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TRANSLATION

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OHIO

FTD-TT- 64-392/1

UNEDITED ROUGH DRAFT TRANSLATION

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English Pages: 9

SOURCE: Khimiya i Tekhnologiya Topliv i Masel (Russian), Nr. 11, 1963, pp 57-61

S/0065-063-000-011

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CHEMICAL COMPOSITION OF MICROIMPURITIES IN JET FUELS FROM SULFUROUS PETROLEUM

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V. N. Zrelov, N. I. Marinchenko, et al.

When one uses on aircraft jet fuels from sulfurous petroleums there results a clogging of the fuel filters and gaps in the connected parts of the fuel apparatus in jet engines by microimpurities of filter ing elements in the fuel.

Up to the present time when evaluating the clogging tendency of fuels the main attention has been given to the quantitative side of the question. One studied the change in the content of microimpurities in the fuel, estimated the size of their particles, and determined the filterability of the fuels [1—3].

However, in order to really evaluate the effect of the microimpurities of the fuel on the working of the fuel apparatus of the engine it is necessary in the first place to know the chemical composition of thes impurities. For fuels obtained from the sulfurous petroleums of the Ural-Volga petroleum region of great significance in the formation of microimpurities are the sulfur-organic compounds contained in the fuels.

The chemical composition of the microimpurities was investigated in the TS-1 fuels from two refineries over the whole course of their movement in the railway tank cars to the fuel apparatus of the engines.

The microimpurities were separated from 20 l of fuel by the centrifugal process on a supercentrifuge making 30,000 RPM with subsequent separation of the fuel by vacuum distillation and flushing with isopentane. On the supercentrifuge there were separated out microimpurities the dimensions of which were greater than 1—5 microns. Afterwards the microimpurities were dried out at the temperatures of 20 and 105°C, which made it possible to get an idea of the content in them of structural moisture. The absolutely dry microimpurities were analysed for C, H, S, and N by the usual methods of microanalysis. After calcination of the absolutely dry microimpurities at 500—550°C the element composition of their ash was determined by the spectral emission method on the ISP-28 spectrograph for 24 elements. The separation of the microimpurities was done with commercial fuels which in their quality fully corresponded with GOST 7149-54.

At the same time there was studied the chemical composition of impurities which in the process of the filtering of the fuel remained behind in the mesh and in cloth filters. They were flushed from the mesh filters with an alcohol-benzene mixture. After distilling away the solvent they were dried and analysed also just as the microimpurities separated from the fuels. They were not flushed from the cloth and paper filters but analyzed together with the filtering material. Along with this filtering material was analyzed of the same dimensions. The chemical content of the precipitate was determined by the difference in the amounts obtained from the dirty and the clean filters.

In the microimpurities on some cloth filters there was found the content of the organic part by the method of its extraction with chloroform in the Soxhlet apparatus into which there were put the pieces of filtering material containing the microimpurities.

The characteristics of the microimpurities of the TS-1 fuel tranported from the refineries in tank cars are presented in Table 1. From the data given one sees that the microimpurities of the fuel consist of three components—ash elements, organic tar part, and "structural moisture." In transporting the fuels on the railroad the microimpurities increase through ash addition with a small content of water and tars.

Table 1

Item	Refinery I	Refinery II	
	Average specimen	Aver age specimen	Residue
Weight of air-dried microimpurities, g/t	1.55	6.0	155
Weight of absolutely dry microimpurities, g/t	1.49	5.4	108
Moisture of microimpurities, %. . .	9.63	10.4	6.2
Ash content of absolutely dry microimpurities, %. .	62.86	59.5	81.9
Element composition of absol tely dry microimpurities, %:			
C	27.94	30.08	8.63
H	5.61	6.95	3.14
S	0.84	0.38	0.15
N	0.98	0.59	only a trace
O	29.93	35.4	53.38
Fe	6.28	8.6	33.0
Si	11.5	5.6	1.12
Ca	4.3	2.3	0.04
Mg	4.64	0.95	0.25
Al	0.82	0.58	0.08
Na	1.37	0.88	Residue

Notes: 1. Ba, Ti, Cr, Ni, Mn, Zn, Pb, Sn, and Cu are present in small quantities.

2. Be, Bi, V, Mo. Co, Ag, P, Cd, and Sb are absent.

3. The given notations hold good for the following tables.

4. The residue amounts to 5% of the whole amount of fuel.

The ash content of these microimpurities in the residue reaches almost 82%. They basically consists of the products of corrosion of the iron. As to products containing sulfur they are very scarce. Compounds of nitrogen are absent.

The microimpurities found in the fuel in the suspension state are enriched by sulfurous and nitrous compounds. The amount of sulfur in them goes as high as 0.38—0.84%, the amount of nitrogen 0.28—0.59%. These microimpurities contain more tar products and water. Among the ash elements admixtures of mineral origin containing compounds of Si, Ca, Mg, and Al occupy an important place.

The increase in the microimpurities contained in the fuel of the amount of the organic-tar part and sulfur causes the microimpurities to remain in suspension and impedes their precipitation from the fuel.

After emptying from the railroad tank cars the fuels under warehouse conditions are put through a settling process and filtration through mesh and cloth filters. On the airplanes the fuels are also filtered through mesh and paper filters with a high degree of filtering. Through this the quantitity of microimpurities in the fuels is diminished.

As a result of the study of the residue and filtration of the fuels it was established that the purification of the fuels depends on the size of the particles of impurities contained in the fuel. Research of the effect of the chemical composition of the microimpurities on the process of their settling and filtration from the fuels was not done.

The data of the change in the amount and composition of the microimpurities in the TS-1 fuel in the process of its sedimentation and filtration in the combustible storage and on the airplane are given in Tables 2 and 3. From the data presented it is seen that in the process of sedimentation and filtration of the fuel there is a sharp decrease in it of the amount of compounds containing sulfur and nitrogen.

In the TS-1 fuel of refinery I the amount of sulfur is brought down to one fourth, and at refinery II to one fifth. The amount of nitrogen is lowered, respectively, by factors of 2.7 and 2. There is a decrease also in the microimpurities of the amount of ash elements.

In Table 4 there are presented the characteristics of the sediments taken from the reservoirs and fuel tank aafter keeping fuel in them under conditions of storage. From the data presented it follows that in the settling there are separated out deposits enriched by the ashes of elements with a small quantity of water and tarry substances. The content of ash in the sediment amounts to 80—84% and moisture 7—8%. In the sediment there is very little sulfur and nitrogen. The basic components of the sediments prove to be products of the corrosion of the Fe and mineral admixtures containing compounds of Si, Ca, and Mg. Into the sediment also go compounds of Zn and Pb.

The micro impurities of the TS-1 fuel which have compounds containing sulfur and nitrogen are separated out in the sediment in lesser quantities.

An analysis of the precipitate accumulated on the meshes of storage and airplane filters is given in Table 5. It is seen that the impurity of the TS-1 fuel, which contains sulfur-organic compounds is practically not caught by the mesh of the filters. The increased amount of nitrogen in the sediment is connected with the fact that on mesh filters fibrous material is caught in greater quantities, such material getting into

Table 2

Item	Fuel from refinery II		
	From R. R. tank cars	From distributing storage	After airplane filtering
Weight of air-dried microimpurities g/t	6.0	2.42	1.58
Weight of absolutely dry microimpurities, g/t . .	5.4	2.10	1.13
Moisture of microimpurities, %	10.4	13.6	28.55
Ash content of absolutely dry microimpurities, %	59.5	60.98	54.5
Element composition of absolutely dry microimpurities, %:			
C	30.08	14.21	17.94
H	6.95	4.51	6.08
S	0.38	0.13	0.07
N	0.59	0.55	0.25
O	35.4	29.5	30.86
Fe	8.6	31.4	19.0
Si	5.6	4.5	6.8
Ca	2.3	1.1	3.82
Mg	0.95	0.92	2.6
Al	0.58	0.28	0.51
Na	0.88	0.62	0.55

Table 3

Item	Fuel from refinery I		
	From R. R. tank cars	From airplane reservoir	After airplane filtering
Moisture of microimpurities, %	9.63	9.0	17.8
Ash content of absolutely dry microimpurities, %	62.86	67.2	69.6
Element composition of absolutely dry microimpurities, %:			
C	27,94	19.33	23.19
H	5.61	5.50	5.1
S	0.84	0.58	0.22
N	0.98	0.43	0.36
O	29.93	37.28	43.02
Fe	6.28	8.51	2.85
Si	11.5	16.1	11.3
Ca /.	4.3	0.45	2.85
Mg	4.64	1.98	3.44
Al	0.82	3.6	3.8
Na	1.37	1.24	0.13

Table 4

Item	Sediment	
	From reservoir	From sediment of supply tank
Weight of air-dried deposit, g/t . .	14.6	2.0
Weight of absolutely dry deposit, g/t	13.0	1.84
Moisture of sediment, %	7.0	7 7
Ash content of absolutely dry sediment, %. . . .	79.5	84.1
Element content of absolutely dry deposit, %:		
C	7.54	12.92
S	0.24	0.1
H	3.02	7.52
N	0.23	0.27
O	44.95	18.12
Fe	35.1	45.4
Si	1.9	12.2
Ca	0.8	2.35
Mg	0.48	1.22
Al	0.54	0.84
Na	Residue	0.74
Zn	1.4	1.7
Pb	1.82	2.86

the fuel in cleaning the tank as a result of the partial breakdown of the

fabric filtering jackets of the storage filters. For this reason the ash

Table 5

Item	Sediment from mesh filters	
	Storage	Airplane
Moisture of sediment, %	5.35	2.5
Ash content of absolutely dry sediment, %	58.43	48.65
Element content of absolutely dry sediment, %:		
C	20.52	31.79
H	5.29	6.19
S	0.29	0.12
N	0.62	0.84
O	29.31	24.25
Fe	29.2	4.55
Si	5.65	10.8
Ca	3.2	0.74
Mg	0.7	5.01
Al	0.58	8.3
Na	0.98	0.5
Zn	1.72	2.92

Table 6

	Organic tar part of absolutely dry sediment, %	Moisture of deposit, %
Storage fabric		
1st step of filtration	75.09	3.89
ditto	85.35	8.03
ditto	84.11	50.3
2nd step of filtration	81.54	15.21
ditto	90.29	32.3
Airplane paper		
After 5 hrs. work	82.46	3.74
" 9 " "	87.19	6.57
" 11 " "	89.95	2.8

Table 7

Filtration	Element composition of tars, %				
	C	H	S	N	O
1st step	70.76	10.75	3.34	1.05	15.1
ditto	70.08	14.36	1.84	0.70	14.02
2nd step	70.21	10.90	1.76	0.71	16.42
ditto	71.09	10.31	1.21	0.60	16.79

fabric filtering jackets of the storage filters. For this reason the ash content of the deposits on the mesh filters is not great and amounts to 48—58%. Of the ash components the mesh filters hold back mainly coarse particles of impurities in the TS-1 fuel, consisting of the products of corrosion of steel and zinc surfaces of the storage equipment and including particles of silicon and other mineral admixtures.

From the data obtained it is seen that the microimpurities of the TS-1 fuel impregnated with compounds containing sulfur are hardly held back by the mesh filters.

The basic mass of microimpurities of the TS-1 fuels, saturated with the organic-tar part, are taken out by the storage fabric filters and the airplane paper filters (Table 6). The storage filters are clogged by microimpurities when the content in them of tar amounts to 75—90%. The airplane paper filters are clocked by microimpurities when the content in them of tars reaches 82—89%, and the longer the work lasts the more the tar content in the deposit on the paper filters will be.

For determining the content of the basic component of the deposits on the fabric filters in the storage places the organic tarry part was extracted from them by chloroform. In Table 7 there is shown the element content of the tars extracted from the storage fabric filters.

From the data obtained it follows that along with the oxygen compounds in the deposits there is a considerable amount of compounds containing sulfur and nitrogen.

The amount of contents containing sulfur in the depostits on the fabric filters reaches 20—35% (from the computation for the average molecule of deposit). The great amount of oxygen in the deposit (up to 3—4 atoms per average molecule) is evidence of the fact that the sulfur-organic compounds held back by the fabric filters are present basically in the form of oxidized products.

Thus the decrease in the compounds containing sulfur in the microimpurities of the TS-1 fuels in their transportation, settling, and filtration, results from the removal of this group of microimpurities from the fuels on the fabric and paper filters. Consequently the microimpurities saturated by compounds containing sulfur cause a clogging of the storage fabric filters and the airplane paper filters.

Conclusions

1. The microimpurities of the jet fuels from sulfurous petroleums consist of ash elements, tars, and "structural" water.

2. In the process of transportation, settling, and filtration of the fuels there occurs a separation of the microimpurities in accordance with their chemical composition. The microimpurities saturated with ash elements settle and are filtered out in the mesh filters of the airplanes. The microimpurities saturated with tar products and water basically remain in the fuel in the suspended state.

3. Into the composition of the tarry part of the microimpurities of the fuels, along with oxygen compounds, there go up to 20—30% of oxidized compounds containing sulfur.

4. In the process of the filtration of fuels there occurs a decrease in the quantity of compounds containing sulfur in the microimpurities of the fuels.

The compounds with sulfur in the fuels are retained in the storage fabric filters and the airplane paper filters , for which reason the latter quickly become clogged.

At the fuel storage places the basic amount of microimpurities containing sulfur is held back by the fabric filters of the 1st step in filtration.

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