PETROLEUM AND GAS PROCESSING

PRODUCTION OF LOW-SULFUR BOILER FUELS FROM MEDIUM AND HIGH-SULFUR CRUDES

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Air pollution is a serious problem in large industrial centers. Some of the main sources of atmospheric pollution are electric power generating stations, boiler furnaces, and industrial furnaces burning residual fuel oils produced from medium and high-sulfur crudes. Straight-run boiler fuels from the major types of medium-sulfur crudes contain up to 2-2.8% sulfur. Reduction of the sulfur content in the fuel to 0.5-1% can effect significant reductions in the discharge of SO_2 with the stack gas. Also, in many branches of industry, boiler fuels with sulfur contents below 0.5% are required by the process specifications.

Sulfur can be removed from petroleum residual stocks (long resids and tars) by hydrogenation under a hydrogen pressure of 15-20 MPa. The fabrication of equipment for such process units involves certain difficulties, and the operating costs in the high-pressure processes are quite high. The easiest route to the economical production of low-sulfur boiler fuels from medium and high-sulfur residual stocks is through vacuum distillation of long resid (atmospheric resid), hydrodesulfurization of the heavy gasoil at comparatively low pressures (about 5 MPa), and blending of the hydrotreated gasoil with the untreated vacuum resid.

Depending on the quantity of vacuum resid used in the commercial boiler fuel and the degree to which the gasoil is desulfurized, fuels may be produced with various sulfur contents. In this article, in the example of three typical crudes (Samotlor, Romashkino, and Arlan), we have analyzed the possibilities of obtaining boiler fuels with sulfur contents at various levels, 0.5% and up, depending on the amount of gasoil taken out in the vacuum distillation. For these crudes, we have listed the potential contents of 500 and 540°C end point gasoils in the atmospheric resids, the corresponding contents of vacuum bottoms, and the sulfur contents of these cuts (Table 1). For the atmospheric resid from Samotlor crude, the yields of all cuts and the quality of these cuts were determined experimentally. In the case of the Romashkino crude, the yield of 500°C end point gasoil and the corresponding yield of a vacuum resid were taken from data reported in [1]; for the 350-540°C cut, these values were determined by extrapolation. Experimental data on the low-bottoms vacuum distillation of atmospheric resid from Arlan crude, up to 525°C, were obtained at BashNII NP [Gashkir Scientific-Research Institute for Petroleum Processing] [2]. From these data we determined the yields and quality of the products distilling below 540°C and the residue above 540°C, by extrapolation.

TABLE 1. Potential Contents of Cuts in Atmospheric Resids from Samotlor, Romashkino, and Arlan Crudes, and Sulfur Contents in These Cuts

Product	Content (mass %) for indicated crude					
	Samotlor		Romashkino		Arlan	
	cut (relative to atm·resid)	sulfur	cut (relative to (atm, resid)	sulfur	cut (relative to atm, resid)	sulfur
Atm. resid (above 350°C)	100,0	1,87	100,0	2,68	100,0	4,1
Cut						
350—500°C	59,3	1,55	44,2	2,09	41,0	3,5
350—540°C	68,1	1,62	53,4	2,20	55,6	3,6
Residue						
above 500°C	40,7	2,30	55,8	3,14	59,0	4,5
above 540°C	41,9	2,40	46,6	3,20	44,4	4,9
Yield of atm. resid, mass % on crude	39,8		52,0		54,0	

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TABLE 2. Component Composition and Sulfur Content of Boiler Fuels

Sulfur content in boiler fuel, mass %	Yield of boiler fuel, mass % on atm. resid	Fuel comp., mass % on atmospheric resid		Unused vac. resid, mass % on atmospheric resid	Yield of boiler fuel, mass % on atm. resid	Fuel comp., mass % on atmospheric resid		Unused vac. resid, mass % on atmospheric resid
		350-500°C cut	vac.resid (> 500°C)			350-540°C cut	vac. resid (> 540°C)	
Samotlor crude								
0,15	55,4	49,8	5,6	35,1	63,2	57,2	6,0	25,9
1,00	76,7	49,8	26,9	13,8	85,8	57,2	28,6	3,3
1,05	—	—	—	—	89,1	57,2	31,9	0
1,20	90,5	49,8	40,7	0	—	—	—	—
Romashkino crude								
0,50	39,9	37,1	2,8	53,0	48,2	44,9	3,3	43,3
1,00	49,2	37,1	12,1	43,7	59,2	44,9	14,3	32,3
1,50	64,3	37,1	27,2	28,6	76,6	44,9	31,7	14,9
1,78	—	—	—	—	91,5	44,9	46,6	0
2,00	92,9	37,1	55,8	0	—	—	—	—
Arlan crude								
0,50	31,0	29,5	1,5	57,5	41,8	40,0	1,8	42,6
1,00	35,4	29,5	5,9	53,1	47,2	40,0	7,2	37,2
1,50	41,3	29,5	11,8	47,2	55,3	40,0	15,3	29,1
2,00	49,6	29,5	20,1	38,9	63,5	40,0	23,5	20,9
2,72	—	—	—	—	84,4	40,0	44,4	0
3,10	88,5	29,5	59,0	0	—	—	—	—

In carrying out the calculations (Table 2) on the basis of experimental data, it was assumed that in hydrotreating the gasoils from the Samotlor and Romashkino crudes, the yield of desulfurized cuts (hydrotreated products) distilling above 350°C would be 84% by mass relative to the original gasoil, and for the gasoil from the Arlan crude the yield would be 72% by mass. The sulfur content was assumed to be the same in these cuts, 0.3%. These data indicate that, when processing the atmospheric resids from these crudes in accordance with this scheme, low-sulfur boiler fuels with 0.5-1% sulfur can be obtained. When the takeoff of vacuum gasoil is increased by raising the cut points to 540°C, the yield of low-sulfur boiler fuel with 0.5% sulfur increases by 7.5, 8.3, and 10.8% for the Samotlor, Romashkino, and Arlan crudes, respectively.

The increased takeoff of vacuum gasoil, for all three crudes, gives a reduction in the sulfur content of the boiler fuel when both the gasoil and vacuum resid are fully utilized. For the Samotlor crude, this difference amounts to 0.15%, for the Romashkino crude 0.22%, and for the Arlan crude 0.38%. Thus we see that an increase takeoff of gasoil with subsequent hydrotreating and compounding with the vacuum resid is most effective for heavy, high-sulfur crudes. However, the degree of sulfur content reduction in the boiler fuel in comparison with the original atmospheric resid in this case is no greater than 25-35%. In order to obtain boiler fuels with lower sulfur contents (0.5-1%), it is preferable to use crudes of the Samotlor type, since when producing low-sulfur boiler fuel from the Arlan crude, only 4-16% of the total amount of available vacuum resid is actually utilized. If it is assumed that asphalt production will use about 10% of the vacuum resid (referred to atmospheric resid), then we see that, without any additional consumption of vacuum resid as a coker feedstock, it is possible to obtain boiler fuels with 0.5-1% sulfur from Samotlor crude, with 1.5-1.8 sulfur from Romashkino crude, and with 2.5-3% from Arlan crude. If further reductions are to be made in the boiler fuel sulfur content, part of the vacuum resid must be used in some sort of independent processing such as delayed coking, fluid coking, etc.

When the gasoil end point is raised from 500 to 540°C, the quantity of feedstock for these processes is reduced by respective amounts of 10.5, 11.5, and 15.9% by mass relative to the atmospheric resids from these three crudes. A decrease in the relative rate of vacuum resid processing should have a favorable effect on the overall scheme of atmospheric resid processing, since rather serious difficulties are encountered in hydrotreating the liquid products from vacuum resid processing and in the efficient use of high-sulfur cokes. Naturally, for a given sulfur content in the boiler fuel from Samotlor, Romashkino, and Arlan crudes, the relative amounts of vacuum resid in these boiler fuels will decrease from crude to crude in the order listed. For example, when producing boiler fuel with 1% sulfur, the respective amounts of vacuum resid in this fuel are 35–33%, 25–24%, and 17–15% for these three crudes. The variation in boiler fuel properties with the content of vacuum resid in the fuel is shown for the Samotlor crude in Fig. 1. With the lowest sulfur content

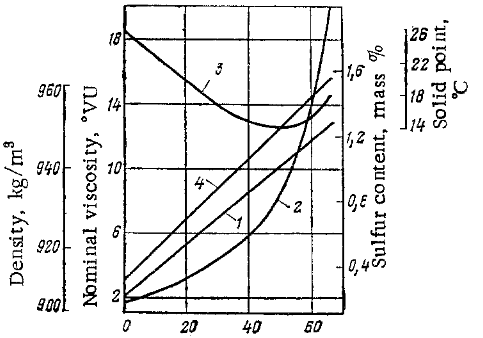

Fig. 1. Variation of most important properties of boiler fuel with the contents of vacuum resid (above 540°C) and hydrotreated vacuum gasoil (350-540°C), from Samotlor crude: 1) density at 20°C; 2) nominal viscosity at 80°C [similar to Engler viscosity]; 3) solid point; 4) sulfur content.

(0.5%), the fuel corresponds to Grade 40 boiler fuel meeting GOST 10585–75; and in the other cases corresponds to Grade 100, being classed in the latter grade mainly because of its high solid point.

LITERATURE CITED

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IMPROVEMENTS IN OPERATION OF DELAYED COKING UNIT AT NADVORNAYA REFINERY

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The delayed coking unit at the Nadvornaya refinery is equipped with two reaction chambers, each 4.6 m in diameter, one pyramidal-type furnace, and distillation equipment of the type conventionally used in delayed coking units [1]. The coker feedstock is a cracked tar from mixed Bitkov and Eastern Ukrainian resids. This coker unit is one of the best in the petroleum industry in the USSR with respect to its basic operating indices. The coker has reached the level specified by the design with respect to the production of total coke, and the yield of electrode coke fractions amounts to 50% by mass; the feedstock capacity is 20-30% above the design level. However, the lengths of the runs in the coker unit between shutdowns for maintenance are no greater than 25-30 days, in comparison with runs of 100 days or more that are made in many delayed coking units in the USSR, and with a run of 170 days that has been made in the coker unit at the Novo-Ufa refinery.

The length of the run in a delayed coker unit between shutdowns for maintenance is affected by a number of factors, principally the feedstock quality (Table 1). We have listed in Table 2 the basic coil dimensions and the operating conditions for the cokers in the Nadvornaya and Novo-Ufa refineries. It can be seen from the data of Table 1 that the coker feedstock at the Nadvornaya refinery contains four times as much paraffinic-naphthenic hydrocarbons and only half as much polycyclic aromatic hydrocarbons and resins as the coker feedstock at the Novo-Ufa refinery. This ratio of components in the coker feedstock at the Nadvornaya refinery is responsible for a lower stability of this stock in terms of aggregation of colloidal particles, and

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