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ENERGY SUPPLY FOR AZERBAIJAN REFINERIES

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The structure of energy outlays at an oil refinery (OR) with a fuel profile is analyzed, and reserves of their economy, and possible means of improving energy demand are revealed. It is demonstrated that in perspective, the energy-saving problem can be rationally solved by the construction of an integrated gasification plant as a component part of the OR with generation of electric power in a combined cycle. A complex flow diagram is proposed for the refining of crude, which will make it possible to create an integrated complex based on traditional processes and the latest electrotechnical technologies. Such a complex can thereafter be readily converted to an oil refinery of the future – a basic supplier of electric power and hydrogen.

Oil refining is a capital- and energy-intensive branch of the economy. Energy consumption at these plants for their own needs is equivalent to 6-7% of the volume of the crude refined, and increases to 10% with increasing complexity of the process. To lower expenditures for heat and power, in addition to the implementation of energy-saving procedures, virtually all OR are striving to adjust their internal production of energy, since prices paid for outside energy will increase. Thus, external conditions are forcing OR to expend resources not on reconstruction of their basic plants, but on construction of steam boilers, since the demand for power and steam is high. Over the long term, the development of their own power generation at OR will be ineffective.

At the same time, implementation of programs for the production of ecologically clean petroleum products is accompanied by implementation of new energy- and capital-intensive processes, and the energy demand will increase at OR. It will be rather problematic to meet this growth under stringent financial conditions. In conformity with new ecological requirements, and also the governmental energy programs of various countries, therefore, economy of material and energy resources, as well as modernization of the energy-saving system are critical trends in the development of oil refining in addition to implementation of new procedures and improvement in the structure of OR. Rational and economical consumption of these resources – diminution of losses, conversion to resource-saving and waste-free procedures, utilization of secondary resources – will ensure economy of hydrocarbon fuel throughout the fuel-power complex.

The problem can be solved by the implementation of new generations of production processes with a high

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Table 1

Plant	Consumption of fuel-energy resources per 1 ton of feedstock								Energy consumption, t.c.f/ton of feedstock
	liquid fuel		gaseous fuel		electric power		steam		
	t.c.f	%	t.c.f	%	t.c.f	%	t.c.f	%	
Primary distillation (EDU-AVD)	28.96	49.63	18.02	30.88	4.83	8.29	6.54	11.20	58.35
Catcracking	49.00	41.02	17.49	14.64	31.76	26.60	21.19	17.74	119.44
Catalytic reforming	86.41	54.06	29.18	18.26	29.68	18.57	14.57	9.11	159.84
Hydrotreating of diesel fuel	–	–	30.32	76.95	9.08	23.0	–	–	39.40
Slow coking (SCP)	65.48	70.67	–	–	13.19	14.24	13.98	15.09	92.65

thermal efficiency, and effective catalysts and heat-exchangers.

To ascertain reserves required for a reduction in expenditures for energy resources, it is necessary to analyze the structure of the energy outlays, and expose reserves for their economy and possible means of improving the energy demand. This paper is devoted to solution of this problem for an OR operating on fuel profile.

As we know, the demand for fuel and power at an oil refinery will depend not only on the nature of the feedstock to be refined, and the output structure of the products and their quality, but also on the design capacity and charge of the active plants. In recent years, the volume of crude refined at the Geidara Alieva OR, which operates on a fuel scheme, has been at a level of 4-5 million tons/year whereas the capacity of the primary refining plant is 6 million tons/year. Operation of the plants under an incomplete charge will result in deviations from design data for the demand of process fuel and energy resources.

Data (Table 1) on the demand for process fuel by the active plants of this OR, and electric power and steam were required to analyze their energy demand. Since liquid (boiler) fuel is used to generate steam and electric power, i.e., is a source of all types of energy, an equivalent unit – ton of conventional fuel (t.c.f) – was used to account for the fuel-energy resources (FER) consumed.

Analysis of the energy supply required for the individual processes indicated:

• the primary-refining process is the least energy-intensive (based on expenditures per one ton of feedstock refined), while catalytic reforming and cat cracking are the most energy-intensive; and,

• despite a low specific energy outlay, the portion of the primary refining of crude in the overall consumption of FER is significant with respect to the refinery; this is associated with the comparatively large amount of feedstock refined. The greater part (51.18%) of the energy is consumed by the electric desalting unit/atmospheric vacuum tubestill plant (capacity of 6 million tons/year), 16.34% by the cat cracker (2 million tons/year), 23.48% by the catalytic reformers (1 million tons/year), and slow-coking plants (1.3 million tons/year), and 9% by the plant employed for the hydrotreating of diesel fuel (2 million tons/year).

The various percentages of the demand for individual types of energy, i.e., steam, electric power, and process fuel, are also characteristic of the individual production processes (Table 2). Thus, the greatest demand for process fuel and thermal energy – 34.24 and 38.74%, respectively, of the energy demands placed on the refinery – is engendered by the primary refining of crude. During cat cracking, electric power (35.67%) ties up a significant portion of the total volume of the FER required in the production. This is associated with the existence of a large number of blowers and compressors in the plants conducting this process.

Use of secondary energy resources is an important reserve for energy saving at the refinery. The energy potential of the production, wastes, by-products, and intermediate products, which are formed in the production plants, and which are not used by the plants themselves, but may be partially or completely utilized for energy supply to other consumers, are understood to be such resources. Flue gases exiting from the regenerator of

Table 2

Process	Portion (%) of overall-plant demand						Total FER
	process fuel		steam		electric power		
	for process	as component part of FER	for process	as component part of FER	for process	as component part of FER	
Total with respect to refinery	100	77.24	100	9.5	100	13.26	100
Primary distillation (EDU-AVD)	34.24	26.45	38.74	3.68	20.51	2.72	32.85
Catcracking	3.36	2.6	33.26	3.16	35.67	4.73	10.49
Catalytic reforming	7.5	5.79	7.68	0.73	11.24	1.49	8.01
Hydrotreating of diesel fuel	5.75	4.44	–	–	10.03	1.33	5.77
Slow coking (SCP)	6.46	4.99	11.16	1.06	7.62	1.01	7.06
Overall-plant services	42.69	32.97	9.16	0.87	14.93	1.98	35.82

the G-43-107 cat cracker and the production furnaces of the OR, which are used to generate steam in boilers-utilizers, are some of the sources of secondary energy reserves.

The effectiveness of the refining of petroleum feedstock also depends heavily on rational utilization of dry hydrocarbon gases that are formed during the refining of the crude and its distillates. These gases can be used as process fuel in the furnaces. Moreover, their production can be increased with deep refining of the crude. It is known that a significant increase in the percentage of secondary processes is required for deepening of crude refining; this will lead to an increase in capital, and operating expenditures per unit of crude refined.

Systematic deepening of refining may, however, lead to elimination of the production of boiler fuel, as a result of which the OR could not provide for its own demand for fuel and energy resources through its own production. Thus, research that we had previously conducted [1] indicates that from 57 to 85-87% of the production of boiler fuel is gradually curtailed, and the manufacture of by-products is reduced from 38 to 5% of the crude refined, and liquid fuel from 37 to 0.1%, while the production of gas is increased from 2 to 5% of the crude refined as the depth of refining is increased from 57 to 85-87%. The consumption of energy resources here will increase by more than 1.5 times.

Figure 1 shows data characteristic of rates of growth (index) in demand for energy resources as a function of depth of crude refining.

Various schemes of crude refining, which include secondary processes contributing to an increase of from 57 to 87% in depth of refining, were examined to determine the optimal depth of crude refining that would make it possible to provide for the energy demand of the OR from its own energy resources. Analysis of these schemes indicated that variation in the charging of the plants performing secondary refining of crude feedstock will affect the increase in depth of refining and demand for energy resources differently. Thus, a twofold increase in the charge of the slow-coking plant will lead to a 3.5% increase in depth of refining; here, energy outlays will increase by a factor of 1.75. When the charge to the cat cracker is increased by 15%, the depth of refining is increased by 8.1%, and energy expenditure increased by a factor of only 1.15. This situation is explained by the fact that a 1% increase in depth of refining through slow coking will demand a more than twofold increase in energy consumption. The yield of petroleum products will amount to 62% when refining is deepened through cat

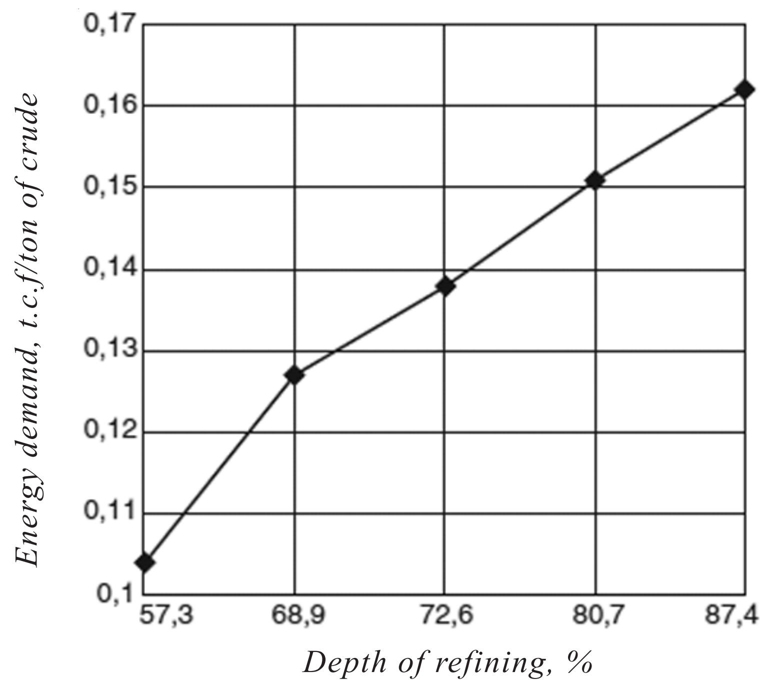

Fig. 1. Dependence of energy-resource demand on depth of crude refining.

cracking, and 40% through slow coking; moreover, the energy outlays required for the refining of 1 ton of production will be 1.2 times greater in the slow-coking process than in the cat-cracking process.

The level of the depth of crude refining, which is optimal with respect to production and FER demand, was ascertained for the Geidara Alieva OR. It amounts to 81%. When the depth of refining is increased, a problem arises with the FER supply to the refinery due to external purchase of fuel. This supply may be economically feasible only on the condition that the refinery's production will correspond to world standards and remain competitive on international markets, while an excess production after demand has been met within the republic will be a means to cover the costs of the refinery and ensure a stable profit.

In perspective, the energy-supply problem can be rationally resolved by the construction of an integrated gasification plant as a component part of the OR with generation of electric power in a combined cycle (IGCC). In the plant generating electric power, the crude is refined as usual: the atmospheric resid is directed into a vacuum tower, and the vacuum resid into a deasphalting plant with a production of ~70% of deasphaltized distillate and 30% of asphalt. The latter are gasified together with other heavy products with use of oxygen in an integrated gasification plant (for the generation of electric power in a combined IGCC cycle) [2].

Water vapor, electric power, and hydrogen, which can be used in hydrodesulfurization and hydroconversion, as well as syngas processes, on the basis of which it is possible to organize the production of methanol, are produced on an asphalt base at this plant. The methanol can then be drawn into the production of high-octane additives (on a hydrocarbon and secondary-gasoline base, and ethylene, as well as special liquids. The construction of these plants will permit organization of an autonomous power and heat supply; this will guarantee the operational reliability and stability of the entire petroleum refining complex.

The complex flow diagram proposed for the refining of crude (Fig. 2) will make it possible to create a closely integrated complex supporting an increase of up to 92% in the depth of crude refining, and the production

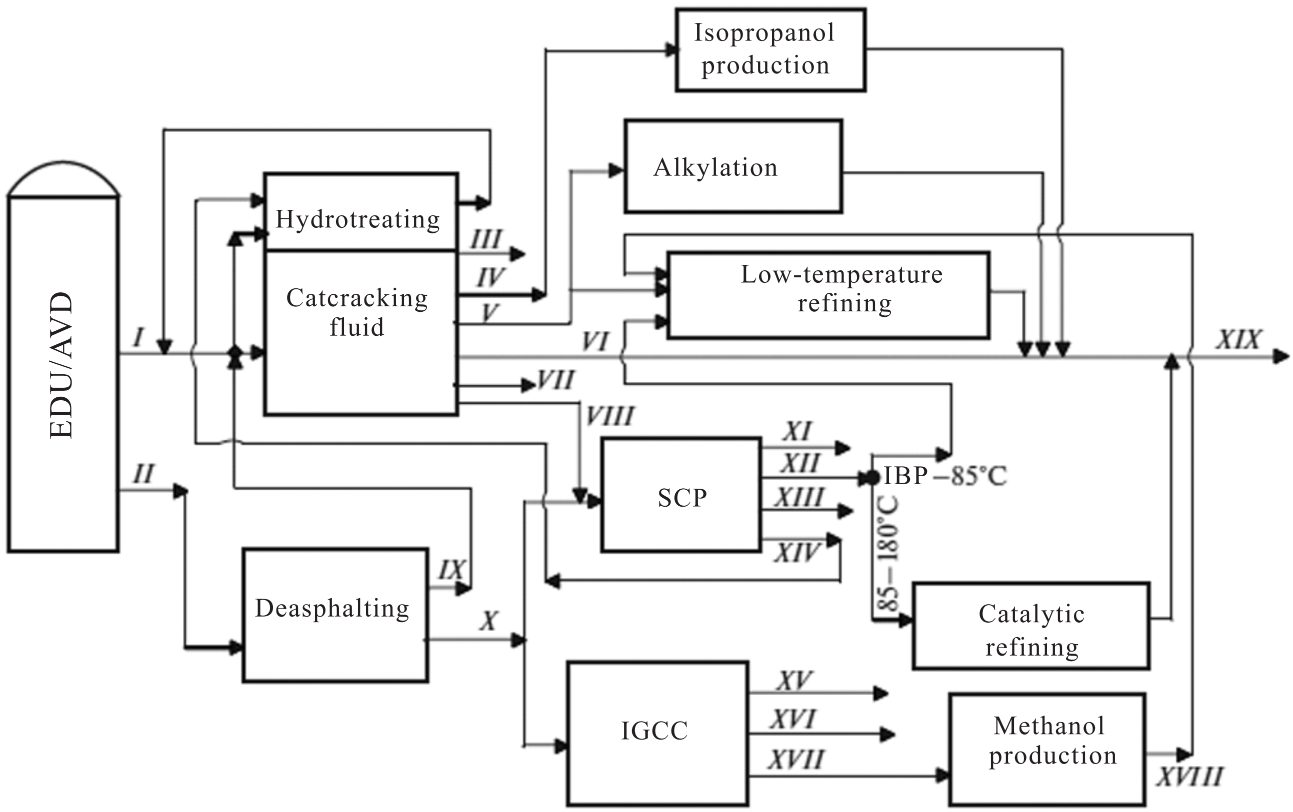

Fig. 2. Complex flow diagram of crude refining: I) 350-540°C cut; II) resid > 540°C; III, XI) dry gas; IV, V) propane-propylene and butane-butylene cuts, respectively; VI, XII) gasolene cuts from cat cracking and coking, respectively; VII, XIII) light gas oils from cat cracking and coking, respectively; VIII, XIV) heavy gasoils from cat cracking and coking, respectively; IX) deasphaltizate; X) asphalt; XV) electric power; XVI) water vapor; XVII) $CO + H_2$; XVII) methanol; XIX) commercial gasoline.

of ecologically clean petroleum products on the basis of traditional processes and the latest electrotechnical technologies.

In perspective, such a complex could be readily converted to an oil refinery of the future, which will become a basic supplier of electric power and hydrogen. The latter will be used in increasing amounts for both the refinery's own needs (which will amount to 10 kg for the production of 1 ton of conventional motor fuel), and also external consumers [2].

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