highly expensive it is necessary elaborated new economical technology and apparatuses. In that article is put in order materials of investigation high-temperature adsorption and succession and parallel sectioning of adsorbers [**)].

INVESTIGATION OF HIGH-TEMPERATURE ADSORPTION

Adsorption stage of divided of hydrocarbons is usually realize at 293-303 K. However, in number investigations are noted case of increasing of activity adsorbents in field of high temperatures at 353-573 K. That occurrences, in particular, may be observed at changing space orientation of asymmetric adsorbed molecules ore at co-adsorption two ore more components with different adsorption potentials. In the latter case the increasing of adsorbent activity by the extractable component is explanation with supplementary sorption of the extractable component on the vacant zones adsorption surface. The rise of that zones is caused by development of desorption appearance.

It is elaborate data the mathematical model of process of co-adsorption binary mixture on the base of thermal equation of adsorption of i-[th] component

$$a_i = a_{0i} \exp[-B_i' T^2 (\lg p_s/p)_i^2]$$

and Lewis 's equation

$$a_{12} [(1-x_2)/a_{01} + x_2/a_{02}] = 1,$$

where a_{0i} - limit size of adsorption; B_i' - thermal coefficient; T - temperature, K; $(p_s/p)_i$ - relation of pressure of saturated vapors of i-th component to its actually pressure; a_{12} - size of co-adsorption two components; x_2 - concentration of the second component in adsorbed layer.

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*) Article is content some materials which was reporting on the 13 International Zeolites Conference , Montpellier, France, 2001 y [1,2].

**)Adsorber is filling with pellet absorbent technological column for sorption process.

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The analysis of model in wide diapason of temperatures (293-533 K) and sizes of relation sorbing ability of components (1-11) [3] is showing that at measure increasing of size of relation sorbing ability and temperature the activity of adsorbent by first (extractable) component is anomaly increased and have characteristic mountain-range picture in diapason. of temperatures 293-350 K (Fig.1); for second (ballast feed) component and for both components together study dependence have trivial character (Fig. 2,3).

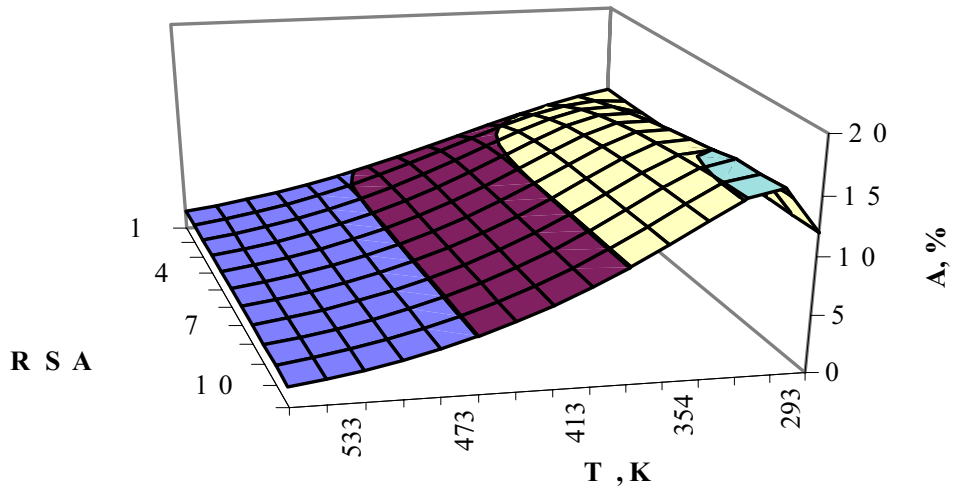

Fig. 1. Field of activity (**A**) of adsorbent by extractable at dependence from temperature of sorption (**T**) and relation sorbing ability (**RSA**) of both components for model mixtures.

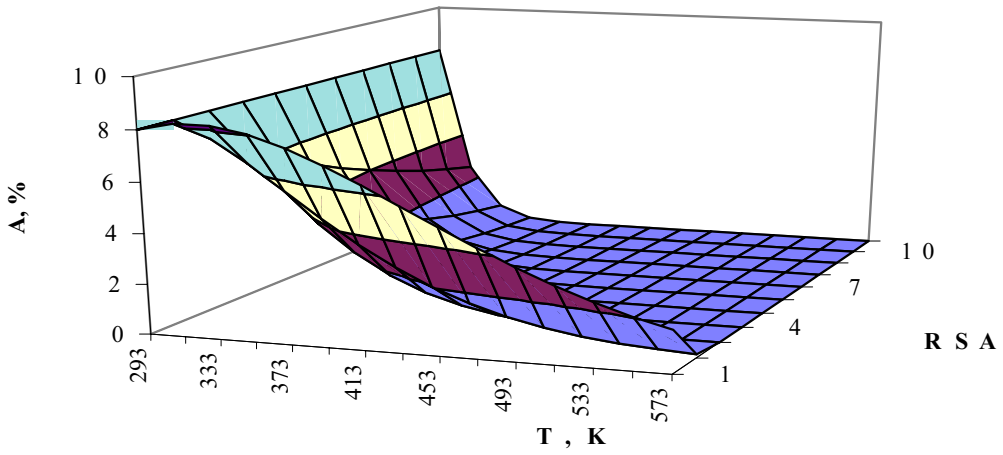

Fig. 2. Field of activity (**A**) of adsorbent by ballast feed's at dependence from temperature of sorption (**T**) and relation sorbing ability (**RSA**) of both components for model mixtures.

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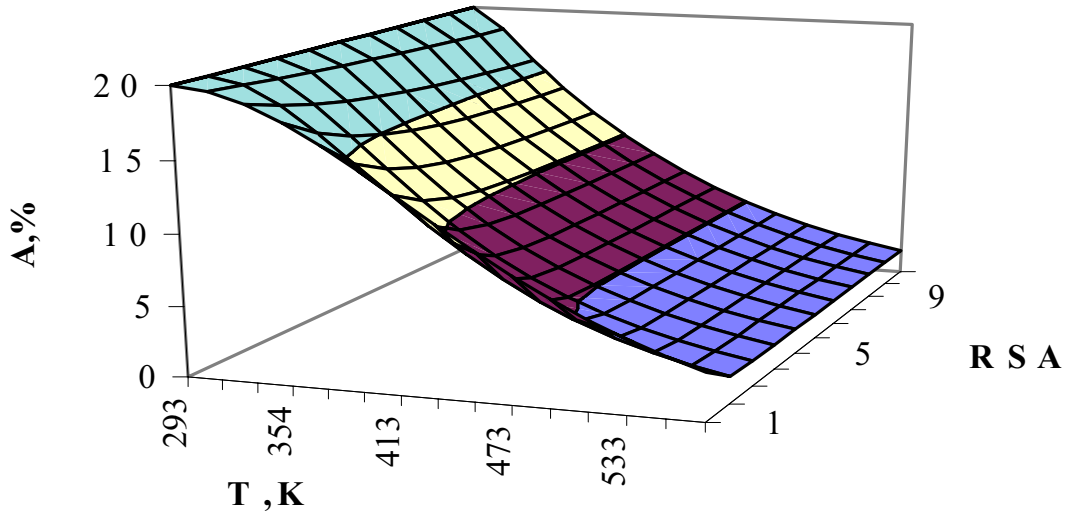

Fig. 3. Field of activity (**A**) of adsorbent for both adsorbed components at dependence from temperature of sorption (**T**) and relation sorbing ability (**RSA**) of both components for model mixtures.

Example of real temperature's anomaly at adsorption is showing on the Fig.4.

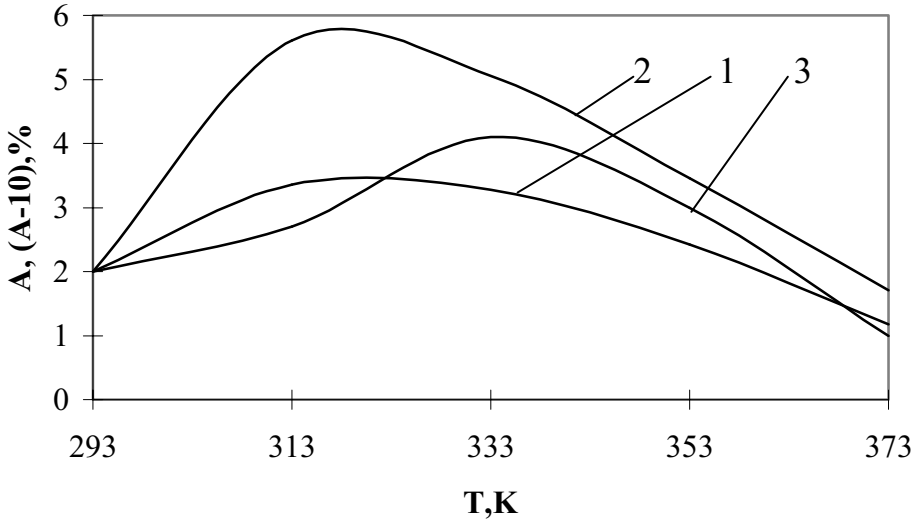

Fig. 4. Temperature's anomaly at adsorption of binary mixture at relation sorbing ability 4 (1) and 10 (2), 3 – data [4] of sorption of propyl-chloride from mixture with cyclopropane on the zeolites CaA at 293-373 K.

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Increasing of temperature is lead to desorption of molecules both special purpose extractable and ballast feed components, however, latter of them are desorbed more intensive; the free vacant places of adsorbent surface are equilibrium fill by mainly molecules of extractable component.

Discovery of anomaly temperature zones where activity of adsorbent is increase may be using for optimization of adsorption process.

SUCCESSION AND PARALLEL SECTIONIND OF ADSORBERS

The place in traditional vertical apparatuses with motionless and moving layers of adsorbent of longitudinal partitions which divide the apparatus on the two or more sections (Fig. 5) is allowed in some cases essential intensively the adsorption process.

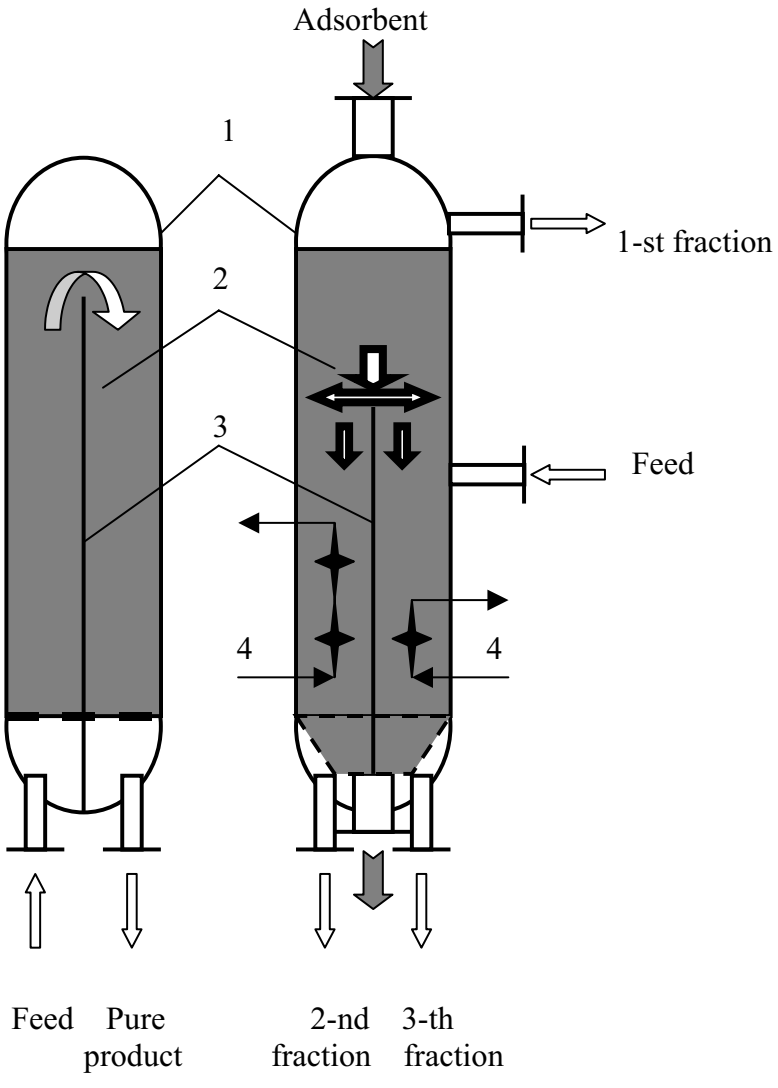

Fig. 5. Principal schemes of sectioning apparatuses with motionless (a) and moving (b) layers of adsorbent.
1 – adsorber; 2 – absorbent; 3 – sectioning partition; 4 – zone heat transfer operation.

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In apparatus with motionless layer of adsorbent the sectioning of adsorber by means of **N** partitions on **N+1** sections is lead to increasing in **N+1** time of height adsorbent layer and velocity of purify flow and in considerable lesser degree – in $(\mathbf{N+1})^{0.5}$ – for increasing of length zone mass transfer operation. That phenomenon is forming supplementary reserve of capacities properties of adsorbent and dynamic activity of adsorbent as integral characteristic of process is increase [5].

In apparatuses with moving layer of adsorbent (hypersorbers) at dividing of feed to several fractions number of partitions on one less of number fractions. The place of partitions is lead to increasing of number theoretical plates in the division zone of fractional adsorber and to increasing purify of receiving fractions. The position of partition in adsorber be conditioned by distribution of adsorbent streams among section and composition of adsorbed phase in chromatographic zone of adsorber.

In the Tabl. 1, 2 are put data of results experimental investigation of sectioning adsorbers with motionless layer [6] and calculation analysis of sectioning adsorbers with mowing layer of adsorbent.

Table 1.

Sorption of toluene in liquid phase from mixture toluene-n. heptane in sectioning adsorber with motionless layer of zeolites.

Quantity sections	Dynamic activity of zeolites NaX by toluene, % wt	
	calculated	experimental
1	9.54	9.54
2	10.85	10.72
3	10/95	10.90

In the first of problems we observed (Tabl. 1) that at constant quality of purify product the dynamic activity of zeolites was increase on 14.3% relative at increasing number of sections from to 3. The dependence of increase activity of adsorbent from number of sections have extreme character as maximum. The optimal number of sections is depend from dimensions of apparatus and limited by conditions of pseudo-liquation of adsorbent in sections with lifting stream of purify feed.

On the Fig. 6 is given the dependence of coefficient effective of adsorbent using (K_e) from some parameters of sorption process in motionless layer of adsorbent in sectioning apparatus. In limit the value of coefficient effective of adsorbent is aspire to one.

In the second of problems we calculated dividing of model three-component mixture which have initial composition 95, 2, 3 % in adsorber with mowing layer of adsorbent (Tabl. 2). The quality of fractions receiving in sectioning adsorber is considerable more than in trivial hypersorber: maintenance of a special purpose components in all fraction is increase on 0.14-8.56 %. The purity of second and third fractions is increase more essential. The expenditure of heat on the desorption in sectioning adsorber is less than in hypersorber.

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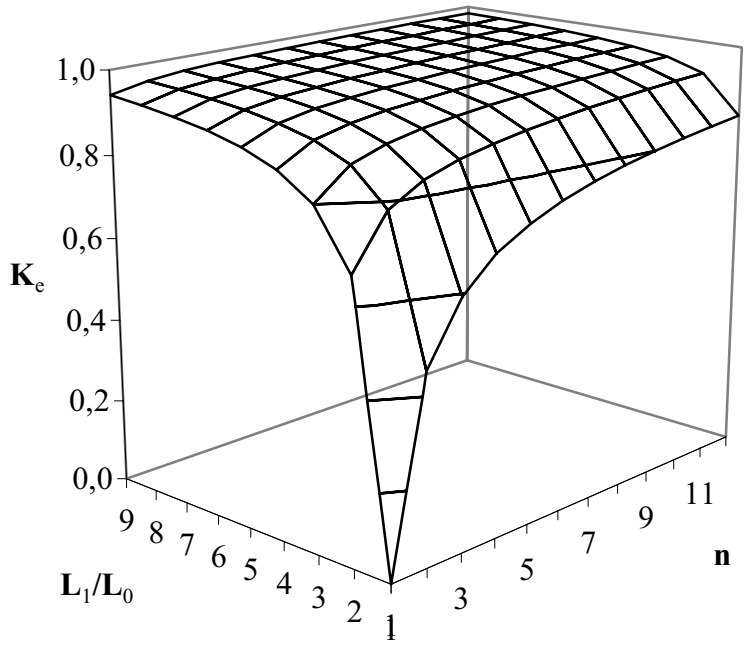

Fig. 6. Dependence of coefficient of effective of adsorbent using (K_e) from number of section in adsorber (n) and ratio of high adsorbent lay to high of mass transfer zone (L_1/L_0) by value of factor symmetry of dynamic sorption curve f=0,5.

Table 2.

Dividing of model three-component mixture in two tapes of adsorbers with mowing layer of adsorbent.

Fractions and components	Composition of fractions, %, for	
	hypersorber	sectioning apparatus
Fraction 1(95%)		
• component 1	99.84	99.98
• component 2	0.16	0.02
• component 3	0.00	0.00
Fraction 2 (2%)		
• component 1	0.10	1.34
• component 2	90.81	98.37
• component 3	9.08	0.29
Fraction 3 (3%)		
• component 1	0.00	0.00
• component 2	6.07	0.25
• component 3	93.93	99.75

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Some variants of development constructions of adsorbers are protected by Patents Russian Federation [8].

CONCLUSION

1. For adsorption dividing of binary mixture components at relative sorption of components more two and temperatures 295-350 K the activity of adsorbent by first (extractable) component is anomaly increased and have characteristic mountain-range picture.
2. The succession sectioning adsorbers with motionless layers of adsorbent and parallel sectioning adsorbers with moving layers of adsorbent is allowed increasing in first case to the dynamic activity of adsorbent and in second case - degree of purification final products.

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