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Conversion of Waste Engine Oil to Diesel and Gasoline Range Fractions Using Cobalt Acetate as a Catalyst

A. L. Rathod
Assistant Professor,
Deptt. of Chemical Technology,
Sant Gadge Baba Amravati University, Amravati,
Maharashtra

Abstract

Increase in energy demand, stringent emission norms and depletion of crude oil resources have led the researchers to find alternative fuels for internal combustion engines. On the other hand, waste engine oils pose a very serious environment challenge because of their disposal problems all over the world. In this context, waste oils are currently receiving renewed interest. In recent years, depleting fossil fuel sources, growing demand and cost of petroleum based fuels, and environmental hazards as a result of burning of them have encouraged researchers to investigate possibility of using alternative fuels instead of the fossil fuels. Therefore, the researchers have focused on finding alternative new energy resources and utilizing them. They have stated that it is necessary to reduce consumption of the petroleum fuels due to the negative effects on human life by producing alternative renewable fuels. As fossil energy sources have been exhausting rapidly nowadays, it is predicted that fossil fuel sources will not last for long. Therefore, scientists and researchers all over the world are now working hard to discover new sources of energy for the future, and also trying to develop new technologies that allow recycling or reusing waste material as a source of energy. Many research works addressed the utilization of waste oils by converting it to diesel and gasoline-like fuels so that it can be used in diesel and gasoline engine applications as a source of energy. This paper gives a brief review about converting waste engine oil to diesel and gasoline range fractions by cracking it in presence of cobalt acetate. It can also be established that the cracking process offers an exciting way to recover both the energetic and chemical value of the waste engine oil by generating potentially useful cracking products suitable for future reuse. The results obtained from the experimental studies on a cracked product are discussed.

Keywords: Waste Engine Oil, Cracking, Combustion Products, Degradation Products, Petrochemicals, ASTM, ^{o}API, Waste to Energy, Recycling Waste, Waste Engine Oil, Cracking, Diesel-Like Fuel.

Introduction

The threat posed by climate change and the striving for security of energy supply is an issue high on the political agenda these days. Governments are putting strategic plans in motion to decrease primary energy use. Throughout the world, many steps are being taken to find the alternative for petroleum based fuels. Waste management is the impact of increase in environmental pollution, rising oil price and the reality of petroleum depletion. Additionally, the disposals of waste once a technical problem, that has to be solved under environmentally acceptable and hygienic conditions.

Disposal of waste engine oil is one of the most important problems that should be solved. It is estimated that worldwide, over 25 million tons waste engine oil is generated annually. Industrial and household wastes are produced on a daily basis and are managed in many ways, depending on their type. According to their combustibility, wastes are basically categorized as either burnable or unburnable. The burnable wastes are normally treated by combustion with or without heat production, while the unburnable wastes are treated by recycling, re-use, or landfilling, depending on the material. Municipal and industrial wastes that contain high heat value, such as waste plastics oil (WPO), waste cooking oil (WCO), and waste engine oil (WEO) are considered efficient feedstocks for energy production in a Waste-to-Energy policy. The main objective of this paper is to study the possibility of converting waste engine oil to high value diesel and gasoline-like fuels by means of cracking it in presence of cobalt acetate.

Aim of the Study

To convert environmentally hazardous waste engine oil to high value petroleum fuels and by doing so conserving the precious source of energy, "Petroleum".

Waste Engine Oil

In recent years, recycling of the waste engine oils and utilizing the products as fuels have become important topics for researchers. Most of the lubricant oils are generally obtained from petroleum resources. The used or waste oils can be refined and treated to produce fuels or lubricating oil base stock. On the other hand, the waste oils pose an environmental hazard due to both their metal content and other contaminants. The high-volume waste oils can be turned into valuable fuel products by cracking and treating processes. Converting waste oils into diesel and gasoline-like fuels to be used in engines without disposing is very important. Utilization of the diesel and gasoline-like fuels produced from the waste engine oils, and blending of the produced fuels decrease consumption of petroleum based fuels, protecting environment from pollution. It also saves foreign exchange, reduces greenhouse gas emissions and enhances regional development especially in developing countries. Characteristics of any fuel are very important from the point of deciding whether the fuel can be used for desired application or not.

Sample

In this study, waste engine oil is used as a sample collected from different private two wheeler service stations in Amravati city and mixed together to form a single homogeneous sample. This sample is a typical feedstock for the experiment.

Prior to the runs the oil was filtered to remove solid particle and then heated to 150°C with continuous stirring and maintained for one hour to eliminate water. This filtered and dehydrated waste oil (FDWO) was used as starting material for the experiment.

Thermal cracking, visbreaking, catalytic cracking, fluid catalytic cracking, hydrocracking, and coking are all well-known crude oil refinery processes based on the basic principle of breaking large hydrocarbon molecules into smaller ones thus increasing the production of high value light products from the heavy portion of crude oil as the Lighter fuels are generally more valuable than heavier ones. Gasoline for example, is more valuable than diesel fuel.

Cracking process can be successfully applied for manufacturing distillates from a used oil feedstock. The significant aspect of this technology is its ability to adjust process operating conditions to tailor the desired products. This can be a tremendous advantage in used oil processing due to the variability of the used oil feedstock. The process parameters can be adjusted to vary the boiling range of product; the process can also be manipulated to maintain a target product quality with feed variability.

Catalytic cracking technology is emerging as the technology of choice for progressive companies as they consider environment friendly technology based choices. Conversion of used oil to diesel and gasoline-like fuels is desirable from an environmental point of view since the product displaces the need to consume a virgin distillates produced from crude oil. This could be a significant benefit to the world environment in aiding to solve the used oil problem. Of all the methods of processing used oil to be consumed for its calorific value, the catalytic conversion to distillates technology is the highest form of processing method available, from an economical and environmental viewpoint.

Waste engine oil (two wheeler petrol engine) is used as a feedstock for cracking. Cobalt acetate is used as the catalyst for this process. The used oil is filtered to remove the solid particles and removed moisture by maintaining 150°C temperature for one hour. This filtered dehydrated waste oil (FDWO) is used as the feedstock for the experiment. Basic tests of this sample are done, e.g. Redwood viscosity, pour point, viscosity index and CCR. The results of these tests are shown in Table-1.

Table-1
Properties of Filtered and Dehydrated Waste Engine Oil

S. N.	Property	Observations
1.	Redwood Viscosity	a) at 40°C--- 424 seconds. b) at 100°C---61 seconds.
2.	Specific Gravity at 29°C	0.8885
3.	API Gravity at 29°C	27.7589°API
4.	Pour Point	-24°C
5.	Flash Point By Clevland Open Cup Method	193°C
6.	Fire Point By Clevland Open Cup Method	252°C
7.	Conradson carbon Residue (wt%)	0.9088%

1200ml (1090.5gms) of feed is cracked in the batch reactor at 420°C in presence of 1% cobalt acetate. At 400°C vapors started coming out of the reactor indicating the start of cracking reactions. The temperature of the reactor is immediately raised and maintained at 420°C as closely as possible. As the reaction reached to completion, vapors stopped coming out of the reactor, heating stopped and allowed the reactor to cool. 929.85gms of distillate is collected and 49.08gms of residue is collected from the reactor. Total material balance on reactor indicates that 111.57gms of feed is gasified.

Table-2
Material Balance of An Experimental Run

1	Feed (gms)	1090.50
2	Liquid product obtained, (gms)	929.85
3	% (wt) Liquid product obtained	85.27
4	Residue formed,(gms)	49.08
5	% (wt) Residue formed	04.50
6	Feed gasified, (gms)	111.57
7	% (wt) Feed gasified	10.23
8	Total amount of product formed (liquid+gases),gms	1041.42
9	% (wt) Total conversion	95.50
10	Time required from 400°C to completion of cracking, (mins)	40
11	Total time required for cracking, (mins)	108

Table-3
Properties of Cracked Liquid Product Obtained

S. N.	Property	Observations
1.	Redwood viscosity (Sec.) at 40°C	45
2.	Specific gravity (at 29°C)	0.8443
3.	API gravity (at 29°C), °API	36.0944
4.	Aniline point (°C)	83.0
5.	Flash & Fire Point by Clevland open cup method, (°C)	41/59
6.	Conradson carbon residue (wt %)	0.0535
7.	Pour point (°C)	-10
8.	Bromine number	05.67
9.	Acid value, mg KOH/gm	0.7489

Liquid products and residue formed in the experiment were measured for the material balance. And the liquid products were subjected to various tests such as ASTM distillation (IP123/93), Redwood viscosity (IP70/62 25th edition), Sp. Gravity, Aniline Point (IP2/91,ASTM D611-87, ISO 2977:1989(E)), Conradson Carbon Residue (CCR) (IP13/82,ASTM D189-88, BS:2000 Part 13:1993), Pour Point (IP15/67,ASTM D97-87, BS:2000:Part 15:1993), Flash and Fire Point by Clevland Open Cup Method (IP 36/84(1989), ASTM D92-90)), Total Acidity (IP 1/74 (1990), BS 2000: Part 1:1993)) Bromine Number (IP129/93, BS2000 :Part 129:1993) etc. (19,20)

ASTM distillation characteristics of the product obtained from this experiment shows that around 13% (vol.) material falls in the gasoline range (<200°C), 67% (vol.) material falls in the gas oil range (200-390°C) i.e. diesel-like range and around 17.5% (vol.) material boils in the range of 390°C-415°C. Details of the ASTM distillation characteristics of liquid products obtained are shown in Table-4.

Table-4
ASTM Distillation Characteristics of Product Obtained

S. N.	Time (mins.)	Temp.°C	% Vol. Distillate	Observations
1.	00	42	---	Heating started
2.	25	82	---	I.B.P.
3.	58	181	10	Foaming observed
4.	92	254	20	
5.	102	307	30	
6.	110	344	40	
7.	112	363	50	
8.	114	376	60	
9.	116	385	70	
10.	119	390	80	
11.	121	408	90	
12.	122	410	97.5	Final boiling point

Total distillate collected: -- 97.50%, Residue: -- 0. 5%, Losses: -- 2.00%.

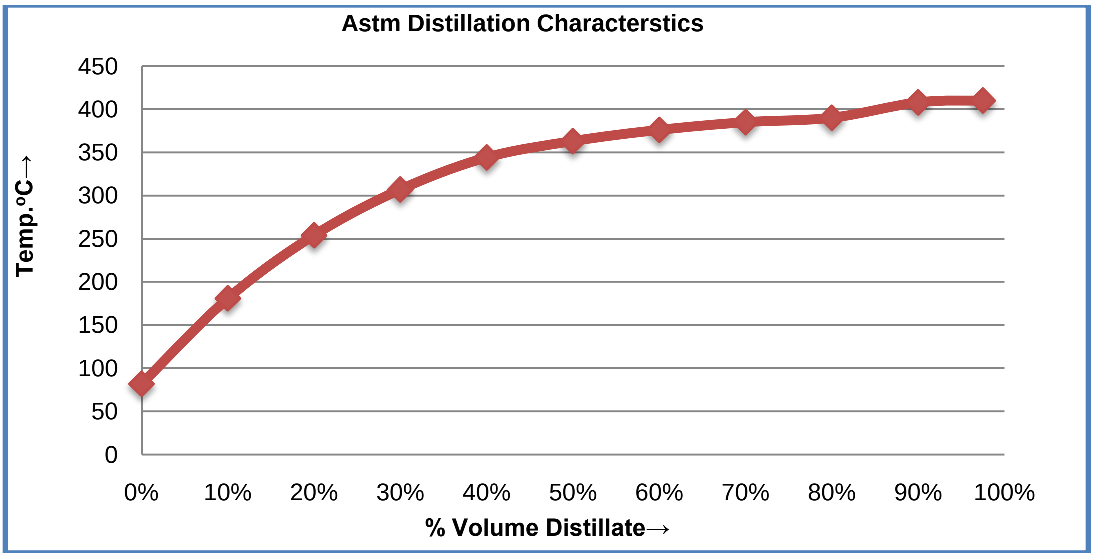

Figure-1: ASTM Distillation Characteristics of Product Obtained

Conclusion

The catalytic cracking of waste engine oil at 420°C in presence of 1% cobalt acetate yields 10.23% (wt) hydrocarbon gases, 85.27% (wt) liquid products and 4.5% (wt) residue. The viscosity, specific gravity/API gravity, flashpoint and fire point of products indicates the extent of cracking occurred. As all the contaminants accumulate in residue, the liquid and gaseous products obtained are free from all type of contaminants. So these products forms high value refinery streams 67% diesel-like product and 13% gasoline range product which can be further processed with respective refinery streams. It should be noted that the problems related to used oil treatments by vacuum distillation, such as fouling of heating and distillation equipment can be avoided by catalytic cracking of these oils, in presence of cobalt acetate.

This can be one of the ways to conserve the valuable oil and reducing the rate of depletion of crude oil. So used lubricating oil may again be a source of fuels. Recycling doesn't just slow the depletion of number one resource; it also saves energy and reduces the pollutions of land, water and air. Mismanagement of waste lube oil is a serious environmental as well as economical problem. Almost all types of waste oil have the potential to be recycled safely, saving a precious non-renewable source and at the same time minimizing environmental pollution. Besides its great adverse impact on the environment, if used oil is properly recycled and/or reused, it could have significant savings on fresh crude oil. Disposal of used lubricating oil into the eco-system creates environmental hazards. Tough laws are being enacted throughout the world for the disposal of waste petroleum products and every genuine effort should be made for its re-use.

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