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INTEGRATED COST CALCULATION PROCEDURES FOR PETROLEUM PRODUCTS

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The industry cost structure for the manufacture of petroleum products (Table 1) is constantly changing under the influence of regular increases of the prices and tariffs on consumable material—technical resources, as well as changes in labor rates and other factors. The share of material costs in the total cost is increasing steadily, with a corresponding decrease in the costs of materialized labor (amortization) and active labor.

In the total production costs in petroleum refining, the costs for elements 2-7 (Table 1), from the standpoint of their economic content, are the operating costs (costs in processing), for which changes in the level for the industry as a whole (Table 2) or for individual plants or associations can be calculated by means of the appropriate indexes. When the changeover was made on September 18, 1992 to free (market) prices and tariffs for crude oil and other material—technical resources, the relative share of material costs in the total cost of petroleum products increased to a still greater degree.

Integrated calculations of the industry-average, regional-average, or individual costs of specific types of final (commercial) petroleum products are performed in two stages. In the first stage, the change in manufacturing cost (commercial product cost) is determined on the basis of economic elements with allowance for the principal cost increase factors in the industry as a whole (or in the region, plant, or association). The number of cost increase factors that are taken into account in determining the product cost changes may vary depending on the particular economic conditions (see Table 2).

As shown by the calculations, for the refining industry as a whole, with the increase in wholesale price for crude furnished to the refineries, along with other cost increase factors, the product cost in petroleum refining has increased (Table 3). Analogous cost calculations for the product cost in petroleum refining with allowance for the influence of the principal cost increase factors have been performed by refineries and refinery associations. Their results have served as the basis for monitoring the government-established wholesale prices of the refineries for petroleum products.

In the second stage, the cost of commercial petroleum products is determined with an accounting for the same cost increase factors. This requires not only data on the product cost in the baseline period, but also requires mainly information on its structure. In application to present-day conditions, the structure of the baseline cost of commercial petroleum products can be determined from the formula

$$C_i = K_{Zi}^{cr}\left(\sum_{i=1}^{n} V_i P_i \Big/ \sum_{i=1}^{n} V_i\right) + Z_i \qquad (1)$$

where C_i is the baseline cost of the i-th commercial product, rubles/tonne; K_{zi} is the coefficient of direct costs for crude in the cost of the i-th commercial product; V_i is the volume of crude oil supplied to the refinery from the i-th supplier, tonne; P_i is the contract (free-market) price for crude supplied to the refinery (f.o.b. refinery) from the i-th supplier, rubles/tonne; Z_i is the total operating cost in producing the i-th commercial product during the baseline period, rubles/tonne.

From Eq. (1) we find the operating costs in the manufacture of any commercial product in the baseline period. If data are available on the cost components of the i-th commercial product during the baseline period, i.e., on the crude oil and operating costs, the product cost C_{ni} under the new conditions can be calculated — i.e., the new cost can be calculated with an accounting for the influence of the main cost-increasing factors. For this purpose, we can use the formula

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$$C_{ni} = K_{zi}^{cr} P_{ni} + Z_i \alpha \quad (2)$$

where P_{ni} is the average contract (free-market) price for the crude oil supplied to the refinery (f.o.b. refinery) under the new conditions, rubles/tonne; α is a coefficient accounting for the change in operating costs under the influence of cost-increasing (or cost-decreasing) factors, the value of α being calculated on the basis of estimated costs for manufacturing the product.

Depending on the assigned task, the baseline costs may be any of the following types of cost C_i of the i-th commercial product: 1) industry-average (weighted average) costs determined by calculation or on the basis of data from the Main Computer Center of the State Committee of Statistics of the Russian Federation (on the basis of an integrated product list); 2) regional average (weighted average) cost, determined by calculation; 3) individual average (for a product manufactured in some specific refinery or refinery association).

From the standpoint of costing individual types of commercial petroleum products, the most important factor is the coefficient K_{zi} of direct costs for crude. Let us examine in more detail the economic content of this cost element. In the refining industry, the raw material (feedstock) for some processes (atmospheric—vacuum and atmospheric distillation units) is crude oil that has been desalted and dehydrated; for other units, the raw materials are intermediates obtained in preceding processes, generally in primary crude oil distillation units.

The cost of petroleum products (or intermediates) in primary crude oil distillation units is made up of the crude oil cost and the operating costs. This means that crude oil is the starting material for any process in the refinery, and the crude oil costs enter into the costs of every product (or component or intermediate), whatever process may be immediately responsible for manufacture of the product.

The coefficient of direct costs for crude K_{zi}^{cr} is defined by the ratio

$$K_{zi}^{cr} = Z_{cr}/P_{cr}$$

where Z_{cr} is the cost of the amount of crude consumed in producing 1 tonne of the component (or intermediate), rubles; P_{cr} is the wholesale price for crude oil supplied to the refinery, rubles/tonne.

From this formula, the coefficient of direct costs for crude can be determined for individual components (or intermediates) of commercial petroleum products manufactured in a single stage of production. When commercial products are obtained by blending individual components from different processes, the coefficient of direct costs for crude is defined by the formula

$$K_{zi}^{t} = \sum_{n=1}^{m} K_{zi}^{cr} Q_n \quad (3)$$

where n = 1, 2, 3, ..., m; K_{zi}^{cr} is the coefficient of direct costs for crude for each component of the blend; Q_n is the fraction of each blend component, %.

Calculation of the coefficient of direct costs for crude is performed in the following sequence:

Determine the crude oil costs for each manufacturing process.

Determine the costs assigned to byproducts (unaccounted), estimated by one of the methods given in Appendix No. 10 to the industry instruction [1].

Eliminate from the total cost of crude (or other petroleum-derived feedstock) those costs assigned to byproducts (unaccounted); the remaining sum represents the cost for crude (or other petroleum feedstock) assigned to all of the primary (accountable) products from the particular process.

Determine the crude oil costs per tonne of basic (accountable) product, by dividing this sum of the costs by the total quantity of basic (accountable) products.

Refer the costs of crude oil consumed in obtaining 1 tonne of product (basic product or byproduct) to the wholesale price of 1 tonne of crude supplied to the refinery; i.e., determine the coefficient of direct costs for crude.

Calculate by means of Eq. (3) the coefficient of direct costs for crude for 1 tonne of commercial product obtained by blending.

By investigating the influence of various factors on the coefficient of direct costs for crude, it was established that the magnitude of this coefficient is independent of the wholesale price level for crude supplied to the refinery and is also indepen-

TABLE 1

Cost element No.	Cost element	% of total costs in manufacture of petroleum products with indicated prices and tariffs					
		before June 1, 1967	starting June 1, 1967	starting January 1, 1982	starting January 1, 1991	starting January 2, 1992	starting May 18, 1992
1	Raw material, basic materials, and intermediates (including crude oil as indicated in parentheses)	61,8 (51,6)	74,6 (67,2)	83,9 (75,6*)	89,1 (81,6[2*])	91,8 (88,6[3*])	91,3 (89,2[4*])
2	Auxiliary materials	5,8	3,7	1,9	1,5	0,7	1,0
3	Fuel from outside sources	0,7	0,9	0,4	0,3	0,3	0,4
4	Energy from outside sources	11,7	8,0	5,7	4,1	3,9	5,0
	Total material costs	80,0	87,2	91,9	95,0	96,7	97,7
5	Payroll, with allotments to social insurance	7,7	4,9	2,1	1,2	0,6	0,2
6	Amortization	9,7	6,2	4,7	3,3	1,1	0,3
7	Other costs	2,6	1,7	1,3	0,5	1,6[5*]	1,8[5*]

*With crude oil cost 30 rubles/tonne.

[2*]Same, 70 rubles/tonne.

[3*]350 rubles/tonne.

[4*]2200 rubles/tonne.

[5*]Including allotments for industry-wide science.

TABLE 2

Factor increasing costs	Cost increase factor in revision of refinery wholesale prices for petroleum products, introduced on indicated date			
	January 1, 1982	January 1, 1991	January 2, 1992	May 18, 1992
Price increase for crude supplied to refineries (on the average), rubles/tonne	30	70	350	2200
cost increase indexes				
costs for auxiliary materials	–	–	2	10
Industry wholesale price for natural gas	0,45	1,0	4,0	6,1
tariffs (average)				
thermal energy (steam)	0,73	0,65	4,0	8,0
electrical energy	0,12	0,45		
payroll (basic and supplementary)	–	–	2,0	2,0
allotments to social insurance	0,14*	25,5*	2,9	2,0
amortization costs	–	–	1,5	2,0
other costs	–	–	2,0	10,0
nonproduction costs	–	–	3,0	10,0
Allotments for industry-wide science, %	–	–	1,5[2*]	1,5[2*]

*In percentage relative to payroll (basic and supplementary).

[2*]Percentage of the value of commercial products. (without allotments to insurance fund).

dent of the process unit capacity; the coefficient is dependent on the yield of byproducts (unaccountable) and the order adopted for its evaluation, and is also dependent on the component composition of the commercial products, the complexity of the processing schemes by which they are manufactured, and the process (nonrecoverable) losses.

The crude oil direct cost coefficient K_{zi}^{cr} depends to the greatest degree on the procedure used to calculate the product cost in complex processes, particularly primary distillation of the crude in atmospheric and atmospheric—vacuum distillation units. Changes in this procedure on January 1, 1982 [2] and January 1, 1991 [1] resulted in certain changes in the calculated coefficient of direct costs for crude: For the black products (fuel for low-speed diesels, marine fuel oil, boiler fuel, asphalt), the calculated coefficient was lower under the new procedure; for the other commercial products, the coefficient was higher.

The great freedom allowed in evaluating byproducts (unaccountable products) in complex processes in petroleum refining, as allowed in Appendix No. 10 to the industry instruction [2], can lead to an even greater differentiation of the crude

TABLE 3

Wholesale price for crude, rubles/tonne	Increase, %	
	in refinery production cost	including operating costs
30	78,5	24
70	100	23
350	450	330
2200	440	630

TABLE 4

Commercial product	Cost,* rubles/tonne	Coefficient of direct costs for crude	Direct costs for crude, rubles/tonne	Operating costs,2* rubles/tonne	Percentage of cost	
					for direct crude oil cost	for operating costs
Automotive gasoline (unleaded)						
A-92	22144	1,38	19320	2824	87	13
A-76	19334	1,19	16660	2674	86	14
Jet fuel TS-1	19066	1,28	17920	1146	94	6
Diesel fuel L						
with 0.1% sulfur	19362	1,32	18480	882	95	5
with 0.2% sulfur	19373	1,33	18620	753	96	4
Diesel fuel Z with 0.2% sulfur	18794	1,29	18060	734	96	4
Fuel oils						
domestic furnace oil with 1.1% sulfur	17833	1,15	16100	1733	90	10
engine fuel DT with 1.5% sulfur	15339	1,03	14420	919	94	4
Asphalt						
construction	11978	0,75	10500	1478	88	12
paving	11267	0,75	10500	767	93	7
Residual fuel oil with 2% sulfur	11140	0,79	11060	80	99	1

*Calculated by Moscow refinery by direct calculation for all stages of production (including the blending of commercial petroleum products) with a crude oil cost of 14,000 rubles/tonne.

2*Determined as the difference between the product cost and the direct cost for crude.

TABLE 5

Commercial product	Coefficient of direct crude oil cost	Direct cost for crude,* rubles/tonne	Operating costs,2*, rubles/tonne	Product cost, rubles/tonne
Automotive gasoline (unleaded)				
A-92	1,38	25530	6213	31743
A-76	1,19	22015	5883	27898
Jet fuel TS-1	1,28	23680	2521	26201
Diesel fuel L				
with 0.1% sulfur	1,32	24420	1940	26360
with 0.2% sulfur	1,33	24605	1657	26262
Diesel fuel Z with 0.2% sulfur	1.29	23865	1615	25480
Fuel oil				
domestic furnace oil with 1.1% sulfur	1.15	21275	3812	25087
engine fuel DT with 1.5% sulfur	1,03	19055	2022	21077
Asphalt				
construction	0,75	13875	3252	17127
paving	0,75	13875	1687	15562
Residual fuel oil with 2% sulfur	0,79	14615	176	14791

*Determined with a crude price of 18,500 rubles/tonne.

2*Calculated by multiplying the operating costs from Table 4 by a coefficient of 2.1.

TABLE 6

Commercial product	Cost (rubles/tonne), calculated by indicated method		Deviation between calculated costs, %
	by direct calculation for refinery	by proposed procedure	
	With crude price 9200 rubles/tonne		
Automotive gasoline (unleaded)			
A-92	13890	13826	+0,5
A-76	12101	12018	+0,7
Jet fuel TS-1	12181	12234	−0,4
Diesel fuel L			
with 0.1% sulfur	12310	12497	−1,5
with 0.2% sulfur	12269	12537	−2,1
Diesel fuel Z with 0.2% sulfur	11941	12162	−1,8
Fuel oils			
domestic furnace oil with 1.1% sulfur	11303	11273	+0,3
engine fuel DT with 1.5% sulfur	9957	9844	+1,1
Asphalt			
construction	7385	7491	−1,4
paving	7161	7207	−0,6
Residual fuel oil with 2% sulfur	7451*	8956	−16,8
	With crude price 16,500 rubles/tonne		
Automotive gasoline (unleaded)			
A-92	26209	26159	+0,2
A-76	22867	22355	+2,3
Jet fuel TS-1	21987	22495	−2,3
Diesel fuel L			
with 0.1% sulfur	22671	22838	−0,7
with 0.2% sulfur	22726	22849	−0,5
Diesel fuel Z with 0.2% sulfur	22028	22166	−0,6
Fuel oils			
domestic furnace oil with 1.1% sulfur	21196	21054	+0,7
engine fuel DT with 1.5% sulfur	18029	18098	−0,4
Asphalt			
construction	16084[2]*	14148	+13,7
paving	14259[2]*	13295	+7,2
Residual fuel oil with 2% sulfur	13363	13131	+1,8
	With crude price 18,500 rubles/tonne		
Automotive gasoline (unleaded)			
A-92	31867	31743	+0,4
A-76	29332	27888	+5,1
Jet fuel TS-1	25682	26201	−2,0
Diesel fuel L			
with 0.1% sulfur	26088	26360	−1,0
with 0.2% sulfur	25839	26262	−1,6
Diesel fuel Z with 0.2% sulfur	24809	25480	−2,6
Fuel oils			
domestic furnace oil with 1.1% sulfur	24541	25087	−2,2
engine fuel DT with 1.5% sulfur	20675	21077	−1,9
Asphalt			
construction	17054	17127	−0,4
paving	15499	15562	−0,4
Residual fuel oil with 2% sulfur	14823	14791	+2,2

*Low cost is due to the use of blend components produced during a period in which the crude price was 2200 rubles/tonne.

[2]*High cost is due to the high labor cost in producing and packaging petroleum asphalts.

oil direct cost coefficients between light products (aviation gasoline, automotive gasoline, aviation kerosene, illuminating kerosene, diesel fuel) and commercial black products.

TABLE 7

Commercial product	Coefficient K_o of operating costs with indicated crude oil price, rubles/tonne					Average K_o
	14000	16500	21140	29400	30800	
Automotive gasoline (unleaded)						
A-92	0,20	0,21	0,18	0,15	0,15	0,18
A-76	0,19	0,20	0,16	0,13	0,13	0,19
Jet fuel TS-1	0,08	0,05	0,09	0,04	0,04	0,06
Diesel fuel L						
with 0.1% sulfur	0,05	0,05	0,04	–	–	0,05
with 0.2% sulfur	0,01	0,04	0,01	–	–	0,03
Diesel fuel Z with 0.2% sulfur	0,05	0,05	0,02	–	–	0,04
Fuel oil						
domestic furnace oil with 1.1% sulfur	0,12	0,13	0,02	0,04	0,04	0,09
engine fuel DT with 1.5% sulfur	0,06	0,06	–	–	–	0,07
Residual fuel oil with 2% sulfur	–	0,02	0,02	0,01	0,01	0,01

TABLE 8

Commercial product	K_z	K_o	$K_g = K_z + K_o$
Automotive gasoline (unleaded)			
A-92	1,38	0,18	1,56
A-76	1,19	0,19	1,38
Jet fuel TS-1	1,28	0,06	1,34
Diesel fuel L			
with 0.1% sulfur	1,32	0,05	1,37
with 0.2% sulfur	1,33	0,03	1,36
Diesel fuel Z with 0.2% sulfur	1,29	0,04	1,33
Fuel oil			
domestic furnace oil with 1.1% sulfur	1,15	0,09	1,24
engine fuel DT with 1.5% sulfur	1,03	0,07	1,10
Residual fuel oil with 2% sulfur	0,79	0,01	0,80

The contract (free-market) price for crude supplied to the refinery (P_i and P_{cri}) represents the sum of the contract (free-market) price for crude as agreed between the consumer (refinery) and supplier (oil-producing association), plus the cost of its transportation, calculated on the basis of a tariff handbook developed by the company Transneft' [3]. Depending on the stated task, either a common price for all refineries of Russia, a regional price, or an individual price may be taken as the contract (free) price for crude (P_{cri}). Here, the level of the given price should be rounded to 1000 rubles per ton.

In the manufacture of the i-th product, the operating costs (processing costs) are subject to the influence of opposing factors. As internal (cost-reducing) factors we should class reductions of specific consumption norms for material and technical resources, increased yields of the desired product from individual manufacturing processes or units, more effective utilization of capital funds, increased productivity of labor, reduction of nonrecoverable process losses, and so on. At the same time, the manufacturing costs in petroleum refining, particularly under the conditions of transition to a market economy, are affected by cost-increasing factors due to increases of prices and tariffs on consumable material and technical resources (see Table 2).

Depending on the assigned task, the coefficient α, which accounts for the change of processing costs under the influence of cost-increasing factors, can be determined by estimating the product costs for the industry as a whole, for a region, or for an individual refinery or association of refineries. In different periods of reexamination of government-regulated refinery wholesale prices for petroleum products, in determining the industry-average baseline cost for different types of commercial products, the following values were taken for this coefficient: starting January 1, 1982, 1.24; starting January 1, 1991, 1.23; starting January 2, 1992, 3.3; starting May 18, 1992, 6.3.

As an example of the practical utilization of the procedure we have described, we calculated the costs of commercial products manufactured by the Moscow refinery. The components of Eq. (1) were determined according to the baseline cost of products (or intermediates) from individual processes and the baseline costs of commercial products calculated by the refinery with a crude oil price of 14,000 rubles/tonne, and also with prices and tariffs for material and technical resources and wages that were effective in the refinery for this period (in January 1993). Correspondingly, crude oil direct cost coefficients were calculated for the manufacturing processes and for the commercial products; also calculated were the operating costs for the baseline period (Table 4).

TABLE 9

Commercial product	Cost (rubles/tonne), calculated by indicated method		Deviation, %
	direct calculation	by means of coefficient K_g	
With crude price 14,000 rubles/tonne			
Automotive gasoline (unleaded)			
A-92	22144	21840	+1,3
A-76	19334	19320	0,0
Jet fuel TS-1	19066	18760	+1,6
Diesel fuel L			
with 0.1% sulfur	19373	19040	+1,7
with 0.2% sulfur	19362	19180	+0,9
Diesel fuel Z with 0.2% sulfur	18794	18620	+0,9
Fuel oil			
domestic furnace oil with 1.1% sulfur	17833	17360	+2,7
engine fuel DT with 1.5% sulfur	15339	15400	−0,4
Residual fuel oil with 2% sulfur	11140	11200	−0,5
With crude price 21,140 rubles/tonne			
Automotive gasoline (unleaded)			
A-92	32973	32978	0,0
A-76	28536	29173	−2,2
Jet fuel TS-1	28877	28328	+1,9
Diesel fuel L			
with 0.1% sulfur	28343	28750	−1,4
with 0.2% sulfur	28751	28962	−0,7
Diesel fuel Z with 0.2% sulfur	27771	28116	−1,2
Fuel oil			
domestic furnace oil with	24704*	26214	−6,1
engine fuel DT with 1.5%	21444*	23254	−8,4
Residual fuel oil with 2%	17085	16912	+1,0

*Low cost is due to the use of blend components produced during the period in which the crude oil price was 18,500 rubles/tonne.

As can be seen, the cost structure varies greatly from one product to another. In the total product cost, the relative operating costs are the highest for the following products: A-92 and A-76 automotive gasolines, owing to the many stages required in their production; domestic furnace fuel with a sulfur content no higher than 1.1%, owing to the inclusion of light catalytic gasoil from the G-43-107 unit in the fuel oil blend; and asphalt, owing to the high costs of labor and material in asphalt production, particularly in packaging.

On the basis of Eq. (2), commercial product costs were calculated with crude prices (in rubles/tonne) of 9200 (October 1992), 16,500 (March 1993), and 18,500 (April 1993). Average values of the index α of operating cost increase with each increase of crude oil price, in comparison with the operating costs in the baseline period (January 1993) were taken on the basis of Moscow refinery data, as follows: in October 1992, 0.4; in March 1993, 1.2; in April 1993, 2.2.

In Table 5 we present results from a product cost calculation with a crude price of 18,500 rubles/tonne. In Table 6, values are listed for the deviation between the commercial product costs with crude prices of 9200, 15,400, and 18,500 rubles/tonne, as evaluated by direct calculation for the Moscow refinery and on the basis of the procedure that has been set forth.

The comparatively small magnitude of these deviations demonstrates that the procedure we have developed is acceptable in practice for the determination of predicted industry-average, regional-average, or individual costs of commercial products, with allowance for future increases of wholesale prices for crude supplied to the refineries and for other cost-increasing or cost-reducing factors under the conditions of the transition to a market economy.

Since the increase of crude oil prices increases the importance of crude costs in the product cost, a simplified method has been proposed for determining processing costs by means of a coefficient K_o that is calculated in the following manner. First, by direct calculation, prospective product costs are determined with various values of the crude oil price and other cost-increasing factors, using the same data as in determining the coefficient of direct costs for crude. This ensures that the calculations will be comparable. Then, from the cost for each product, we deduct the direct costs for crude, i.e., the product $K_{zi}^{cr} \cdot P_{cri}$.

The data obtained in these calculations consist of a series of operating costs for each product as a function of the crude oil cost and other cost-increasing factors. After dividing the operating costs by the corresponding crude oil price, we obtain the coefficient K_o, showing what part of the operating costs must be added to the direct costs for crude in order to obtain the total cost of commercial products under the new conditions.

Of course, the dependence of the operating costs on the crude oil price is not as obvious as their dependence on the coefficient of direct costs for crude; however, this dependence does exist. Experience has shown that as the crude price increases, there are also increases in the operating costs, corresponding to increases of each element of these costs. From the series of operating cost coefficients obtained in this manner, the average coefficient is determined (Table 7).

Thus, by summing the values calculated by the proposed method for the coefficient K_z of direct costs for crude and the coefficient K_o of operating costs, we can obtain a generalized coefficient K_g (Table 8), which, when multiplied by any crude oil cost, will give the new level of commercial product cost.

The proposed method is simple and quite accurate, as indicated by the data of Table 9. Comparing the commercial product costs obtained by direct calculation with the corresponding costs determined by means of the coefficient K_g with two different levels of crude oil price, we can see that the difference between them varies from -2.7% to $+2.2\%$.

When determining commercial product costs by means of the coefficients, it should be kept in view that these coefficients were calculated by a method that sets straight-run residual fuel oil prices at 80% of the wholesale price of the basis crude entering the refinery [1]. Starting on July 1, 1993, a new method of calculation is required, in which the straight-run residual fuel oil is priced at 40-80% of the basis price of crude entering the refinery [4]. From the essence of the coefficients K_{zi}^{cr} and K_o, it follows that when the residual fuel oil price is reduced, the coefficients will be increased for light products and reduced for residual fuel oil and other black products.

On the basis of the procedure we have examined in this article, costs can be determined for the most important (large-volume) petroleum products: aviation and automotive gasolines, jet fuel, diesel fuel, domestic furnace oil, gas-turbine fuel, engine fuel for medium- and low-speed diesels, boiler fuel, and other types of fuels, as well as illuminating kerosine and industrial kerosine — i.e., those petroleum products for which the wholesale and retail prices were government-controlled up to September 18, 1992.

The procedures described in this article can be used by specialists of the Ministry of Fuel and Energetics of the Russian Federation, and also specialists in the plants and associations of the petroleum refining industry.

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