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ADSORPTION REFINEMENT OF WASTE TRANSFORMER OIL USING INDUSTRIAL MONTMORILLONITE-CONTAINING SORBENTS

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The possibilities of adsorption contact refining of waste transformer oil with active montmorillonite-containing sorbents of «Filtrol» series of BASF Catalysts LLC corporation and Zikeevsk M-80 deposit sorbent have been investigated. Usage of F-160 sorbents of «Filtrol» series in the refinement process allows achieving high quality degree of lean transformer oil, permitting its further use in the equipment with operating voltage to 750 kV.

Mineral oils step-by-step undergo deep changes in operating process as the result of accumulation oxidation products and degradation fragments of hydrocarbon base, products of resins firming, as well as products of wearing and corrosion of structural materials and fouling in them [1]. Oil purification and regeneration are the most perspective areas of resources recycling solving both economical and environmental problems.

For waste oils purification the same ways as for base oils purifications are used. They are distillation, acid-base purification, purification with solvent refining agents, contacting (adsorption refining), hydrofining. Treatment of oils, containing dissolved aging products, with adsorbents, for example natural or activated discoloring clays, is technologically efficient and simple way of oil purification [2, 3].

Samples of waste mineral transformer oils, weakly-contaminated (OST-1) and strong-contaminated (OST-2) ones, unsuitable for further use by such quality indices as acid number, chromaticity, loss-angle tangent, breakdown voltage have been chosen as the objects of investigation.

On the basis of literary data analysis and products availability on domestic market the sorbents of domestic and imported manufacturing have been chosen for oils contacting investigation (Table 1).

Table 1. *Base sorbents characteristic*

Name	Grade	Mineral composition	Manufacturee	Packed density, kg/m^3	Specific surface, m^2/g
Blanch soil of Zikeevsk deposit	M-80	Opal-cristobalite, montmorillonite, minor admixtures of silica and clinoptilita	«Sorbent» Russia	No data	80...200
Activated adsorbent of Filtrol series	F-1 F-160 F-105SF F-24 Mb LVM	Main component – montmorillonite	BASF Catalysts LLC corporation	500...800	250...400

Optimal process variables of waste oils adsorption refining, recommended by sorbent manufacturer, are the following: after water removal by centrifuging 0,5...10 % of adsorbent is entered into oil at temperature 80...120 °C and the mixture is stirred during 30...60 min. Adsorbent is separated from oil by filtra-

tion. To estimate sorbent efficiency the contacting of waste oil samples was carried out at temperature 100...110 °C and contact time 60 min. using 5 % of adsorbent (Table 2).

Acid number values determined according to the technique [4] and transmittance were used as express methods of investigations for estimating secondary raffinate quality. Transmittance was measured by photocolorimeter KFK-2 relative to distilled water in ditches with 10 mm thickness at wavelength λ=490 nm.

Table 2. *Comparison of oil refining quality with different sorbents*

Transformer oil of selective treatment	Sorbent grade	Sorbent amount, wt. %	Acid number, mg KOH per 1 g of oil	Transmittance, %
Raw OST	–	–	0,004/0,02*	85...90
Waste OST-1	–	–	0,018	31
Regenerated OST-1	F-160	2,5	0,014	84
	F-1		0,018	86
	F-24		0,014	52
	F-105SF		0,012	71
	MB LVM 30/60		0,007	44
	M-80		0,015	53
Waste OST-2	–	–	0,053	9
Regenerated OST-2	F-160	5 10	0,016 0,006	66 87
	F-1	5 10	0,021 0,017	63 79
	F-24	5 10	0,034 0,016	21 48
	F-105SF	5 10	0,023 0,015	48 73
	MB LVM 30/60	5 10	0,017 0,014	16 22
	M-80	5 10	0,014 0,010	23 29

**Maximal value by SS limiting further use of the given product*

It follows from the data presented in Table 2 that the most efficient adsorbent for refining both strong-contaminated (OST-2) and weakly-contaminated (OST-1) oils is Filtrol F-160.

The degree of raffinate refining depends on adsorbent quantity, contact time of sorbent with oil and temperature of the process carrying out. Influence of the given parameters on the degree of refining of waste oil samples were determined using sorbents Filtrol F-160 and M-80. The latter was of interest due to its low cost (5 rubles per 1 kg in comparison with 23 rubles per 1 kg of Filtrol F-160).

Choosing the optimal amount of sorbent the refining process was carried out at temperature 100...110 °C and contact time 60 min. The value of raffinate acid number, meeting the requirements of normative documentation [5], is achieved using 4 % of adsorbent F-160 and 5 % of adsorbent M-80 (Fig. 1).

To achieve the transmittance value, corresponding to raw oil of selective treatment is possible when using not less than 10 % of adsorbent F-160. Application of even 25% of sorbent M-80 does not allow achieving the required index for waste oil (Fig. 2).

To determine the optimal process temperature the series of experiments was carried out at the same ratio sorbent:oil. Carrying out the adsorption process at temperature 110 °C the decrease of acid number value to the indices corresponding to raw oils during contact time equal 15...20 min using 10 % of adsorbent F-160 was achieved (Fig. 3). Reducing temperature to 90 or 20 °C the same results are achieved at contact time of 45 and 60 min, correspondingly.

To achieve the value of transmittance corresponding to the requirements of normative documents is possible only at temperature of process higher than 90 °C. The adsorption process carrying out at 110 °C allows obtai-

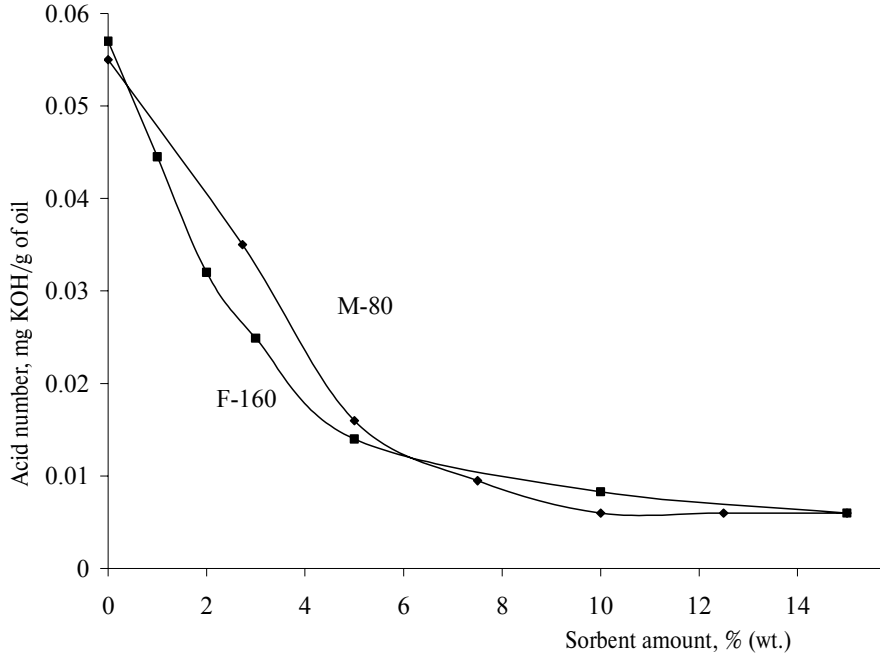

Fig. 1. *Dependence of raffinate acid number on quantity of used sorbent*

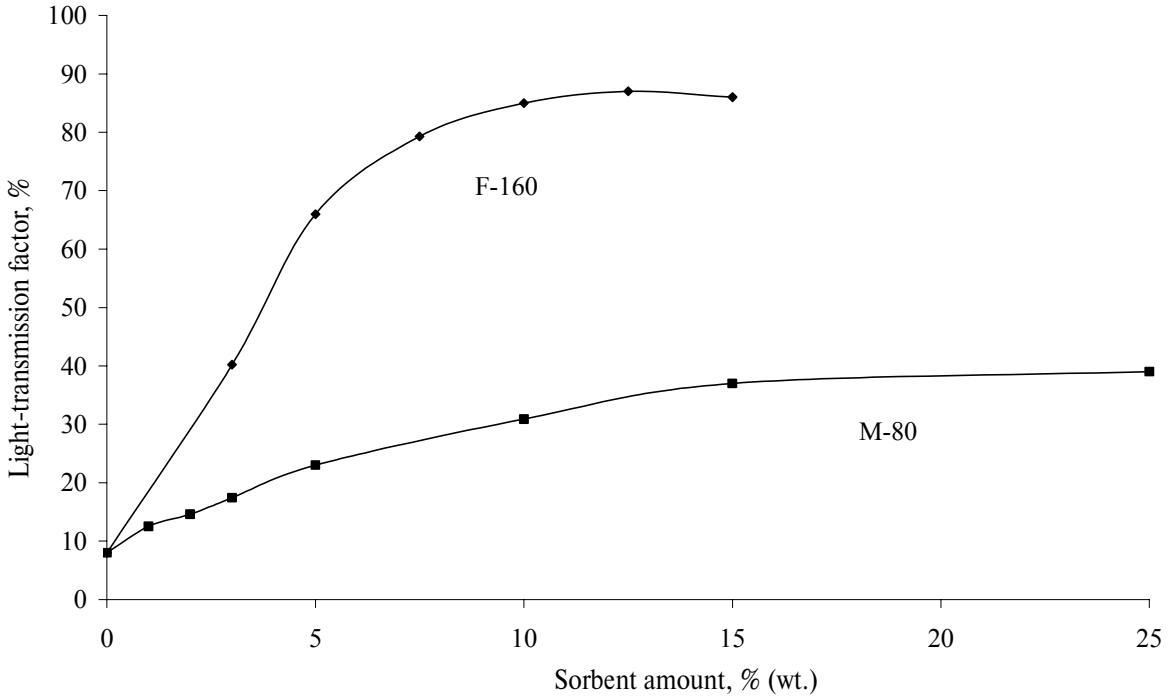

Fig. 2. *Dependence of raffinate transmittance on sorbent amount*

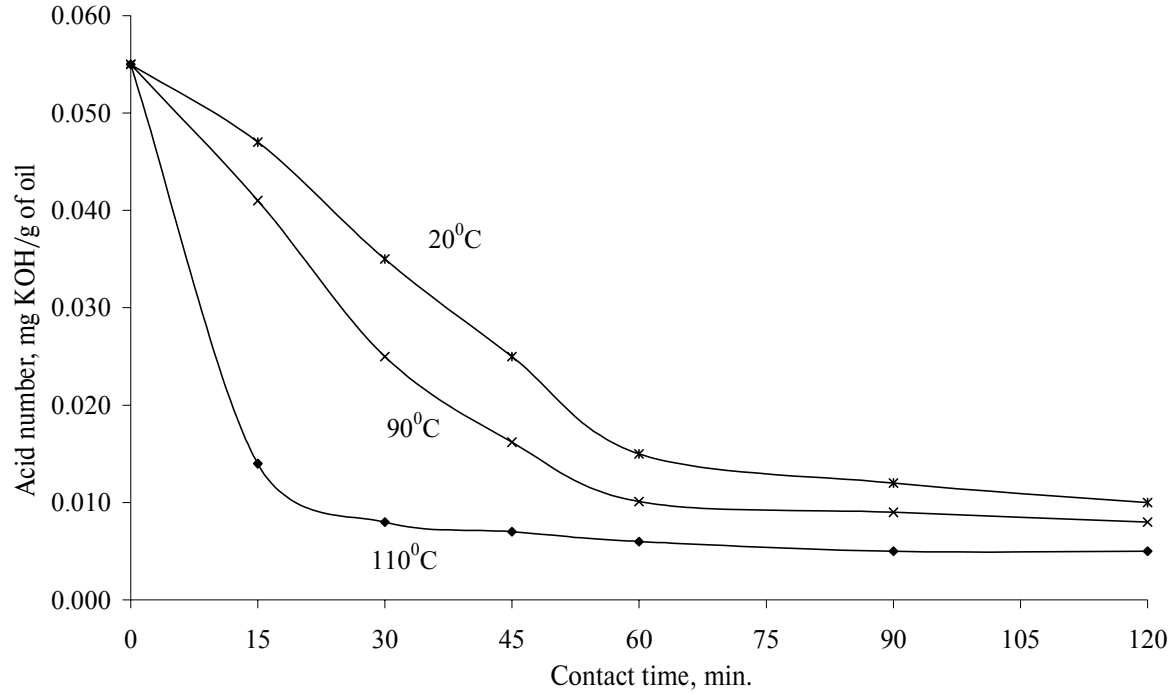

Fig. 3. *Dependence of raffinate acid number on temperature and process time*

ning raffinate with transmittance, meeting raw oil requirements during contact time of 50...60 min. (Fig. 4). Using sorbent M-80 in the same conditions raffinate with high transmittance could not be obtained.

Electrical insulating properties of transformer oils are determined by loss-angle tangent and breakdown voltage. Sorption oil refining decreases significantly the content of acid groups and correspondingly increases oil dielectric strength. Sorption refining of oil OST-2 with discoloring clay M-80 at 100...110 °C during 60 min allows decreasing loss-angle tangent from 80,4 % for waste oil OST-2 to 2,23 % for raffinate (Table 3). Filtrol F-160, used in the same conditions in number of 5%wt. decreases the value of loss-angle tangent to 0, 5 % that is significantly lower than SS 10121 demands for raw oil (1,7 %). Oil refining with sorbents M-80 and Filtrol

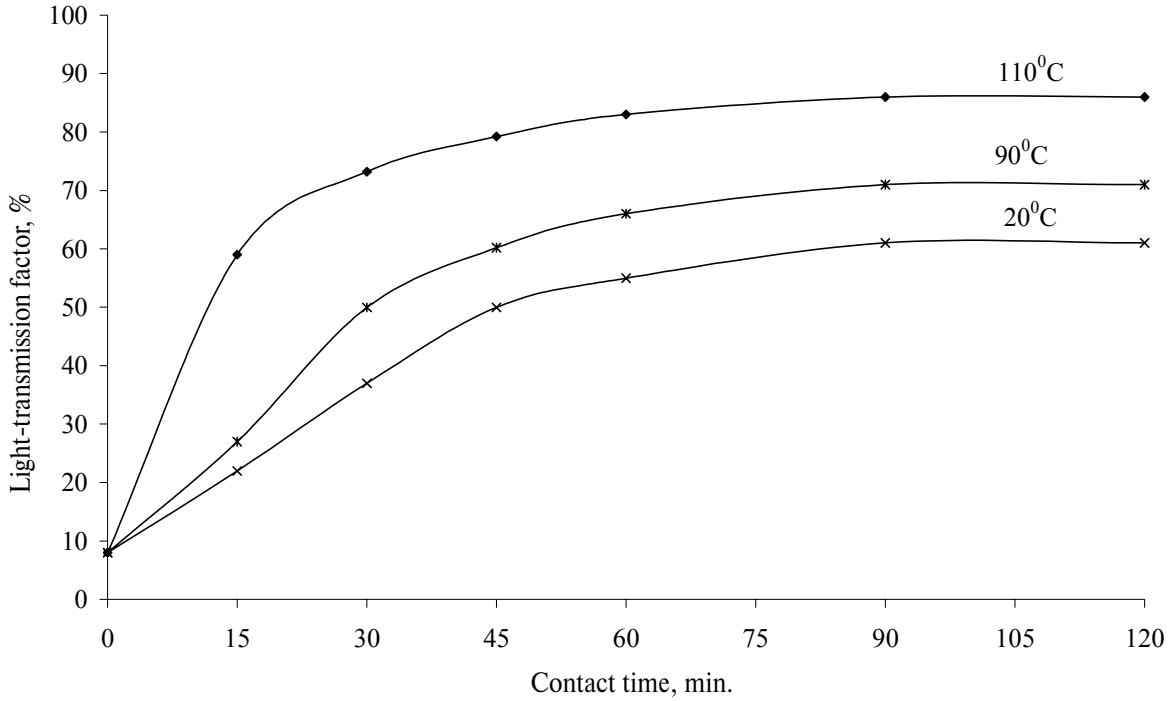

Fig. 4. *Dependence of raffinate transmittance on temperature and process time*

F-160 with further conditioning allows achieving breakdown voltage index to 80 kV (Table 3) that allows using the given oils in electrical equipment with operating voltage to 750 kV [6].

Table 3. *Electrical insulating properties of raffinates*

Sorbent name	Sorbent amount, wt. %	Breakdown voltage at frequency 50 Hz, kV	Loss-angle tangent at 90 °C, %
F-160	5	70	0,5
F-160	10	80	0,48
M-80	10	63	2,23

Thus, the most efficient sorbent for waste transformer oils regeneration is F-160 one of BASF Catalysts LLC corporation. Refining with sorbent F-160 with further conditioning allows achieving the value of breakdown voltage to 80 kV and loss-angle tangent of 0,48 % that allows using the given oil in electrical equipment with operating voltage to 750 kV. The optimal process variables of contacting are determined individually according to the degree of waste oil contamination. Using discoloring clay of Zikeevsk deposit M-80 does not allow achieving oil quality indices obtained when using sorbent F-160. The color remains higher than the normative one. Besides, to achieve the comparable quality indices of oil refined with sorbents F-160 and M-80 the large quantity of the latter is needed. Using M-80 for transformer oil prerefinig and sorbent F-160 for further aftertreatment may be economically appropriate.

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