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Experimental regeneration process of used motor oils

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Abstract - *The present work, on an experimental basis, consists of an analysis and treatment of used motor oil (used oil collected by NAFTAL stored at the port of Algiers). For this, we carried out tests in the laboratory in order to develop an adequate re-refining process. First we made a comparative analysis between the sample taken from a storage tank and a new engine oil produced in the Arzew refinery. The results of these analysis allowed us to identify the different stages of the process of regeneration (Pre-treatment, metal removal by a chemical agent, a finishing treatment by passage through the bentonite and filtration). This process has enabled us to eliminate most of the impurities and the optimization of different parameters, the engine oil obtained at the end of the process is a basic oil ready to be used again.*

Résumé - *Le présent travail, à caractère expérimental, consiste en l'analyse et le traitement d'une huile usagée moteur (huiles de vidange collectées par NAFTAL, stockée au port d'Alger). Pour cela, nous avons réalisé des essais à l'échelle du laboratoire en vue de mettre au point un procédé de re-raffinage adéquat. En premier lieu, nous avons effectué des analyses comparatives entre l'échantillon prélevé du bac de stockage et une huile neuve produite à la raffinerie d'Arzew. Par la suite, les résultats issus de ces analyses nous ont aidésà mieux cerner les différentes étapes du procédé de régénération (Prétraitement, élimination des métaux par un agent chimique, traitement de finition par un passage dans la bentonite et la filtration). Finalement, les différentes étapes que nous avons effectuées, nous ont permis l'élimination de la majorité des impuretés et la régularisation de différents paramètres, ainsi, l'huile obtenue à la fin du procédé est une huile de base prête à l'emploi.*

Keywords: Regeneration process - Waste material - Drain oil - Heavy metals - Adsorption.

1. INTRODUCTION

All lubricants used or stored degrade over time depending on the type of oil, conditions of use and the environment, as well, the engine oil used are oils which become contaminated after using, they can't continue to perform their duties properly.

However, such used oils can be considered as a special crude with viscometric intrinsic characteristics and freezing point as the new based oils [1], indeed, after treatment of these oils by one process of regeneration [2, 3], they can be reused in the engines. For this reason they are considered a source of recycling very important.

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Indeed, many studies have been made in order to find the best methods of management and reproduction of these oils. Among the works, evoking studies carried by Bachelder *et al.*, [4], who studied the most important methods for recycling (re-refining and upgrading).

Umesi [5] examined the recycling of used lubricating oil of an internal engine combustion, it was concluded that, most of the great treatment processes comprise: system centrifugation and decantation, the process acid-earth filtration method with a fixed bed of fine sand and also during the re-refining the properties of oils are modified in stages order to produce a base oil relatively clean [6].

In Algeria, the engine used oil have not ceased to multiply due to the growth of the car fleet, more than 180.000 tons of lubricants per year. Consequently considerable quantities of used oil are generated and classified as hazardous waste, not very biodegradable and carcinogenic; their release into the environment is strictly forbidden by the authorities.

Given the lack of operating installation approved for disposal of such oils used the company, Naftal was responsible for implementing a collection scheme throughout the national network in order to lead a good management of the oils, namely that all the oils are collected destined for export. But today with the ratification of Algeria Bâle Convention [7], which requires following the new international regulations for waste oils strict orders (administrative procedures to ensure safe trans boundary movement from one country to another), then the export of used oils has become increasingly uncertain and challenging, so it is necessary to find outlets for this product.

To contribute to the management of these oils, we carried out tests in the laboratory to develop an adequate re-refining process. We started with a comparative study between the used oil (sample taken from the storage tank at the port of Algiers) and a new oil (from the Arzew refinery), it allowed us to choose the treatment process, we made more processing steps, such as using a chemical agent (dilution in xylene) for the elimination of heavy metals and the bentonite from Maghnia as adsorbent. We reanalysed the oil has several steps until obtaining a base oil lends to use in engines.

2. ANALYSIS AND TREATMENT OF ENGINE OILS

2.1 Analysis of used oil compared to the new oil

Following our visit to the port of Algiers, where tanks of used oils collected by Naftal are stored, we selected a representative sample of twenty litres of oil, mixing ten litres from the top and the bottom of the tank.

In order to see the degree of degradation of the sample, we conducted a series of tests in the laboratory, comparing a sample of the used oil with new oil (20W50 from Arzew refinery).

The physic-chemical characteristics of waste oil collected and new oil are shown in the following **Table**.

Table 1: The physic-chemical characteristics of used engine

Characteristics	Norms	Units	Used oil	New oil 20W50
Color	ASTM D1500	-	> 8	4.5
Density 15°C	ASTM D1298	-	0.8893	0.8793
Viscosity 40°C	ASTM D445	CST	106.37	153.84

Viscosity 100°C	ASTM D445	CST	12.66	17.04
Index viscosity	ASTM D2270	-	113	114
Flash point (open cup)	ASTM D92	°C	210	236
Flow point	ASTM D97	°C	-21	-22
Ashes	ASTM D874	% Pds	0.6	-
Index Conradson	ASTM D482	% Pds	1.3	-
Water content	ASTM D95	% Pds	4.2	-
Sulfur content	ASTM D2622	% Pds	0.299	-
Test dilution fuel	ASTM D322	% V	0.4	-
Tan	ASTM D2896	Mg.KOH/g	2.74	2.40
TBN	ASTM D2896	Mg.KOH/g	4.66	6.26

Subsequently, we proceeded to the determination of heavy metals in our sample, let us know that among the role of lubricating oils removal of mineral particles generated by usury of two metal friction parts.

The usury of the mechanism results in a release of fine metallic particles, which are driven by the oil. To detect these fine particles, was used emission spectrometry (Spectroil M) for determination of the content of trace metals (metals additives and usury). According to the analysis we obtained the following results:

Table 2: The metals content (ppm) of the sample of used oil engine and standard oil

Metals	Metals content of the sample (ppm)	Concentration of the elements preventing from additives	Concentration of wear metals
Fe	58.6	-	50 - 100
Cr	3.2	-	-
Pb	403	50	-
Cu	9.4	25 – 40	-
Sn	9.7	-	-
Al	11.2	5 - 30	3 – 5
Ni	0.0	-	-
Ag	0.0	-	-
Si	21.9	30 - 120	-
B	7.8	75 - 100	-
Na	32.7	50 - 100	-
Mg	43.5	100 – 300	-
Ca	924	2000 - 3000	-
Ba	0.0	-	-
P	227	800 - 1200	-
Zn	247	1000 – 1200	-
Mo	18.3	5 - 20	-
Ti	1.2	-	-
V	0.0	-	-

2.2 Results of comparison between the used oil and the new oil

After obtaining the results of analysis, we found that the characteristics of the used oil have been altered to proportions more or less weak. Seen that the values of the physico-chemical characteristics are less than the limits values, the used oil taken was considered as a particular "crude oil" very rich in oil regenerable basis.

The properties of the freezing point and viscosity index is preserved, it should all the same not underestimate the presence of soluble oxidized contaminants, additive derivatives and suspended impurities such as metals for wear motor.

3. REGENERATION PROCESS PROPOSED

Previous attempts to the regeneration of used oils are often based on acid / earth technology. But the waste generated contain a fairly large percentage of acid.

In our study, we have been processing the used oil to eliminate the maximum impurities. We proposed a process based on several stages,by using of less harmful chemicals than the acid process. The process steps are shown in the diagram below.

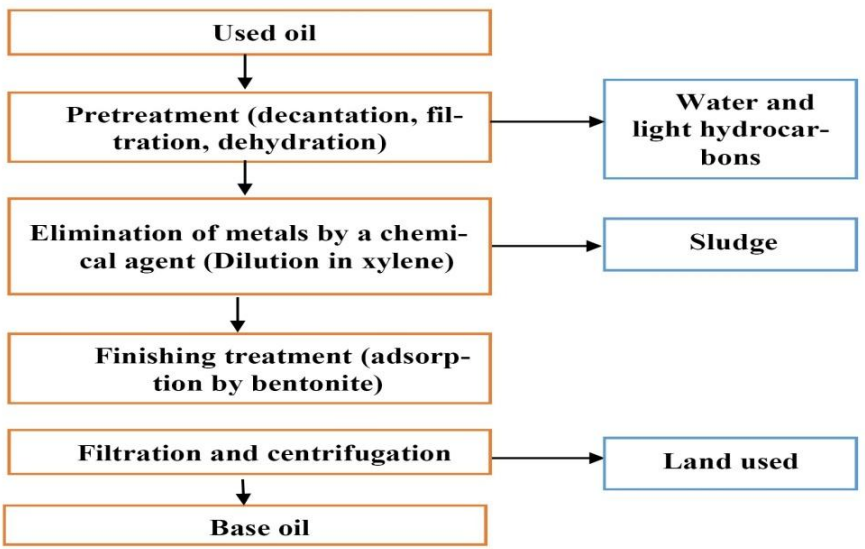

Fig. 1: Diagram proposed of regeneration process

3.1 Pre-treament

This step is required at the beginning of the process. After settling and filtration, we performed a fresh oil distillation to remove water, gasoline, glycol solvents and some derivatives additives.

3.2 Elimination of metals

This step generally consists of make an oil purification by precipitation of suspended solids. However, oil still contains partially oxidized soluble compounds that must be removed by chemical action in the following step. There are many methods for the elimination of metals (acid attack, vacuum distillation, dilution and flocculation ...).

The agent used for the removal of metals is xylene [9] by an action of dilution. This operation in the organic medium destabilizes links and precipitates heavy particles after centrifugation. We made this dilution at different percentages of Xylene.

The results are presented in the **Table** below.

Table 3: The content of the metals in ppm after dilution in xylene

Elements	Metal content of the used oil(ppm)	Used oil Treated by dilution			
		10% xylene	10% xylene	10% xylene	10% xylene
Fe	58.6	20.1	14.5	0.7	2.2
Cr	3.2	0.0	0.0	0.0	0.0
Pb	403	12.3	7.5	0.8	3.4
Cu	9.4	0.0	0.0	0.0	0.0
Sn	9.7	0.5	0.0	0.0	0.2
Al	11.2	1.2	1.0	0.0	0.0
Ni	0.0	0.0	0.0	0.0	0.0
Ag	0.0	0.0	0.0	0.0	0.0
Si	21.9	10.1	5.7	1.3	2.5
B	7.8	6.2	4.8	0.0	0.0
Na	32.7	15.0	5.1	1.7	0.8
Mg	43.5	13.5	9.6	4.4	6.8
Ca	924	0.4	0.6	0.1	0.1
Ba	0.0	0.0	0.0	0.0	0.0
P	227	8.1	9.0	4.1	6.2
Zn	247	0.1	0.1	0.0	0.0
Mo	18.3	2.3	2.5	0.0	0.0
Ti	1.2	0.0	0.0	0.0	0.0
V	0.0	0.0	0.0	0.0	0.0
Total met.	2018.5	89.9	60.4	14.1	22.2

We note that, the metal content in the treated oil was reduced by dilution of a significant amount, especially for testing 20% xylene.

The results of analysis obtained for the elimination of metals approve that the method of elimination is satisfactory.

3.3 Finishing treatment

This treatment is designed to regulate the following parameters, namely color, viscosity, acid index and Conradson carbon, by using the bentonite. According to the literature study, this treatment depends on some parameters such as the amount of adsorbent, contact time and contact temperature

We have chosen as an adsorbent the bentonite, from the deposit of Maghnia [10]. We have fixed the temperature, contact time and we varied the amount of adsorbent. After 48 hours of decantation, the sludge of land formed at the bottom of the container with an oil phase on the surface, we observed a change in the color from black to brown.

We recovered the oil phase in order to separate sludge land by carrying a vacuum filtration assembly. To better ensure the separation we performed centrifugation at 1000 r / min for 10 minutes

3.4 Analysis of regenerated oil

After filtration and centrifugation, we realized the analysis of the different samples of oils, the results are presented in the following **Table**:

Table 4: The physic-chemical characteristics of the regenerated oil and base oil produced in the refinery

Proprieties'	Base oil viscosity medium (SAE)		Used oil	Regenerated oil at 40g of the bentonite	Regenerated oil at 40g of the bentonite	Regenerated oil at 40g of the bentonite
	Min.	Max.				
Density at 15°C	0.8700	-	0.8893	0.8870	0.8838	0.8881
Viscosity inc Stat 40°C	91.0	-	106.37	118.87	117.77	121.49
Viscosity inc Stat 100°C	10.5	-	12.66	12.12	11.36	11.02
Viscosity index	95	-	113	90	78	77
TBN (mg KOH/g)	0.0	-	4.66	0.0	0.0	0.0
Flow point (°C)	-	-12	-21	-8	-7	-7
Flashpoint (°C)	230	-	210	221	225	225
Water content (% Vol)	0.0	-	4.2	0.0	0.0	0.0
Sulfur content (ppm)	-	0.08	0.299	0.06	0.06	0.06
Color	-	2.5	> 8	4.5	4	4

Based on the obtained results we noticed a neat improvement in the differentparameters of the treated engine oil particularly the color which became clearer this is due to the adsorption of different impurities present in the used engine oil. Of more than the improvement of flow point and flash point is due to the elimination of carbonaceous materials and volatile compounds. Which confirms the importance of the adsorption by the bentonite.

In general we notice that, we ended up with a finished engine oil with highly improved characteristics, they are close to that of the base oil, where the efficiency of the realised process.

Therefore the obtained oil can no longer be regarded as a pollutant but sooner as a richness which should be reused.

4. CONCLUSION

With the increase in the fossil fuel costs and the concern about the disposal problems (including soil and groundwater pollution) of used lubricants, the waste-to-energy currently offers the best alternative for utilizing these combustible substances because of their high contents of hydrocarbons.

Thus, the reprocessing or refining of used lubricants plays a vital process for reusing them as valuable energy source, not only for environmental pollution but also for energy conservation.

An analysis and treatment of used engine oil (used oil collected by NAFTAL stored at the port of Algiers) has been studied by proposing a process of regeneration (Pretreatment, metal removal by dilution in xylene, a finishing treatment by passage through the bentonite and a filtration).

The final analyses reveal that we had ended up with a finished engine oil with highly improved characteristics, they are close to that of the base oil, where the efficiency of the proposed process.

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