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Full Length Research Paper

Regeneration of base-oil from waste-oil under different conditions and variables

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The demand for lubricants is continuously increasing with the increase in the establishment of factories and the tremendous increase in the number of vehicles and other means of transportation. The oil consumed can be a great source of contamination if it is thrown as a waste or can be considered as a new source of energy if properly used, and all depends on methods of how oil can be reused. This study shows how to be innovative on reusing waste-oil while keeping the basic characteristics of base oil. In this experiment, a process known as acid clay is used to restore the basic characteristics of original oil. The oil-waste is collected from different places and a number of experiments are conducted under different conditions with different set of variables. The impact of these variables on the quality of the product is discussed. The possibility of restoring and reviving nearly two-thirds of the oil consumed is proved in this investigation.

Key words: Waste oil, base-oil, regeneration of base-oil.

INTRODUCTION

Jordan, a developing country, has witnessed a rapid growth in the industrial sector. This can be seen by the establishment of industrial cities in different provinces which contributed to the establishment of laboratories and factories to meet the needs of the country of various goods, and to export also to neighbouring markets. This requires an increase in the consumption of lubrication oil to reduce friction between metal surfaces in engines, generators, power plants and other appliances and mechanical equipments which require lubrication oil for operation.

The oil demand in Jordan increased due to the growing number of vehicles and machines which need to change lubrication oil constantly on average of once every three months and knowing that the number of vehicles registered in Jordan has exceeded one million vehicles as indicated in the annual reports at the department of statistics (Statistical Department, 2006) and the study conducted at the Jordan Petroleum Refinery Company (Jordan Petroleum Refinery Company, 2009). The vehicle owners change the lubrication oil once in each (Jsusa and Pobla , 2007; Rahman et al., 2008) thousand kilo-meters. The total country's consumption of lubricating oil is about 50,000 ton per year. In Jordan, the treatment of all waste oil including those burned in industrial furnaces, is opposite to what happens in other countries where they restore some of the oil, mainly from waste oil by using the traditional method (acid clay). Different places and different sources using the traditional method (acid clay) were used for the study of the effect of different variables on the properties of renewable oil generated in the studies of Rahman et al. (2008), Kim and Kim (2000) and Graziano and Daniels (1995).

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These used oils are consumed either as a source of fuel in the furnaces to produce energy or to be put up as waste in the sewage or waste on the ground. Both of these practices lead to non-end environmental problems, whether through the smoke of furnaces and the contents of soot and toxic metals or contamination of surface water sources and groundwater. In extreme cases, these contaminants damage furnaces, thus leading to increase environmental pollution (Kajdas, 2000). Emission of zinc (Zn) can be as high as 600 times and copper (Cu) can be 2100 times if waste oil is burnt instead of re-refining (Boughton and Horvath, 2004). One gallon of oil is able to contaminate million gallons of drinking water and can form a thin layer of oil on the surface of the water which prevents oxygen from being dissolved in water, which hampers all kinds of aquatic life and the processes of photosynthesis as indicated in Rahman et al. (2008) and in Boughton and Horvath (2004).

On the other hand, this vast amount of waste petroleum oil can be considered as a very valuable source of energy, and could be restored by re-refining and processing. This will be beneficial for the country both economically and environmentally. If thrown as waste, on the other hand, the used oil will be a major source of pollution and the loss of an essential resource for the production of base oil.

This current investigation aims at regenerating base oil from waste oil which was collected from different places and different sources by using the traditional method (acid clay) and studying the effect of different variables on the properties of renewable oil generated in the studies of Rahma et al. (2008), Kim and Kim (2000) and Graziano and Daniels (1995).

MATERIALS AND METHODS

An experimental laboratory unit has been set up to recover base oil from waste oil. Figure 1 shows the major steps in the process of re-refining. Samples of waste oil were collected from different sources and a variety of oil, including lubrication of vehicles and machines in the workshops and places of various industries around the city of Irbid. These oils were then mixed together to form a complete sample representing the different types of waste oil. Solid particles and water from oil were removed by gravity sedimentation (gravity settler) before the treatment originally took place. Two layers were formed and the top was waste oil. This waste oil was collected and sent to the next step for further processing.

The process of catalytic cracking of waste oil in the next stage was applied on the crude oil at atmospheric pressure and for 3 h and the zeolite was used as a catalyst. The objective of this work was to remove carbon particles from the oil. The oil was heated to 140°C and under atmospheric pressure for a period of 1 h to eliminate the free water and emulsified water. Then, it was cooled to a temperature of 30°C. The oil was treated and washed with H_2SO_4 with a concentration of 92% and left for 24 h for de-asphalting and settling of acid sludge from acid treated oil (Hamad, 2005). The treated oil was then mixed with Fuller's earth to feed the vacuum distillation unit. The light fraction was collected from the top of the unit, and the product from the bottom of the unit (the filtered one) which consisted of soil (clay) and the refined oil, where it was subsequently separated by filtration.

RESULTS AND DISCUSSION

Different sets of variables were used in this investigation to study their impact on regenerating the properties of lubricating oil (lube oil). These included the proportion of the added materials to the waste-oil, the catalytic cracking unit, the vacuum pressure in the distillation unit of vacuum and the duration of the distillation as shown in Table 1. Different runs were conducted. For each run, the base oil was collected, analysed and compared with ASTM standard to determine the different properties of the base-oil. At the end, the product was graded according to its viscosity by following (ISO) standards (ISO 3448, 1975). The characteristics of used oil (waste-oil) and the regenerated base oil are shown in Table 2.

The catalytic cracking temperature for the first stage was 180°C and in the stimulating waste oil, it was under 130°C. Then, the regenerated oil was characterised to prove whether the percentage of catalyst for the waste oil was changed in the properties; increase of the regenerated oil is an indication of the increase in the viscosity index.

The acid treatment process was conducted under the atmospheric pressure and the aim was to make the oil free of oxidized polar compounds, acidic products, additives and suspended particles and others and also, to keep the hydrocarbon families in the oil unmodified. The latter was not changed during the experiment. The pour point and cloud point of the oil generated was determined and it did not affect the operational variables as shown in Table 2.

The light hydrocarbons produced can be obtained and separated from the top of the distillation unit by collecting, condensing and then measuring it. The light materials increased in the discharge unit. The time of the distillation decreased while increasing the discharge but the amount of light material did not give an adequate explanation and part of the light materials, during the process of hydration leaked outside. The flash point of the base-oil was mainly a function of the vacuum created in the distillation column and the temperature in the column. The column was operated at different vacuum pressure but at a fixed temperature (350°C). The flash point of the base-oil was facilitated by the removal of the light fraction. Similar trend were observed for specific gravity of the oil.

Petroleum products contain acidic components, additives or degradation products. Total Acid number (TAN) can be expressed as a base amount of milligrams of potassium hydroxide per gram in each sample and this is an essential requirement to calibrate the sample to the endpoint green / green – brown with the p-pnapthanol-benzeine indicator (Speight, 2002).

The pH number was used as a guide in monitoring the quality of the lubricating oil and as a measure of the deterioration of degradation of the lubrication oil during the service or the performance. The pH found was equal to 2.1 KOH/g, while the oil generated was between 0.1 and 0.21. The specifications of the TAN for the lubrication

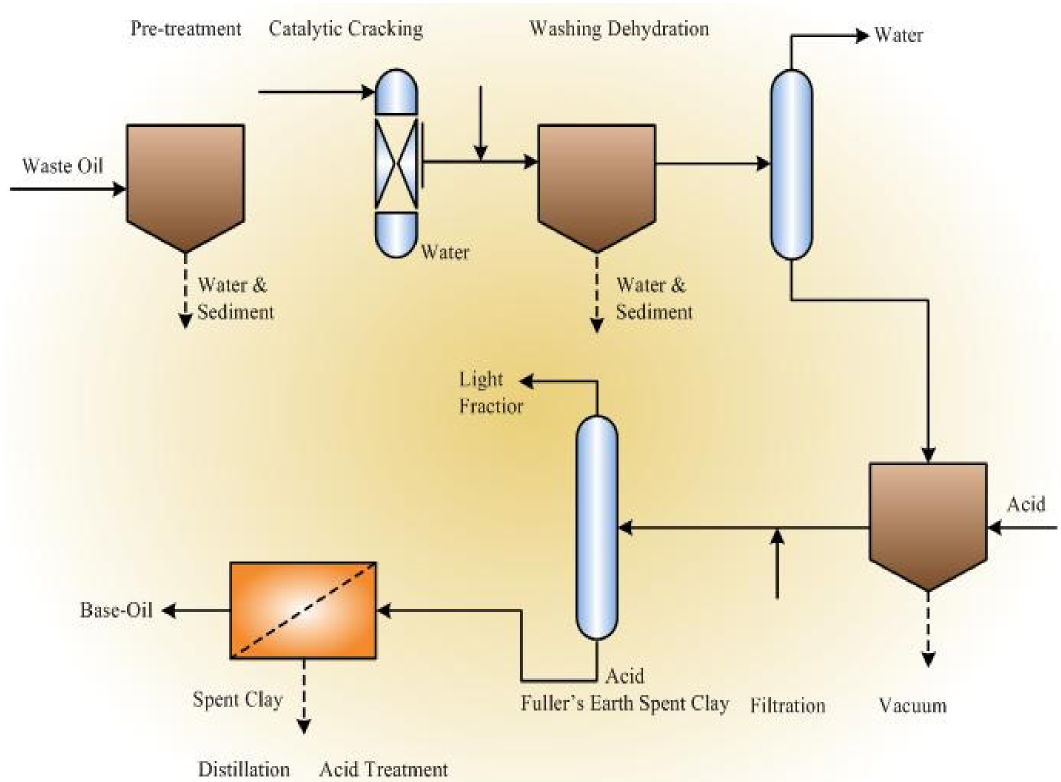

Figure 1. Base-oil regeneration process

Table 1. Process parameter.

Process variable	1st Run	2nd Run	3rd Run	4th Run
Catalyst-waste oil ratio (g/L)	7. 94	7. 94	11. 62	16.88
Cracking temperature (°C)	180	130	130	130C
Distillation time (h)	3	2	1.5	1
Distillation column pressure (mm Hg)	580	500	450	350

Table 2. Waste and regenerated base-oil properties.

Parameter	Standards	Waste Oil	1st Run	2nd Run	3rd Run	4th Run
Viscosity index	ASTM D2270	97	102	105	106	107
Pour point (°C)	ASTM D97	-9	-12	-12	-11	-12
Could point ((°C)	ASTM D5773	-10	-14	-13	-13	-14
Light Fraction from distillation column as % of feed	-	-	0.55	1.23	1.30	1.20
Flash point(°C)	ASTM D92	-	225	265	269	270
Specific gravity @ 40((°C)	ASTM D1298	0.834	0.865	0.870	0.868	0.874
ASTM color	ASTM D1500	>8	K 4.5	L 3.5	L 4.0	L 3.0
Total Acid Number mg KOH\g	ASTM D664 ASTM D974	2.1	0.110	0.116	0.185	0.210
Ash Content (%)	ASTM D 482	2.3	0.58	0.48	0.50	0.55
Recovery (%)	-	-	66	63	62	62
Viscosity grade	ISO 3448	-	VG 220	VG 220	VG 220	VG 220

lube oil varied depending on the degree of the end-use.

Ash content in the products was found to be high. After treatment with Fuller's earth (clay) and distillation vacuum, the oil was filtered by a garment. Using accurate filter and medium pressure, the filtration of ash content in the product could be substantially reduced. Fuller's earth was used to neutralize the acid of the treated oil in addition to the removal of colour (Graziano and Daniels, 1995; Speight, 2002) by the same amount of clay used to run each phase. The work included addition of the clay and blending with the oil in all phases of varied degrees. The mixing of the clay with proper oil was conducted for all stages except one. In all these stages, the colour was removed according to the amount of clay added and the removal of the colour can be linked with the amount of clay used. The use of more Fuller's earth meant the liquidation of lighter and pure base oil. The colour of the oil in the excluded phase clearly appeared under a suitable mixing for the removal of colour. In all conditions, usually, the degree of colour for the renewable oil-base was comparable with ASTM standard which was less than 2.0, while the nitrogen was a major contributor to the oil colour and the traditional acid clay was used to produce brighter oil instead of high quality. Hydro treating of oil could produce base-oil with a brighter colour.

Recovery of the base oil was found to be between 62 and 66% and this was the link with the light products. The separation of impurities produced the renewal process for sludge with four stages of processing oil. These were catalytic cracking, treatment with acid and filtration. If the sludge is thrown in the environment, it could cause pollution with great concentration of pollutants but this can therefore be used to produce carbon bars as an example, or for heating, as 1 kg produces 4000 kcal with especially and suitably designed stoves to reduce pollution (Rahman et al. 2008; Speight, 2002) while the generated oil which depends on the viscosity can be classified with a category of ISO VG220 and used in accordance with its specifications (ISO 3448: 1975).

Conclusion

Every year, approximately 50,000 tonnes of waste oil is generated. Most of it is either disposed to the environment or burnt improperly, contributing significant adverse effect to the environment. Proper collection and regeneration of waste oil can be beneficial for us by:

1. Reducing environmental pollution;
2. Saving foreign exchange for importing virgin lube oils and
3. Conserving of mineral resources.

It can be said that to produce one gallon of base-oil, which is environmentally friendly, one gallon of waste-oil is needed which is considered as a source of contamination to the environment at the end of this process. However, low profit and weak market structure drive the waste oil management method selection toward the untreated fuel oil market. Regeneration of waste oil and associated product markets should be patronized by the government.

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