TO INVESTIGATE THE POSIBILITIES OF USING CRUDE PALM OIL FOR MARINE DIESEL ENGINES OF INLAND WATERWAY FLEET IN VIETNAM

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ABSTRACT

At present time, the climate change has been effecting on the over world. There are many reasons to make the climate changed including the emissions from the diesel engines equipped on board the ships. The International Maritime Organization through the Annex VI of the MARPOL 73/78 Convention strongly requests the all Governmental Parties to take a part in the reduce the emissions from their fleet to the atmosphere. However, how to reduce the emissions from the ships is always a rather difficult question for the whole government.

To reduce the emission from the ships, there are some countermeasures to be used such as: exhaust gas treatment, modification of diesel engines and using alternative fuel as a biodiesel. Using of biodiesel as fuel for diesel engines is very well-known, however the biodiesel is rather expensive if it is used for marine diesel engines as the cost to transesterify the triglyceride to three fatty methyl esters (bio-diesel fuel) is very high. Therefore, responding to the emission reduction plan of the Vietnamese Government, the Vietnam Maritime Universty is carry out a research on using the crude palm oil for the marine diesel engines equipped on board of inland waterway ships. The crude palm oil means the pure palm oil which is not transesterified (It is not 3 fatty acid methyl esters). The research come to make sure:

- Whether we can use the crude palm oil for marine diesel engines?
- How many percent of the crude palm oil should we mix with the DO then the mixed fuel do not make harm to the technical and economical features of the marine diesel engines;
- How much we can reduce the exhaust gas emissions from the ships when we use the mixture fuel for the marine diesel engines in Vietnam.

The research started since 2010 at Vietnam Maritime University facilities and a sizable number of experiment has been done. As the output of research, positive result at the considerable reduction of engines exhaust gas emissions has been obtained. The paper is discussing on the methodology and possibility of using crude palm oil for diesel engine of in-land water fleet in Vienam and the obtained result as well.

Keywords: *Climate change; Emissions; MARPOL 73/78 Convention; Biodiesel; Vietnam Maritime University; Crude palm oil; In-land water fleet; Marine diesel engine.*

1. INTRODUCTION

The diesel engine is an attractive power unit widely used in many field such as onshore transportation, maritime transportation, agricultural machinery and so on. The diesel engine has great advantages over petrol engine as lower fuel consumption, lower carbon monoxide emissions, better generated torque characteristics and higher reliabilities.

In Vietnam there are more than one hundred thousand transportation means equipped with diesel engines as main power units [1]. Yearly, these diesel engines use a million tons of diesel oil and also discharge to the environment a lot of toxic emissions that cause pollution to the atmosphere and make the sea level higher [4].

How to control these emissions is one of the most important tasks that people on over the world have to face off, including Vietnam. There are many ways to overcome this problem, but in this article we will introduce our research on using crude palm oil and blends as alternative fuel for marine diesel engines.

2. BIODIESEL AS ALTERNATIVE FUEL FOR DIESEL ENGINES

The very first diesel engine which was invented by famous engineer Rudolph Diesel, ran on peanut oil in 1905, but thereafter, the increased cheap supply of crude oil totally replaced the use of the fuel produced from vegetables. However, at present time due to the higher price of the crude oil and high pressure of pollution to the environment, many countries have found the solution based on using the fuel that produced from the agricultural products and from the animals fast.

In the past time, the fuel that made from vegetable was taken a name based on the name of the agricultural product such as peanut oil, sunflower oil etc. Nowadays, the vegetable oil used as a fuel for diesel engines is commonly named as biodiesel. Basically, biodiesel may be made from the pure vegetable oil (soybean, palm, sunflower..) and rendered animals fats or waste cooking oil. To obtain biodiesel, the oil must be passed through a chemical process so called “transesterification”. After the process, glycerin is removed as a byproduct, and the final Methyl Ester can be blended with fossil diesel oil or used directly as alternative fuel for the diesel engines.

The effects of replacing fossil-based fuel with biodiesel much depends on the inherent properties of the fuel and diesel engine operating principles. A comparison of the properties between fossil-based diesel oil and biodiesel is as shown in Table 1.

Table 1. The diesel oil and biodiesel properties

No	Fuel properties	Fossil-based diesel oil	Biodiesel
1	Density,15^{o}C (g/cm^{3})	0,86-0,90	0,82-0,845
2	Viscosity at 40^{o}C(mm^{2}/s)	3,5-5,0	2,0-4,8
3	Lower heating value (MJ/kg)	45,218	36,782
4	Flash point, ^{o}C	60-80	100-170
5	Sulfur content, S (%)	0,05 max	0-0,00024
6	Carbon content, C (%)	87	77
7	Hydro content, H_2 (%)	13	12
8	Oxy content, O_2 (%)	0	11
9	Water content, (%)	0,05 max	0,05 max
10	Boiling point, ^{o}C	180-340	315-350
11	Cetane number	40-55	48-65
12	Lubrication ability, SLBOCLE (g)	2000-5000	>7000

Recently, biodiesel is being used widely in Europe, United States and Brazil for diesel engines equipped in the shore transportation units, but it is still not so popularly used for the marine diesel engines, because the price of biodiesel is rather high for marine application.

In Vietnam, the inland waterway fleet and fishing fleet consists of more than one hundred thousand vessels and boats. Yearly fuel consumption of the fleet counts for 3 to 4 million tons diesel oil (DO) and also they discharge toxic emissions to the atmosphere as much as 28 million tons. The graph of Fig.1 shows that the fuel consumption of Vietnam is increasing dramatically by years.

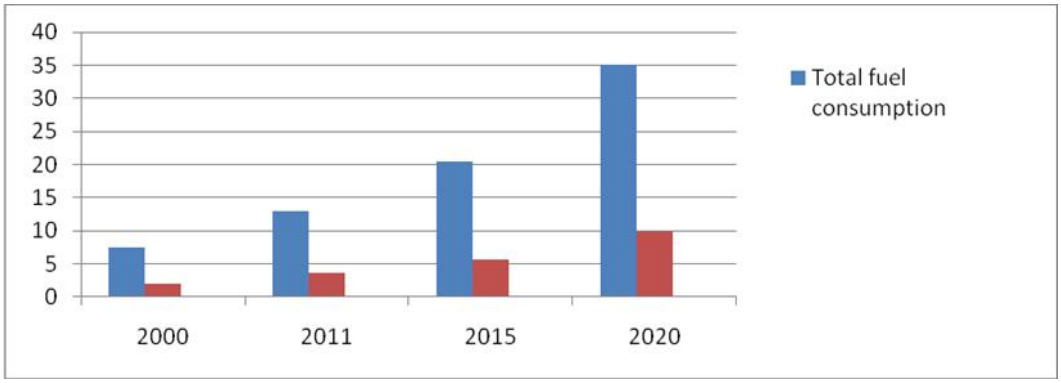


Figure 1 Fossil - based fuel consumption

In order to respond the demands of fuel consumption for the country economy development in general and for transportation particularly, Vietnamese Government issued Decision No 177/2007/QD-TTg to ratify the plan to produce and use biofuel in Vietnam to year 2015 and in sight by 2020. Based on the governmental plan and actual economical situation in Vietnam, the demand of bio-diesel is for-seen as shown in Table 2.

Table 2. Demands of bio-diesel for marine use in Vietnam

Blended fuel	Biodiesel requested [Ton/ year]		
	2012	2015	2020
B5	183.500	244.235	393.300
B10	367.000	488.470	786.600
B20	734.000	976.940	1.573.200

3. INVESTIGATION OF USING THE CRUDE PALM OIL FOR MARINE DIESEL ENGINE

3.1 Crude palm oil selected as biodiesel

At present moment, to use biodiesel and blended fuel (biodiesel-diesel oil) for the marine diesel engines is not visible due to the price of biodiesel. Therefore, the research team of Vietnam Maritime University decided to carry out a research on using the crude palm oil and its blended fuel (crude palm oil-diesel oil) for marine diesel engines.

The crude palm oil is defined as a fuel oil that made from the palm fruit without taking the transesterification process. Therefore, the price of crude palm oil counts for only 65-70% price of biodiesel produced from the same palm oil fruit [2]. The specification of the crude palm oil and blended fuel is shown in Table 3 [2].

Table 3. Technical specification of biodiesel and blended fuel

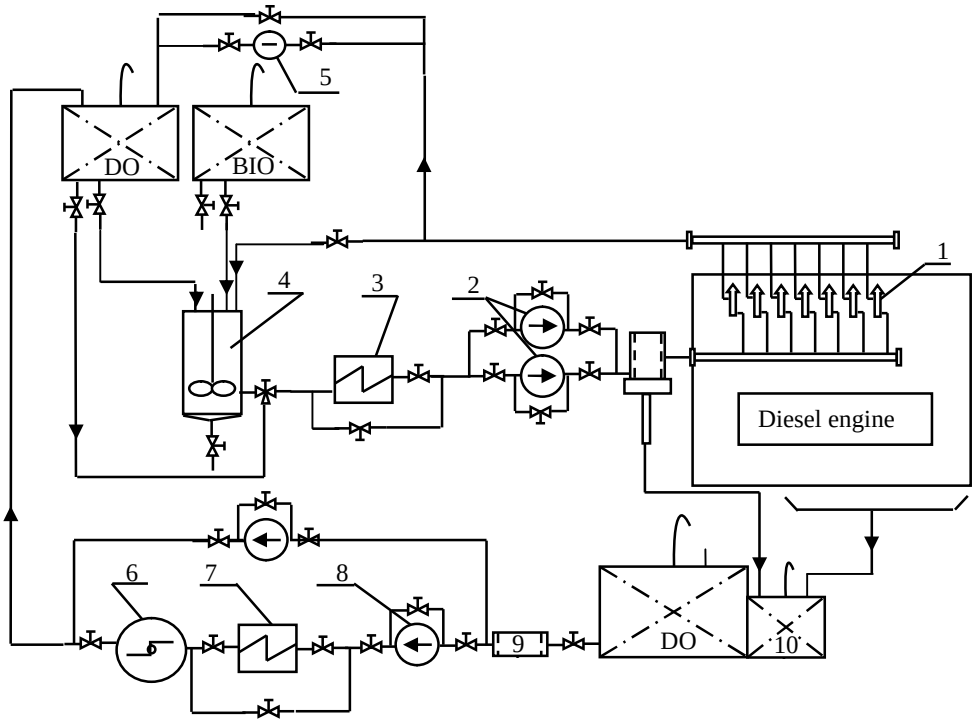
No	Technical specification	BIODIESEL (PALM OIL) AND BLENDED FUEL							DO
		B100	B5	B10	B15	B20	B25	B30	
1	Density,15^{o}C, [kg/m^{3}]	0,9225	0,8489	0,8538	0,8568	0,8599	0,8632	0,8668	0,8464
2	Viscosity,40^{o}C, [mm2/s]	85,80	7,0	7,42	8,20	9,31	9,87	10,45	6,38
3	Cetane number	42,89	52,11	51,25	50,91	50,66	50,13	49,63	52,92
4	Flash point, ^{o}C	224	72	73	74	75	76	77	72
5	Điểm đông đặc, ^{o}C	16	-3	-1	0	1	2	2	-6
6	Ash content, [%]	0,0061	0,0057	0,0057	0,0057	0,0058	0,0058	0,0058	0,0054
7	Copper corrosion, 50^{o}C in 3h	1A	1A	1A	1A	1A	1A	1A	1A
8	Water content[mg/kg]	315	182	189	195	201	208	215	170
9	Acid number [mgKOH/g]	0,4	0,36	0,37	0,37	0,38	0,38	0,4	0,35
10	Lower Heating Value [kcal/kg]	10.325	10.700	10.625	10.600	10.580	10.475	10.350	10.750

The technical specifications of the crude palm oil and blended fuel have been evaluated according to the protocols outlined in the Biodiesel Standard ASTM (American Society for Testing and Materials).

Based on the properties of crude palm oil and the blended fuel as shown on the Table 3 there can conclude that in general, the properties of crude palm oil and the blended fuel are similar to the properties of fossil-based diesel oil. The largest differences can be found in the density and viscosity of the crude palm oil and DO. While the blended fuels (from B5 to B30) have very similar physical and chemical features to those of diesel oil.

3.2 Modification of fuel supplying system

The purposes of our experiments are to evaluate the combustion characteristics, heat released efficiency, effective power generated of marine diesel engines when blended fuels would be used as fuel for marine diesel engines [3], [5]. Before implementing experiments, we have to modify the fuel supplying system of a tested diesel engine. In general, we keep the construction of a fuel supplying system almost same as original one, we only design and build in a new fuel mixer for this system as shown in Fig. 2.



1 - High pressure pump; 2 - Fuel supplying pump; 3 - Fuel heater; 4 - Fuel mixer;
5 - Flow-meter; 6 - Purifier; 7 - Heater; 8 - Transferring pump; 9 - Filter; 10 - Sludge tank

Figure 2 Modification of fuel supplying system

The fuel mixer /4/ of this system has important functions as following:

- Preparing blended fuels for marine diesel engines by mixing the crude palm oil with diesel oil in requested ratio (B5, B10, B15..);
- Heating the blended fuels to make a suitable viscosity of the fuel for a diesel engine use;
- Supplying fuel with adequate pressure to a diesel engine.

The detail construction and real picture of fuel mixer which has been designed and made by our research team, is presented in Fig. 3 and Fig.4.

The fuel mixer is suitable design for different kind of marine diesel engines with ability to work by a batch or work “on line” with diesel engines.

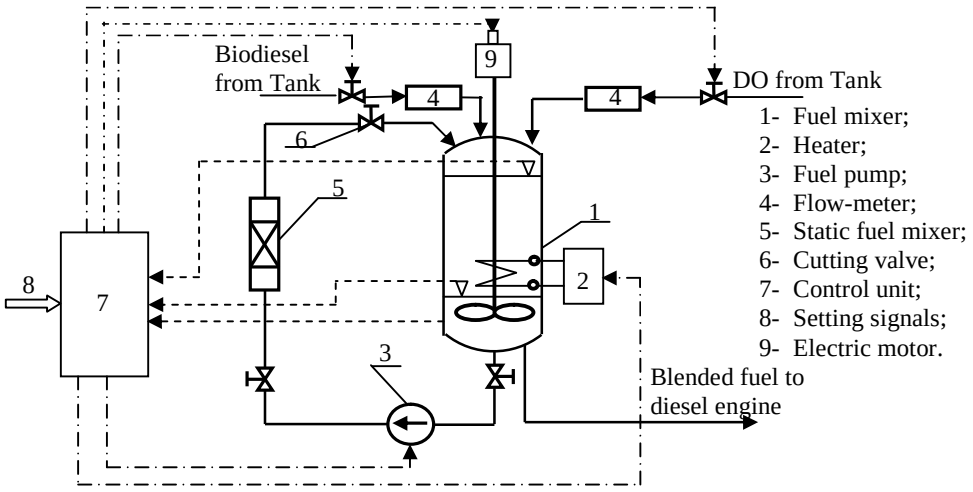


Figure 3 Fuel mixer system

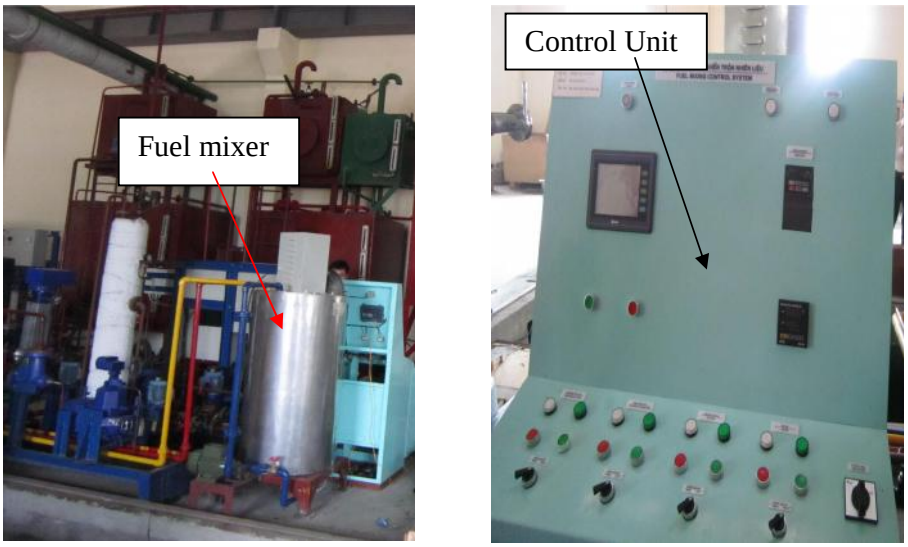


Figure 4 Real picture of fuel mixer

4. RESULTS OF EXPERIMENTS ON MARINE DIESEL ENGINES

4.1 The selected diesel engines for test

As an objective of our research, we selected two diesel engines that can be used as main engines for inland water way vessels. One is a Russian product, type K657 M2 64Ч18/14 and the other is 6LU32 made by Japanese famous company HANSHIN. The both engines are equipped at Diesel Engines Operation Lab of Vietnam Maritime University. The technical specifications of two marine diesel engines are presented in Table 4 [6].

Table 4. Technical specification of marine diesel engines for research

No	TECHNICAL SPECIFICATIONS	TYPE OF ENGINES	
		K657 M2 64Ч18/14	6LU32
1	Engine type, (stroke)	4	4
2	No. of cylinder	6	6
3	Cylinder bore, (mm)	120	320
4	Length of stroke, (mm)	140	510
5	Nominal speed, (rpm)	1500	340
6	Max. continuous output, (kW)	50	970
7	Effective fuel consumption, (g/kW.h)	264	200
8	Length of crank, (mm)	70	225
9	Connecting rod, (mm)	252	918

4.2 Results of research

The tests of using the crude palm oil blends have been carried out on the marine diesel engine 6UL32. There used 5 kinds of fuels such as: DO, B5, B10, B15 and B20. The diesel engine was running with 5 kinds of fuel at different loads and adquate speeds. At each load, a fuel consumption of the engine has been taken in five minutes. The all experimental results are given in Table 5.

Table 5. Fuel consumption in different loads of the diesel engine

NO	SPEED [RPM]	OUTPUT [KW]	FUEL CONSUMPTION [KG/5MIN]				
			DO	B5	B10	B15	B20
1	187	200	4.68	4.79	4.89	4.98	5.12
2	238	400	8,16	8.22	8.30	8.40	8.67
3	272	600	10.60	10.95	11.10	11.30	11.69
4	312312	900	16.50	16.90	17.05	17.12	17.30

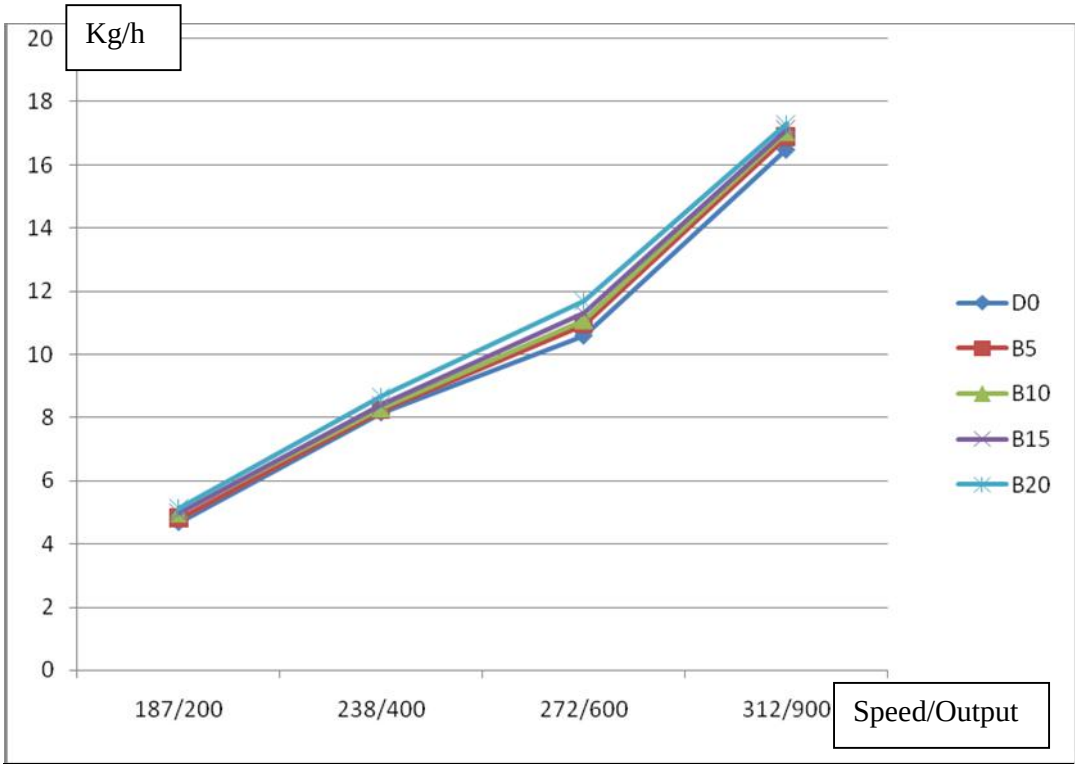


Figure 5 Fuel consumption at different loads

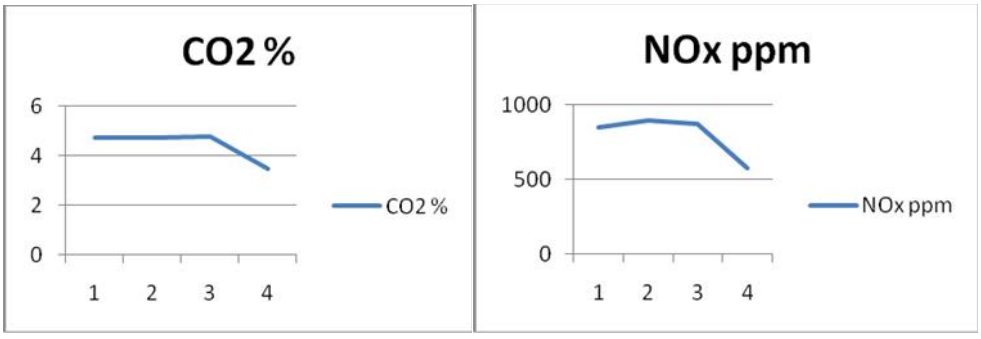


Figure 6 Emission figure when palm oil bends used

5. CONCLUSION

Based on the results which have been taken from the experiments on using crude palm oil blends for the diesel engine 6UL32, there can conclude that:

- The combustion process of blends of palm oil in the cylinders of the tested marine diesel engine has happened similarly to what of diesel oil (DO)*;*
- Fuel consumption of the diesel engine is increasing in accordance with increasing percentage of palm oil in the blends. This phenomenon can be explained by the lower heating value of the crude palm oil in comparison with DO. If the diesel engine is running by blends B5 and B10, the performance of the engine is very similar with that when it is running by DO (see Fig. 5);
- The emissions of exhaust gas from the diesel engine is also much improved when the engine is running by the blends. The contents of CO2 and NOx in exhaust gas of the engine are much lower when the engine is running by blend B20 (see Fig. 6);
- Finally, there can affirm that the blends of the crude palm oil (B5, B10, B15..) can be used as alternative fuel for marine diesel engines.

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