Production of Diesel Fuel From Used Engine Oil

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***Abstract* — Due to scarcity of petroleum products, the used engine oils can be used in engine as engine oil after purifying it. Production of diesel fuel from used engine oil is involving chemical filtrations and blending process. It could solve some of the energy problem with increasing the blending percentage of pre-treated used engine oil (UEO) or by using pre-treated used engine oil as a diesel fuel. In the present study, samples of shipyard and light vehicles (bus and truck) pre-treated used engine oil and different percentage of blending of pre-treated used engine oil (including clay treatment, CT) into fresh diesel have been considered. Results show that pre-treated (including CT) used engine oil of shipyard (UEO) and 35% blending of pre-treated (including CT) used engine oil (UEO) into fresh diesel are suitable to use as a diesel fuel considering Caterpillar Specific Limit and comparing with the fresh diesel.**

***Index Term*– Engine Oil, Caterpillar Specific Limit, filtrations**

I. INTRODUCTION

*D*iesel is one of the petroleum products, which is used in all kinds of compression ignition engine as a fuel. It is produced from crude oil by various refining processes, which come out from the oil wells. It assumes that the source of crude oil would be ruined in future, as the demand of petroleum products is growing at faster rate day by day. Natural gas is the largest energy resource in Bangladesh. But the country contains one present of the world's total natural gas [1]. Again, there are no sufficient resources of crude oil. So, Bangladesh completely depends on the crude mineral oils of Middle -East countries and spends 15% of its foreign exchange for importing crude oils and refined petroleum products [2].

Due to the high cost of crude oil, the country is facing a big amount of import bill for crude oil in every year and the economic structure becomes in scattered condition to carry on this expenditure. This puts extra burden on its home economy. So, all possible measures or attempts should be adopted to increase or to find out the alternative way for fuel production so that the people of this country, even of the whole world can survive the situation. For smooth functioning of an engine, lubricating oils or engine oils are used for lubrication. After a certain period of time these used engine oils are taken out. During lubrication about 20% of the lubricating oil are consumed and the rest 80% are remain as such with some impurities. Thus a huge quantity of used engine oil is left and wastage from different transport sectors everyday .Due to scarcity of petroleum products, these used engine oils can be used in engine as engine oil after purifying it. Production of diesel fuel from used engine oil is involving chemical, filtration and blending process. Very few numbers of studies have been carried out using used engine oil [3, 4]. They used up to 10% used engine oil into the heating oils and blended up to 5% used engine oil into the diesel fuel. From the test result of their blended fuel sample, they claimed that the blended fuel sample is cleaner and contains less harmful products than the clean low sulphur diesel. They also found that the blended fuel had good lubricity property and the acid number was below detectable limits. Thus, there is a great scope to utilize these waste used engine oil in better way which would help to decrease environmental liability, save waste oil disposal fees and reduce burden of fuel import.

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II. PRODUCTION PROCESS

The production process is broadly divided into two steps.

i) Pre-treatment of used engine oil
ii) Blending and filtrations

Pre-treatment of used engine oil basically depends upon the sequence of operation of acid treatment, neutralization treatment and clay treatment. Other types of chemical treatment, acid treatment is the most important one because total success of reclamation of used engine oil (UEO) depends upon it. The whole processes are presented in the flow sheet (Fig. 1).

(i) Used engine oil
(ii) Fresh diesel.
(iii) Concentrated sulfuric acid (98% H_2 S04).
(iv) Caustic soda.
(v) Activated clay (activated bleaching earth)

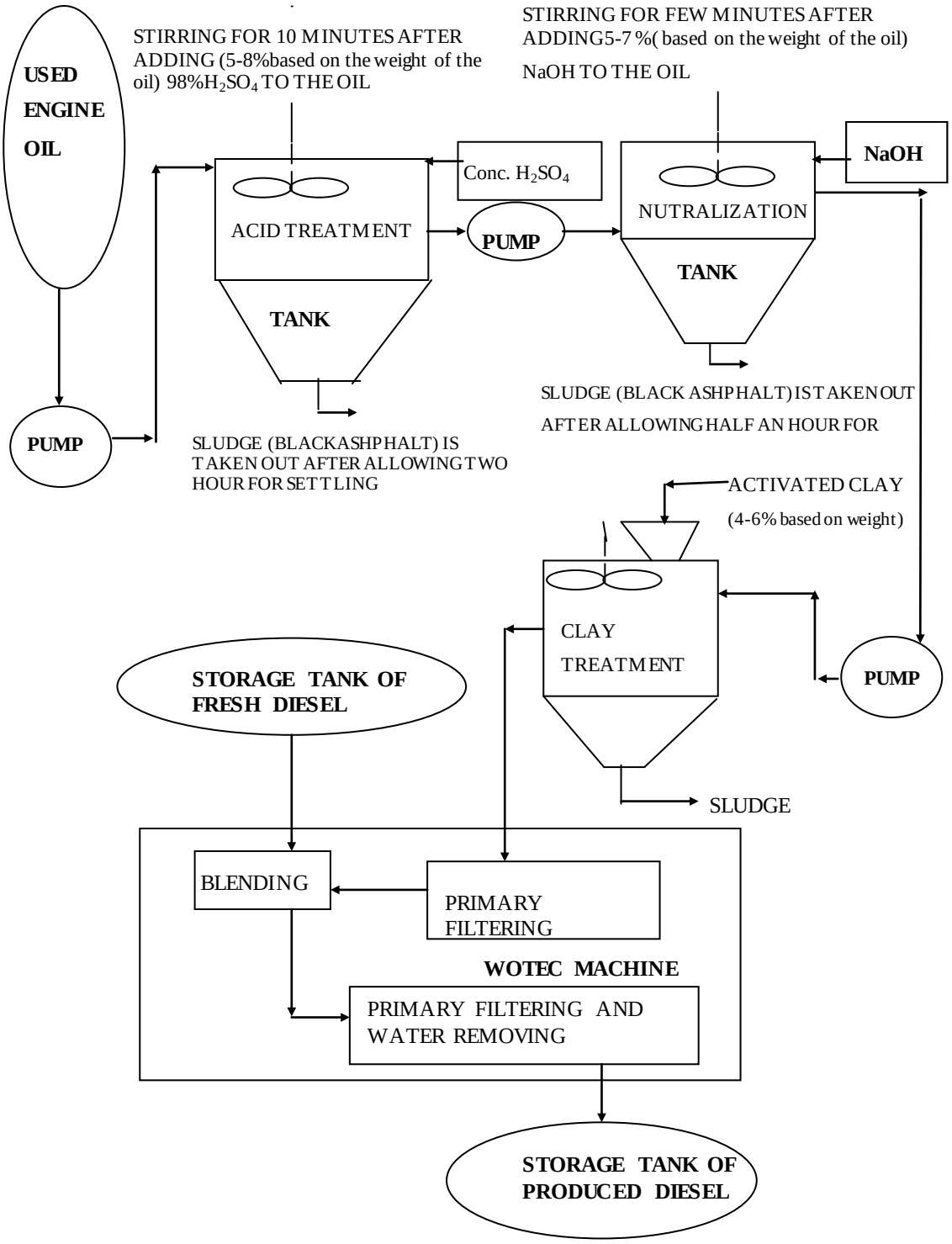

Fig. 1. Flow Sheet of Diesel Fuel production from Used Engine Oil

III. TEST PROCEDURE

In the present study, tests were conducted with the samples of shipyards and light vehicle's (bus, truck) pre-treated used engine oil (UEO) and 25%, 35%, 45%and 55%blending of pre-treated UEO (including clay treatment, CT) into fresh diesel [5]. Blending in various proportions and filtration were prepared with the help of WOTEC (waste oil to energy converter) machine.

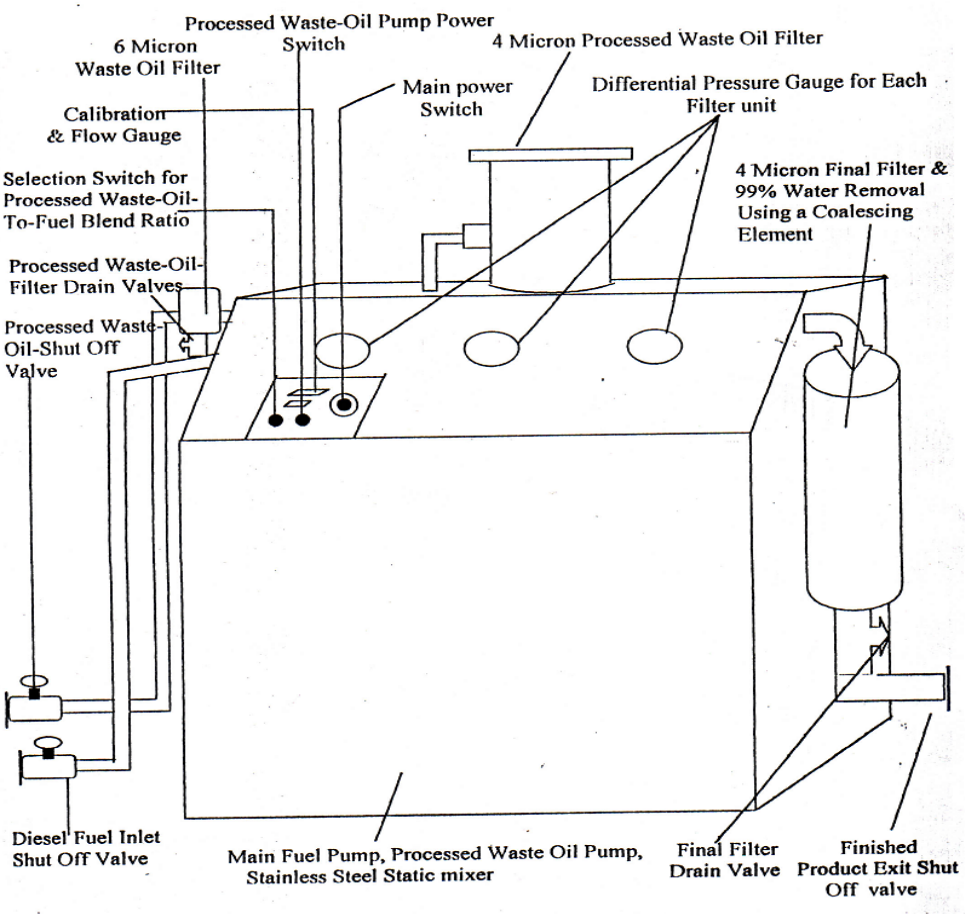

Fig. 2. WOTEC (Waste-Oil-To-Energy Converter) Machine

IV. FUEL PROPERTIES DETERMINATION

A. Caloric Value:

It is determined by Oxygen Bomb Calorimeter [6].

Higher calorific value, HCV = $\frac{t_w - e}{m}$

Where,

t= Temperature difference between final temp. and initial temp.

w = energy equivalent of the calorimeter

=2426 cal/°C

e = correction in calories for heat of combustion of fuse wire

= 2.3×c when using nickel-chromium fuse wire

c= fuse wire consumed in firing, cm=$LW_{bf} - LW_{af}$

LW_{bf} = length of wire before firing= 10 cm

LW_{af} = length of wire after firing, cm

m = weight of sample in gm

B. API Gravity:

Specific gravity (S.G) at °C

$= \frac{Density\ of\ substance}{Density\ of\ water\ of\ same\ volume}$

Procedure:

Graduated beaker is washed with warm distilled water and then wiped with a clean cloth. By weight balance the weight of empty beaker & the beaker filled with 100cc is measured.

C. Aniline Point:

Specified volumes of aniline and sample are pleased in a tube and mixed mechanically. The mixture is heated at a control rate until the two phases become miscible. The mixture is then cooled at a controlled rate and the temperature at which the two phases separate is recorded as the aniline point or mixed aniline point.

D. Diesel Index:

Diesel Index [7] is determined by calculation from the API gravity and the aniline point of the sample using the following equation:

Diesel Index= GA/100

Where G is the API gravity;

A is the aniline point in °F

E. Viscosity

The viscosity is determined by the Oswald viscometer.
Co-efficient of viscosity or dynamic viscosity,
μ= Aρt
Kinematic viscosity, $\nu = \frac{\mu}{\rho}$ = At

Where
t = falling time of a liquid for a particular distance through the tube of Oswald viscometer.
ρ= density of liquid
A=calibration constant of Oswald viscometer, which is numerically equal for every liquid flowing past a particular distance through the tube of Oswald viscometer.

Hence
ν_w = A×t_w; 'w' refers the water.
»A =ν_w / t_w; The value of A can be easily determined by putting the chart value of ν_w corresponding to room temperature and measured value of t_w in this equation.
And
ν_f= A×t_f; 'f' refers to diesel fuel.
Using the last above equation the kinematic viscosity of different diesel fuel sample can be determined.

F. Flash Point and Fire Point:

This method covers the determination of flash point & fire point by Pensky-Martens Closed Cup tester of fuel oils, lube oils, suspensions of solids, liquids that tend to form a surface film under test conditions and other liquids.
The sample is heated at a slow, constant rate with continual stirring. A small flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is the lowest temperature at which application of the test flame causes the vapor above the sample to ignite.

Fire point is the temperature at which the flash will sustain itself as a steady flame for at least five seconds.

G. Cloud Point:

After preliminary heating, the sample is cooled at a specified rate and examined at intervals of 2 °F (1 °C) for flow characteristics. The lowest temperature at which a cloud or haze of wax crystal appears at the bottom of the test jar when the oil is cooled under prescribed condition.

H. Pour Point:

After preliminary heating, the sample is cooled at a specified rate and examined at intervals of 5 °F (3 °C) for flow characteristics. The lowest temperature at which the movement of the oil is observed is recorded as the pour point.

I. Lead (Pb) Concentration:

Lead concentration is determined with the Ultraviolet-Photo-Spectra-Meter while experiment is conducted at Bangladesh Council for Scientific & Industrial Research (BCSIR), Dhaka, Bangladesh.

V. RESULTS AND DISCUSSIONS

To determine optimum percentage of blending, blended diesel (fresh diesel and pre-treated used engine oil) and also clay treated used engine oil could be used directly (without blending with fresh diesel) as a diesel fuel, then some important properties of the produced diesel of different percentage of blending and pre-treated used engine oil (including clay treatment) were evaluated. The values as obtained were compared with the fresh diesel and Caterpillar Specific Limit is presented in table I.

From table I, it is clear that pre-treated (including clay treatment, CT) used engine oil (UEO) of shipyards could be used directly as a diesel fuel according to the Caterpillar Specific Limit. Moreover, under consideration of Caterpillar Specific limit maximum blending percentage of pre -treated (including, CT) used engine oil of both shipyard and light vehicles are 35%.

From table I, it is evident that diesels produced from light vehicle's used engine oil are too viscous and that's why it has lower cloud point and pour point and comparatively high flash point and fire point. From table I it is also observed that all samples except 55%blending of pre-treated (including clay treatment) used engine oil (UEO) of shipyard with fresh diesel contain less than 1 ppm lead. Pre-treated (including, CT) used engine oil of shipyard and 35% blending of pre- treated (including, CT) used engines oil of both shipyard and light vehicles (bus, truck) contain 0.2053

TABLE I
SUMMARY OF EXPERIMENTAL RESULTS & COMPARISONS WITH THAT OF FRESH DIESEL AND CATERPILLAR SPECIFIC LIMIT.

	Caterpillar Specific limit	Fresh diesel	SHIPYARD					BUS AND TRUCK				
			CT	25% (CT)	35% (CT)	45% (CT)	55% (CT)	CT	25% (CT)	35% (CT)	45% (CT)	55% (CT)
HCV KJ/KG	----------	42592.2	42930.79	45632.44	45979.37	45290.32	45293.89	47001.88	44962.96	45638.22	46647.56	48010.90
API gravity	Min 30 Max 45	34.05	30.06	32.78	31.65	25.60	21.04	23.00	25.46	25.97	20.99	19.88
Aniline Point (°C)	----------	51.6	61.0	54.0	55.5	56.0	56.8	104.0	66.0	68.8	73.4	75
Diesel index	Min 40	43	43	43	42	34	29	51	39	39	35	34
Viscosity (cst)	Min 1. 4 Max 20	1.98	5.05	2.42	3.33	3.39	3.46	14.03	5.45	5.99	6.97	8.04
Flash point (°C)	Min legal	60	73	63	65	68	70	71	59	62	64	67
Fire point (°C)	Min legal	68	77	71	73	75	76	78	68	71	74	78
Cloud point (C)	Not above ambient	-15	-8	-14	-13.2	-12	-11.5	-8	-12.6	-11.5	-10	-8
Pour point (°C)	Min 9°C below ambient	<-18	-16	<-18	<-18	<-18	<-18	-1	-16.8	-15.6	-14	-13
Pb (ppm)	No specific limit	0.1723	0.2053	0.7386	0.2682	0.1753	1.0061	0.6617	0.4434	0.1599	0.1094	0.0107

ppm, 0.2682 ppm and 0.1599 ppm respectively. So, obviously, these would be less harmful to the environment.

VI. FUTURE RECOMENDATION

Since produced diesel oil is technically suitable, economically viable, less responsible to pollute environment and have more marketing aspect, so the research subject on this topic should be given higher priority.

The following points are recommended for the future work:

1. Reduce viscosity of produce diesel oil.

2. Further research work may be carried to produce diesel from used engine oil of Railway.

3. The remaining properties such as distillation, aromatic content, water and sediment content & concentration of sulphur should have to be determined and have to be observed their effect on engine performance.

VII. CONCLUSION

From the experimental study, it is evident that pre-treated (including clay treatment, CT) used engine oil (UEO) and 35%blending of pre- pretreated (including, CT) used engine oil of shipyard (UEO) into fresh diesel are suitable to use as a diesel fuel considering Caterpillar Specific Limit and comparing with the fresh diesel. Though the samples have a little bit higher value of viscosity (kinematics), flash point fire point but these value are in tolerable range. Produced diesel is technically suitable, economically viable and less responsible to pollute environment

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