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TECHNICAL AND ECONOMIC ASPECTS OF PROCESSING PYROLYSIS DISTILLATE INTO MOTOR FUEL

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Abstract: The main results of the study on the development of an effective technology for processing pyrolysis distillate into motor fuel, based on the catalytic process of hydrotreating raw materials and hydrogenation of intermediate technological products under relatively mild conditions, are presented. The main stages of the new technology are heating of raw materials and hydrogenated product in furnaces, two-stage catalytic processing of distillate and hydrogenated product, heating of raw materials and cooling of reaction products and separation of the gas product mixture with the release of hydrogen-containing gas.

Keywords: gas processing, pyrolysis distillate, hydrotreating, hydrogenation, heating, cooling, heat exchanger, reactor, catalyst, process flow diagram.

Introduction. Natural gas is the main source of energy production and motor fuel. Therefore, the development of methods for its deep processing, targeted disposal of process waste, production of petroleum products from them with improved environmental performance that meet the requirements of international standards, and improvement of the design of process equipment are one of the priority areas for the further development of oil and gas processing enterprises.

In this aspect, scientific research aimed at developing highly efficient processes and apparatus for deep processing of technological waste, based on catalytic processes of hydro-treatment of raw materials and hydrogenation of intermediate products, thereby expanding the range and volume of production of petroleum products becomes important.

Methods. The object of study - pyrolysis distillate is a mixture of saturated hydrocarbons, monoolefins, recombination of low molecular weight unsaturated compounds, including aromatic hydrocarbons, in essence it is a technological waste of production. It is known that when processing natural gas at the JV Uz-Kor Gas Chemical LLC, 103,000 tons of pyrolysis distillate are generated per year, which is currently not processed in the republic and is therefore exported to foreign countries at low prices.

Studies have shown that in terms of physicochemical properties, the pyrolysis distillate corresponds to broad gasoline fractions of direct distillation, since the content of gasoline fractions in raw material samples is more than 80%.

Processing the existing volume of pyrolysis distillate into target products at the refinery makes it possible to expand the production of petroleum products in the republic, in the future it will produce more than 72100 tons of gasoline, 28840 tons of light naphtha and 1300 tons of pyrolysis oil.

In this aspect, the development of scientific and practical foundations for the development of an effective technology for processing pyrolysis distillate into motor fuel, based on the catalytic processes of hydrotreating raw materials and hydrogenation of intermediate technological products [1], is an urgent task that has significant scientific and practical value.

Results. Based on the results of studies carried out to study the fractional composition, physicochemical and thermophysical properties of pyrolysis distillate [2-7], we have developed a new technology for its preparation for processing (distillation), which is based on catalytic processes for processing raw materials, during which the largest part of its sulfur compounds and unsaturated hydrocarbons undergoes splitting under relatively mild conditions [8].

The main stages of the new technology for preparing pyrolysis distillate for distillation are heating the raw materials and hydrogenate in furnaces, two-stage catalytic processing of the pyrolysis distillate and hydrogenate, heating the raw materials and cooling the reaction products, and separating the gas product mixture with the release of hydrogen-containing gas.

The proposed technological scheme for the processing of pyrolysis distillate with a capacity of 103 thousand tons per year (fig. 1) includes two coil furnaces for heating the initial pyrolysis distillate and intermediate products, two parallel operating first-stage catalytic distillate processing reactors, a reactor for conducting the second stage, four shell-and-tube heat exchangers for heating and cooling the feedstock and reaction products, four gas separators for separating the gas product mixture with the extraction of hydrogen-containing gas, as well as three centrifugal pumps for transferring process liquids. The facility has a hydrogen production unit and a compressor station.

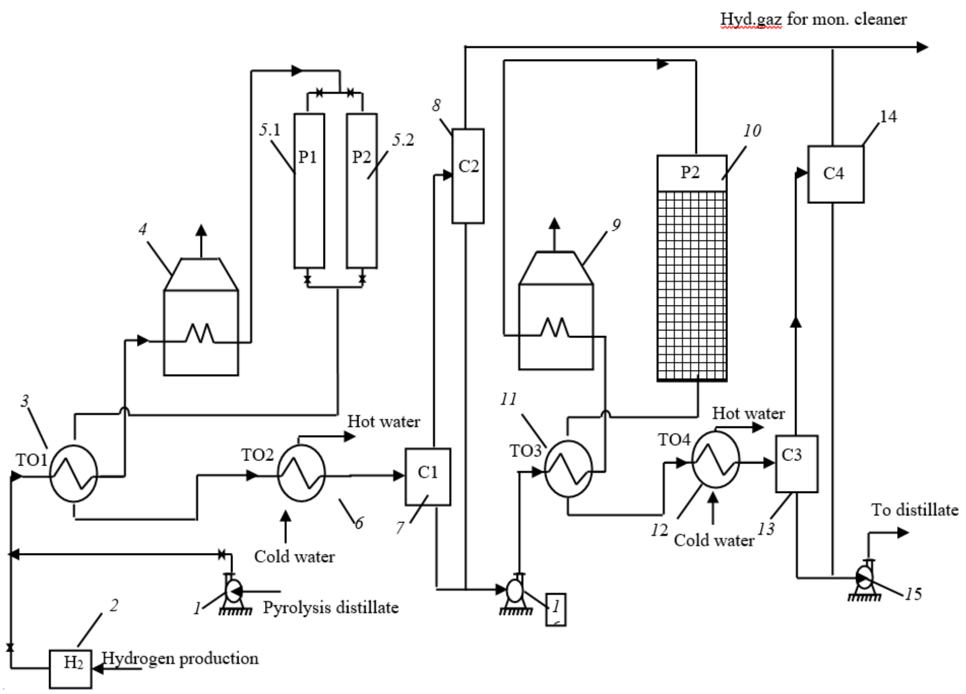

Figure. 1. Technological scheme for preparing pyrolysis distillate for distillation: 1 - raw material pump; 2 - hydrogen collector; 3, 6, 11 and 12 - shell-and-tube heat exchanger; 4 and 9 - coil furnace; 5.1 and 5.2 - stage I reactors; 7, 8, 13 and 14 - gas separators; 10 - stage II reactor; 15 and 16 - centrifugal pump for pumping distillate.

The raw material is initially heated in a heat exchanger with a hot stream of hydrogenate coming from stage I reactors, after which it is mixed with hydrogen and purified monoethanolamine hydrogen-containing gas from the installation. The resulting gas product mixture is sent to a tubular coil furnace, where it is heated to the reaction temperature (150°S) and enters stage I reactors, where the hydrotreating processes of the pyrolysis distillate take place in the presence of a palladium catalyst, made in the form of a catalytic mesh.

The gas product mixture leaving these reactors enters the heat exchanger, where it is partially cooled to 129.4°S and then sent to the second shell-and-tube heat exchanger-cooler, where it is cooled with cold water to 40°S. The cooled unstable hydrogenation product enters the gas separator, where due to the difference in phase densities, hydrogen gas is separated from its composition. The final separation of gas from a liquid drop under the influence of gravity occurs in a vertical gas separator.

The hydrotreated pyrolysis distillate is pumped through the tubes of the heat exchanger using a pump, where it is heated by the heat of the hot hydrogenate stream leaving the stage II reactor. The heated hydrogenation product enters the second coil furnace, in which it is heated to 300°S. Subsequently, a mixture of heated hydrogenation product, hydrogen and purified hydrogen gas is fed into the hydrogenation reactor. The process of hydrogenation of this mixture in the reactor is carried out in a stationary bed of ANM and AKM catalysts at 300÷306°S. During the process, under hydrogen pressure, the sulfur compounds contained in it are destroyed and sulfur is removed in the form of hydrogen sulfide. As a result, the quality and stability of commercial fuel improves.

Subsequently, the reaction products leaving the reactor sequentially enter heat exchangers, where they are cooled to 40°S. The cooled process product is reseparated from the gases under the influence of gravity in gas separators and pumped out to subsequent operations - atmospheric distillation.

During the technological process, the volumetric flow rate of raw materials into the reactors fluctuates within 2.5÷4 h^{-1}, the depth of its desulfurization is 99.6% (wt.) and the circulation rate of WASH to the raw materials is 300 nm^3/m^3. The hydrogen concentration in the hydrogen gas must be at least 70% (vol.).

Taking into account the technological modes of the installation, the conditions of the process and based on the results of the studies [8,9], rational design and technological parameters of shell-and-tube heat exchangers [10] for heating the pyrolysis distillate and cooling the hydrogenation product with water (Table 1) and reactors [11] with catalytic grids and with a stationary layer of aluminum-cobalt-molybdenum catalyst (Table 2).

Table 1. Main design and technological parameters of shell-and-tube heat exchangers

№	Name of indicators	unit measured	Parameter meaning	
			heater	cooler
1	Cold coolant consumption (pyrolysis distillate/cold water)	kg/s (m3/h)	12262	22
	- initial temperature	oS	30	20
	- final temperature	oS	80	50
2	Consumption of hot coolant (hydrogenation agent)	kg/h	12318,5	12318,5
	- initial temperature	oS	175,4	129,6
	- final temperature	oS	129,6	40
3	Thermal power of the device	kVt	378	761,5
4	Heat transfer surface	m2	37,3	131,4
5	Tube diameter	Mm	20/25	20/25
6	Single pipe length	mm	4000	5582

Table 2. Main design and technological parameters of reactors with catalytic grids and AlCoMo catalyst

№	Name of indicators	unit measured	reactor value	
			catalytic meshes	AlCoMo catalyst
1	Performance	kg/h	12262	12230
2	Process pressure	MPa	3,0	3,0
3	Distillate flow rate	h-1	4,0	3,0
4	Circulation ratio hydrous gas	m3/m3	300	300
5	Hydrogen concentration as part of hydrous gas	% general.)	70	70
6	Process temperature:			
	- initial	oS	150	300
	- final	oS	175,4	306
7	Thermal load	kVt	1274,22	3140
8	Catalyst layer:			
	- height	mm		1540
	- volume	m3		4,824
	- weight	kg		3280
	- hydraulic layer resistance	MPa		0,175
9	Design parameters:			
	- geometric volume	m3	12,04	
	- internal diameter	mm	1800	2000
10	Overall height	mm	4430	4030
11	Weight	kg	14500	20000

A distinctive feature of the new technology for processing prolyse distillate is the high yield of gasoline fractions (80%) with its intensive contact with the catalyst.

As is known [10,11], in the near future, in accordance with the projected increase in the volume of natural gas processing in the republic, the above-mentioned volumes of production of petroleum products from pyrolysis distillate will increase. Therefore, in the future, the processing of pyrolysis distillate into target products will make it possible to expand the production of petroleum products at the enterprise and will allow the production of more than 72,100 tons of distillate fractions of gasoline (35÷205°S), 28,840 tons of light naphtha (30÷80°S) and 1,300 tons of bottoms - pyrolysis oil (350°S and above).

The economic effect of introducing into production the developed technology for preparing pyrolysis distillate for distillation was determined according to the methodology described in the regulatory document of Uzbekneftegaz LLC [12].

The cost of generating thermal energy (in water vapor equivalent) at the Bukhara Oil Refinery declared for 2021 is C_{wv} = 127,690 sum/Gcal, electric energy C_{el} = 295 sum/kWt, drinking water C_{v1} = 1110 sum/m3 and process gases burned in furnaces for heating. - heating of raw materials C_{w2} = 380 sum/m^3.

The following Table 3 shows the consumption rates of raw materials, reagents and energy resources in accordance with the technological regulations for the hydrotreating of naphtha (a pyrolysis distillate similar in composition) in the Bukhara Oil Refinery [13].

Table 2. Specific rates of consumption of raw materials and energy resources in naphtha hydrotreating processes

Name of indicators	unit measurements	meaning of indicators specific consumption rate	price, sum	sum, sum
Electrical energy	K Vt/t	0,28	295	82,6
Thermal energy	G kal/t	0,014	127690	1787,66
Recycled water	m3/t	2,56	1110	2841,6

The wholesale selling price of 1 ton of pyrolysis distillate in 2022 was $165.7.

Below, Table 4 shows the cost of production of 1 ton of gasoline under the conditions of Uz-Kor Gaz CHEMICAL.

Table 4. Cost calculation for 1 ton of gasoline from pyrolysis distillate

№	Cost items	units of measurement	quantity, t/y	price, thousand. sum/t	sums, thousand. sum
1	Raw materials:				
	- pyrolysis distillate	ton/year	103000	1651,648	170119744
	- hydrogen	ton/year	108,7	240	26088
	- catalysts (0,002x103000)	t/t	206	224040	46152240
2	Energy costs:				
	- electrical energy	sum/t	82,6		8507,8
	- thermal energy	sum/t	1787,66		184128,98
	- recycled water	sum/t	2841,6		292684,8
	Total:				216783393,68
3	Product cost	sum/t			2104,693

4	Expenses for the maintenance and operation of equipment (50% of the cost of production)	sum	1052,347
5	Personnel wage fund	sum	2,5
6	Full cost of production		3159,54

The selling (wholesale) price of products is determined by the expression:

$Ц = C + P \cdot C$ = 3159.54+0.2. 3159.54 = 3791.448 thousand sum/t, (4.86)

where C is the cost of production, thousand soums; P is the level of profitability, taken equal to 20%.

Conclusion. Thus, the assessment of the technical and economic efficiency of introducing into production the proposed technology for producing motor fuel (gasoline) based on pyrolysis distillate shows that by processing 103,000 tons of raw materials it will be possible to make a profit of 45.561 billion soums per year. If the plant has a net profit of 3% of this amount, then the expected annual economic effect from the implementation of the proposed technology for producing additional petroleum products will be Ey = 1367 million soums.

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