ENGINEERING SCIENCES

MODERN TECHNOLOGICAL OPTIONS RECTIFICATION SEPARATION OF HYDRICARBON-OXYGENATE BLENDS

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Abstract. *The aim of this study is to explore the technological options distillation broad hydrocarbon fractions of different origin in the search for energy-saving environmental conservation technologies in the production of the hydrocarbon fraction of the material and raw materials of various origins including the recycling and reprocessing of heavy oil residues as liquid hydrocarbons are formed during coking of petroleum residues. n the results of analytical studies focused on dry method and technology of petroleum distillates hydrocarbon-oxygenate blends in different origins seem to evidence-based possibility of intensifying mass transfer processes by replacing the traditional stripping agent in the hydrocarbon vapors in a distillation column which allows to save heat and energy costs.*

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When humanity feels the depletion of natural hydrocarbon reserves will be forced it refers to raw materials alternative or secondary origin. Regardless of the origin of high-molecular liquid hydrocarbon cyclic solid mixtures as the thermal decomposition products of hydrocarbon raw materials and many products of organic synthesis, and Fischer Tropeshu to obtain hydrocarbon fractions oxygenate purpose will have to be subjected to distillation to obtain a wide fraction of light hydrocarbons. Besides worldwide intensively waving energy-saving environmental technology industry that requires new technological options for the production of goods for industrial and household purpose. The sharp increase all over the world number of cars and various vehicles demands manufacture qualitative motor fuel on basis energy-savings technologies. Since 2005 on present time all over the world the oil recovery and gas has increased more than by 55 %, and investigation of their underground stocks more than 3 times. Manufacture motor fuels from oil-gas condensate (OGC) mixes is based on the expense of a considerable quantity of energy and use of difficult devices. Last years requirements of quality motor fuels steadily grow, and at the same time instability on quantity and the prices of oil raw materials all over the world is observed. Technical and technological updating of oil refining factories, application energy-saving manufacture methods are the basic criteria providing decrease of expenses by manufacture of mineral oil, in particular motor fuels and improvements of their quality. The above-stated strategic directions of development of manufacture in oil and gas branch correspond to a complex of actions for development of the enterprises. As is known, manufacture motor fuels from oil-gas condensate mixes is based on one of power-intensive processes - difficult distillation (rectification). Thus now as the steaming agent it is used superheated water steam. Analyses show, that giving of water steam as the steaming agent, at distillation of hydrocarbon raw materials, attracts such negative consequences as: considerable power and technological expenses of manufacture superheated water steam; giving of water steam in rectification columns causes formation, in the course of condensation of hydrocarbon steams, a water condensate. In turn the branch of a water condensate from the received fractions demands special devices, carrying out of technological processes of clearing and additional power expenses; water steam and its condensate, being in structure of a mix of hydrocarbons, reduce intensity heat-mass-exchange processes and efficiency of technological indicators equipment for their realization; high value of warmth of condensation of water steams (2260 kJ/kg) concerning this parameter at hydrocarbon steams (250-350 kJ/kg) promotes increase in power expenses at their condensation; the water condensate promotes strengthening of corrosion of contacting surfaces of devices; as a part of a water condensate there are rests of mineral oil, sulphurous and others the chemical compounds demanding additional expenses, connected with their removal and recycling. In turn these impurity aggravate manufacture environmental problems; watering of distillation fractions (especially avionic-kerosene and diesel fuel) a condensate of water steam demands additional expenses connected with their dehydration.

Proceeding from the above-stated, a special urgency get a theoretical and experimental substantiation of expediency of application of hydrocarbon steams at rectification of a OGC mix on distillation fractions and black oil, revealing of features mass-exchange and efficiency of use of the hydrocarbon steaming agent. At present, the scientific and analytical information presents the results of analytical studies focused on dry method and technology of petroleum distillates hydrocarbon-oxygenate fractions of different origin. In the advanced research centers and the higher educational institutions of the world, including Chicago university, Colorado school of mines, Shell Global Solutions Inc. (USA), Japan Petroleum Institute, Tokyo national university (Japan), Royal Military College of Canada (Canada), French Petroleum Institute (France) are conducted scientific researches on increase of efficiency and an intensification of processing of liquid hydrocarbons. As a result of the scientific researches spent in the world on distillation perfection oil-gas condensate mixes following scientific and practical results, in particular, are received: effective ways of an intensification of process of rectification are developed at processing of liquid hydrocarbons (Australian institute of petroleum, Australia); high-efficiency contact devices for perfection of process of rectification are created at oil refining (Japan Petroleum Institute, Japan); improvement of quality of production at reception motor fuel from liquid hydrocarbons the technique of definition of influence of technological parameters in the course of distillation (Research Institute of Petroleum Processing Germany, Indian Institute of Petroleum India) also is developed. Now scientific researches in such priority directions as an intensification mass-exchange to rectification column by application recirculation the alternative steaming agent, perfection of scientific both practical bases and increase of efficiency of distillation oil-gas condensate mixes are conducted. Now in scientific works of large scientists (O.F.Glagoleva, V.M.Kapustin, S.A.Ahmetov, A.S.Bagaturov, A.K.Manovjan,etc.) conclusions are drawn on perceptivity of application of stripping agents, alternative to water steam, such as nitrogen, oxide and carbon dioxide, and also inert gases. Technological and constructive decisions of a problem of reduction of water steam as stripping agent in the course of distillation were offered by many researchers and experts of the given branch. For reduction of power losses and quantity overheated water steam a number of researchers offers various variants on change of the scheme of distillation of the oil, based on creation of additional heating a bottom product by "hot stream». However in references there are no deep studies on application of hydrocarbon steams as the stripping agent instead of overheated water steam at rectification of a OGC mix. Also there is no information about an intensification mass-exchange process at rectification of liquid hydrocarbons with application of alternative stripping agents. Existing literary materials and other theoretical results of researches do not give sufficient possibility for the all-round analysis of process of rectification with application of the hydrocarbon stripping agent. Taking into consideration lacks of application of water steam as the stripping agent, last years in world oil refining appears the tendency to essential restriction of its application and transfer rectification installations on technology of dry distillation. In this connection in the field of oil refining there was a new actual scientific and technical problem on replacement of water steam on alternative stripping agents in the course of distillation of the hydrocarbon raw materials, connected with necessity of creation of scientific bases of new technology - dry distillation of liquid hydrocarbons and working out of an effective method of division of raw materials on fuel fractions. The aim of this study is to explore the technological options distillation broad hydrocarbon fractions of different origin in the search for energy-saving environmental conservation technologies in the production of the hydrocarbon fraction of the material and raw materials of various origins including the recycling and reprocessing of heavy oil residues as liquid hydrocarbons are formed during coking of petroleum residues. From the analysis of a modern condition of the theory and practice of distillation of liquids follows, that in references specific features and lacks of application of water steam are widely resulted at rectification of hydrocarbon raw materials. In works of large scientists of oil refining the above-stated negative moments of use overheated water steam, as the stripping agent are shined, at rectification of liquid hydrocarbons. The main objective of the present research was formed of this analysis. Such statement of a question assumes the decision above-stated concrete and little-study research problems. Successful performance of tasks in view will allow to create scientific bases energy-saving technologies of dry distillation oil-gas-condensate mixes by a process intensification mass given in a steam phase and to develop the basic scheme of a supply of the hydrocarbon stripping agent to rectification to columns. For carrying out of researches by definition of influence of the stripping agent on those or other indicators of process of distillation definition and the comparative analysis of the cores physical and chemical and thermal properties of stripping agents is spent at temperature of 200°S and pressure 0,26 MPa (table 1).

Table 1. The cores physical and chemical and thermal properties of stripping agents (at 200°S and 0,26 MPa)

Stripping agent	M, kg/kmol	V, sm^3/mol	ρ, kg/m^3	μ, mkPa·s	ν, mm^2/s	C_p, kJ/kg·K	λ, Wt/m·K
Water steam	18	18,9	1,286	16,2	12,6	1,974	0,0275
Steams easy gasoline	84-89	140,6	6,90	8,56	1,20	2,255	0,0138
Steams heavy gasoline	112-117	185	9,60	8,16	0,85	2,211	0,0101

There are essential differences from data of this table it is visible, that between the basic indicators traditional (water steam) and hydrocarbon stripping agents. So, for example, dynamic viscosity overheated water steam makes $16{,}2\cdot10^{-6}$ Pa·s, and steams of easy and heavy gasoline matter this indicator accordingly $8{,}56\cdot10^{-6}$and $8{,}16\cdot10^{-6}$Pa·s. and kinematic viscosity of water steam $12{,}6\cdot10^{6}$m^2/s, thus easy and heavy gasoline matter this indicator accordingly $1{,}20\cdot10^{-6}$ m^2/s and $0{,}85\cdot10^{-6}$ m^2/s. From here it is visible, that kinematic viscosity of hydro carbonic steams on the average 12 times is less, than viscosity of water steam. If to take into consideration, that speed molecular and convective diffusions in more degrees depends on size of viscosity of environment there is clear a positive effect of application as the stripping agent of hydrocarbon steams instead of water steam .This factor also promotes acceleration of processes warmly - and mass given at rectification with application of hydrocarbon evaporating agents instead of water steam. In the course of distillation along with mass-exchange there is an intensive heat exchange between vials of the steam phase having a heat and a liquid phase, having lower temperature. Value of factor of heat exchange can be defined by the criteria equation, by means of the generalized Nusselt's Nu criterion, which including modified Reynolds's Re criterion and Prandtl's Pr criterion:

$$Nu = C\cdot \mathrm{Re}^{n_1}\cdot \mathrm{Pr}^{n_2} \qquad (1)$$

For a wide range of pressure it is possible to define from the equation

$$Nu = 0{,}125\cdot \mathrm{Re}^{2/3}\cdot \mathrm{Pr}^{1/3} \qquad (2)$$

Criterion Nu and further value of factor heat exchange α was defined at bubble mode of boiling of a liquid was defined from expression:

$$\alpha = Nu\cdot \lambda / l\ , \qquad (3)$$

where C, n_1, n_2 - constants; α - factor heat exchange, J/(m^2·K); l - the characteristic linear size of process heat exchange – radius of a bubble of the stripping agent, m; λ - heat conductivity factor, Wt/(m·K). Factor definition of heat exchange a steam phase at rectification of OGC mixes by this technique has shown, that the factor heat exchange water steam makes 27,03 J/(m^2·K), and (taking into account structure of hydrocarbon C2-C10) this indicator makes the hydrocarbon stripping agent from 55,4 to 277,32 J/(m^2·K). Value of factor mass given in phases depends on physical and chemical characteristics of this phase and the component. Definition of mass-exchange factors by experimental way is very difficult. Calculation of factor mass given is based on calculations of criteria the equations describing parameters of process. Quantity of the distributed weight are described by laws Fick's and convective diffusions. Comparison of the equations of these laws

$$D(dc/dn)dF = \beta \cdot \Delta c \cdot dF \quad (4)$$

forms a basis of a conclusion of the equation diffusion criterion of the Nusselts

$$Nu_{Д} = (\beta \cdot l)/D \quad (5)$$

where l - the characteristic linear size. In expression of the Nusselts criterion the required size - factor mass given β contains. For definition diffusion of the Nusselts criterion for the plate columns is recommended the following equation

$$Nu_{д} = 0{,}69 \cdot \Pr'^{0,5} \cdot \mathrm{Re}^{0,72} \cdot Ga^{0,24} \quad (6)$$

to be deduced from the equation of the factor equation of mass given β:

$$\beta = (Nu_{Д} \cdot D)/l \quad (7)$$

Application instead of water steam of the hydrocarbon stripping agent changes parameters of mass given in a steam phase and values characterizing criterion. Proceeding from it, we carry out calculations of values of factor mass given at rectification of OGC mixes with application of various stripping agents. As alternative stripping agents water steam (WS) was served by steams of hydrocarbons: steams light (LG) and heavy (HG) gasoline. As distributed substances fractions (limits of boiling fr.1 - 60-80^{o}S, fr.2 - 120-130^{o}S and fr.3 -170-180^{o}S) OGC mixes have been chosen. The factor oil-gas-condensate was calculated at speed of the stripping agent in free section of device w=0,6 of m/s, height of a layer of a light liquid over a plate h=0,05 m and temperature of system of 180^{o}S. Results of calculation of factor mass given in a steam phase at application of various stripping agents are resulted in table 2.

Table 2. Values of factor of mass given in a steam phase [β_y, m/h] at stripping fractions of a OGC mix with use of various stripping agents

Fractions	Parameters	Stripping agent		
		Water steam	Steams LG	Steams HG
Fr. 1	Pr′	4,23	–	0,41
	$\mathrm{Re}\cdot 10^{-3}$	0,85	–	3,53
	$\mathrm{Ga}\cdot 10^{-6}$	0,99	–	1700
	$\beta_y\cdot 10^{-3}$, м/ч	5,72	–	20,2
Fr. 2	Pr′	5,69	1,88	–
	$\mathrm{Re}\cdot 10^{-3}$	0,85	7,8	–
	$\mathrm{Ga}\cdot 10^{-6}$	0,99	82,8	–
	$\beta_y\cdot 10^{-3}$, м/ч	5,32	15,5	–
Fr. 3	Pr′	6,38	2,12	0,55
	$\mathrm{Re}\cdot 10^{-3}$	0,85	7,8	3,53
	$\mathrm{Ga}\cdot 10^{-6}$	0,99	82,8	1700
	$\beta_y\cdot 10^{-3}$, м/ч	5,03	14,6	17,5

Results of calculations show, that average value of factor mass-exchange in a steam phase at stripping the above-stated fractions water steam has made $5{,}52\cdot 10^{3}$ m/h, and value of factor mass-exchange at stripping in steams LG - $15{,}1\cdot 10^{3}$ m/h, steams HG - $18{,}8\cdot 10^{3}$m/h. In an interphase interface layer there is a sharp change of concentration of diffusing component; as in this area of a stream speed of process is defined by molecular diffusion, the role convective diffusions is small. This results from the fact that on border of section of phases braking action of power of a friction between phases and power of a superficial tension amplifies. Based on scientific analyzes of published materials in the direction of the dry distillation of hydrocarbon-oxygenate blends of various origins seem to evidence-based possibility of intensifying mass transfer processes by replacing the traditional stripping agent to the hydrocarbon vapors in a distillation column which allows to save heat and energy costs.

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