Potential Application of Biofuel Fuel On the Marine Diesel Engines in Vietnam

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Abstract—Energy in the transportation sector has become a hot issue all over the world because it can affect the energy security of nations. Finding a new type of energy to replace fossil energy is a top concern of many countries, including biofuels. Over the past two decades, there have been many studies on the use of biodiesel and its mix for diesel engines, the results are very positive. In Vietnam, there have also been studies on the use of biodiesel and its mixes on road transport vehicles. However, in the field of waterway transport, there has not been any specific research. Through a comprehensive synthesis of the application situation and research directions in the world, as well as the ability to produce biodiesel in Vietnam, the article wishes to create a premise to develop more research to find develop new technology solutions to apply clean fuels, especially biofuels on the domestic fleet, in line with the development trend of the world on the use of biodiesel fuel.

Index Terms—Energy, Biofuel, Biodiesel, Marine Diesel, Vietnam Transportation Sector.

I. INTRODUCTION

Energy always plays an essential role for socio-economic development and improving the quality of life. Energy issues in the world today and in the future are being concerned and placed on top of all countries [1]. Ensuring more clean energy sources replacing fossil energy is becoming increasingly urgent, especially when oil is running out and becoming expensive [2][3]. The increase in population, economic growth, increasing the energy for life is increasing, leading to increasing demand for energy, leading to a deteriorating natural environment [4][5]. Global climate phenomenon is heating up as one of the biggest challenges of all mankind in this century. Around the world, nearly 2 billion poor people in developing countries do not have access to modern energy [6]. All these can only be achieved when using renewable energy. Economic and environmental experts all share the same comment: The form of policy making and socio-economic development mainly relies on fossil fuels such as oil, gas, ... is a model. unsustainable development of energy security and ecological environment in the future [7][5]. Many countries and energy groups in the world have recently adopted policies and strategies to combine the economical and efficient use of existing energy forms, and invest in research on the use of clean fuel forms a part of mineral fuels, including biofuels [8].

Biofuel is understood as renewable fuel (Renewable Fuel) produced from biomass - biomass, including compounds of

animal or plant origin such as animal fat, coconut oil, palm oil, cereals (wheat, corn, soybeans), agricultural wastes (straw, corn stalks, beans, etc.), industrial wastes (sawdust, waste wood, etc.) [9]. Depending on the mode of production and use, biofuels can be divided into four main groups: biodiesel; original vegetable oil; biomass fuel and ethanol[10].

Compared to traditional fuels, the advantage of using biofuels is that it does not increase the greenhouse effect, reduce environmental pollution. Currently, the world emits about 25 billion tons / year of toxic gas and greenhouse gas. Concentration of CO₂ [11], the main greenhouse gas, increased by over 30% compared to the pre-industrial period (from 280 ppm to 360 ppm), the earth temperature increased 0.2 - 0.4°C [12]. If there is no positive solution, greenhouse gas concentrations can increase to 400 ppm by 2050 and 500 ppm by the end of the 21st century, the temperature of the earth is 2 - 4°C hotter, causing unintended environmental consequences living [13]. Studies show that because biofuels contain an extremely small amount of sulfur and contain 11% oxygen, the combustion process is cleaner, 70% less CO₂ and 30% toxic gas than mineral oil [14].

With the increasing supply of fossil fuels, rising oil prices, energy safety becomes urgent for all countries in the world. Research and use of biofuels in the world also have great development[15]. Norway, which is an oil exporter, also has 50% of its energy supplied from biofuels. The United States also set a plan to reduce the economy's dependence on oil[16]. Therefore, the research and application of biofuels in Vietnam is also an issue that needs attention, however, how to develop must be due to domestic technological capabilities [17].

Vietnam is an agricultural country with favorable conditions to produce biofuels [18]. The Government and ministries and branches have tried to promote the potential of developing some crops to provide raw materials for bio-fuels production such as maize, cassava, sugarcane (alcohol production); oil plants such as groundnut, soybean, sesame, sunflower, coconut, cotton (diesel production), ... [19] Due to the specificity of plant species and actual conditions, in the future, 3 species of Vietnamese plants Men such as cassava, sugarcane and *Jatropha* need to be specifically researched with appropriate and long-term strategic solutions to meet the biofuel development objective under Decision No. 177/2007 / QĐ- The Prime Minister on November 20, 2007, approved the biofuel development project to 2015, with a vision to 2025.

II. APPLICATION OF BIOFUELS IN THE FIELD OF TRANSPORTATION

Vietnam, like other developing countries, is now facing many challenges including the gradual depletion of domestic fossil fuels, a greater reliance on world energy prices.

Transportation is one of the areas with a large proportion of energy consumption, after industry and civil, so the development of clean fuels in general and biofuels in particular in transportation is a problem. extremely urgent[20]. On a small scale, biofuels can be a source of energy for lighting, cooking and transportation[15].

Biomass E5, E10 (ethanol-blended gasoline) has been proven to be widely used in vehicles, reducing fuel consumption and significantly reducing emissions. The use of biofuels is also one of the solutions to sustainable transport development. So far, all countries in the Greater Mekong Subregion (GMS) have built and are implementing a plan to develop biofuels in their country, in which Thailand and Cambodia are currently There is a rapid growth in this type of fuel[21].

In the field of transportation, biofuels are applied including: Clean vegetable oil, ethanol, biodiesel, dimethyl ester (DME), ethyl tertiary butyl ester (ETBE) and products from them, in It is mainly ethanol and biodiesel. Currently there are about 50 countries in all continents exploiting and using biofuels at different levels. In 2006, the world produced about 50 billion liters of ethanol (75% used as fuel) compared to 38 billion liters in 2003, expected to be around 80 billion liters in 2012; in 2005 produced 4 million tons of biodiesel (B100), in 2010 increased to over 20 million tons[22]. The first country to use ethanol as an industrial scale fuel since 1970 is Brazil. All types of gasoline in this country are blended with about 25% ethanol (E25), saving over \$ 2 billion a year due to not having to import oil. Currently, there are 3 million cars fully using ethanol and over 17 million cars using E25. The United States is the world's largest ethanol producer, reaching nearly 19 billion liters in 2006, of which 15 billion liters are used for fuel - about 3% of the gasoline market. In 2012, the US will supply over 28 billion liters of ethanol and biodiesel, accounting for 3.5% of the gasoline used[23]. China uses 2.4 - 2.5 million barrels of oil a day, of which 50% must be imported. To cope with the energy shortage, on the one hand, China invests heavily outside the territory to exploit oil, on the other hand concentrates on exploiting and using renewable energy, investing in many scientific research facilities. Save on biofuels. In early 2003, gasoline E10 (10% ethanol and 90% gasoline) was officially used in 5 major cities and expanded to 9 other densely populated provinces of China. In 2005, ethanol fuel produced and put into use was 1.2 billion liters. At the end of 2005, the 600,000 tons / year fuel ethanol factory (the world's largest) was put into operation in Jilin. It is expected that ethanol fuel will increase by over 2 billion liters by 2010, about 10 billion liters by 2020[24]. And many other countries have strategies for developing biofuels for the transportation industry.

Fig. 1. Biofuels for transport[25]

III. BIODIESEL AND RESEARCH ORIENTATION OF USING BIODIESEL

A. Properties of biodiesel

Biodiesel is extracted from vegetable oil or animal fat which is equivalent to diesel. Chemically, biodiesel is composed of 14 different fatty acids and is converted into esters of fatty acids - FAME (Fatty Acid Methyl Este). The most common source of raw materials for biodiesel production is listed in Table 1[18].

TABLE I: RAW MATERIALS USED FOR BIODIESEL PRODUCTION

Vegetable oil		Animal oil	Other sources
Soybean oil;	Sunflower oil;	Pig fat;	Reusable cooking oil at restaurants
Rapeseed oil; Canola oil (a special grape seed oil); Safflower oil (Safflower)	Mustard oil; Jatropa curcas; Coconut oil; Palm oil	Chicken fat; Fish fat	

The basis of biodiesel extraction is based on the large branching molecular structure of these sources of material that translates into more straightforward molecular structures (methyl esters) as the diesel component of petroleum. This transformation requires the participation of ethanol or methanol and a catalyst of NaOH or KOH. The reaction result will produce methyl ester or ethyl esters (including components of biodiesel) and glycerin [4]. According to the American Society of Testing and Materials (ASTM) standards, the properties of biodiesel fuel are shown in Table 2[16].

TABLE II: PROPERTIES OF BIODIESEL

PROPERTY	Biodiesel B100	Biodiesel B 20	Diesel fuel from "SOCAR"
Density at 15°C, kg/m ³	884,0	848,0	834,0
Density °API	28,56	35,36	38,16
Viscosity, mm ² /s at 40°C	5,2	3,3	2,0
Flash point, °C	120	64	56
Acid number, mg KOH/g	0,015	0,0069	0,0048
Cetane Number	51		48
Sulfur content, mg/kg	-	5	10
Ash content, %	0,021	0,0091	0,0155
Polycyclic aromatic hydrocarbons, %	-	5	6
Carbon residue (on 10% residue), %	0,4	0,28	0,3
Copper strip Corrosion, (3 hours 50°C)	Nº3	Nº2	Nº1,5
Corrosion resistance, g/m ³	6	6	6
Content of fatty acids and methyl ester, %	5	5	5
Total contamination, mg/kg	-	-	20,5
Distillation			
50%	270°C	260°C	240°C
96%	300°C	305°C	295°C

Components due to different origins of FAMES will create different properties of the fuel. Also according to ASTM, the differences in the properties of biodiesel and diesel diesel are comparable as shown in Table 2[21].

In terms of structure, biodiesel has lower carbon content (C), sulfur (S) and water than diesel, but has more oxygen content in the component[26].

Biodiesel has a higher solubility index than diesel due to the oxygen content in the component. The index of tanning is a characteristic quantity for the combustion ability of the fuel when sprayed into the engine, the quality of combustion and the time of fire is delayed. The biodiesel content of biodiesel ranges from 48 to 65 and varies depending on the difference in the fatty acid composition of the fuel material of this type and the degree of saturation of fatty acids[11][27]. Normally, diesel oil has a value of 40 - 46 and high quality diesel oil with values from 45 - 50.

Biodiesel has a higher flash point than diesel. Pure biodiesel (B100) has the smallest flash point of 130°C, while diesel is 60°C. The more biodiesel in the mix, the higher the flash point. Due to this characteristic, biodiesel as well as its mixture will reduce the risk of fire and increase safety when transporting or storing on transport vehicles.

Biodiesel has high lubricating properties, reduces friction and engine wear. In fact, 1% of biodiesel in the mixture can increase the lubricating properties of the fuel by 65%.

Biodiesel is more soluble in water than diesel because its structure is relatively simple, including straight carbon circuits with 2 oxygen atoms at the end, very susceptible to changes by bacteria in the environment. country. At the end of the 28-day period, 95% of biodiesel decays in water, while only 40% of diesel is decomposed.

B. Research orientation of using biodiesel

Vietnam is a country that is endowed by nature with sufficient energy resources. However, the ability to exploit, process and use energy resources is limited. According to the analysis of the situation of economic development and energy supplies, it is expected that in the coming time (by 2020) our country will continue to import petroleum products, while oil prices are always under pressure. great to economic development[1].

To solve this problem, many research projects on biofuel production have been conducted: diesel production from soybean, sesame, waste oil; ethanol production from sugarcane, corn, rice, and cassava ... The research and production of clean fuels for transportation has been assigned to a number of agencies such as Petrolimex, Petro Vietnam, and Technical University. Da Nang and had an encouraging initial application result.

Currently, the world is divided into 2 directions to research and apply mainly biofuels on diesel engines:

1) Research on production and development of biodiesel (biodiesel) and its mixture with petroleum diesel:

After implementing the chemical reactions mentioned in section 2.1, the obtained FAME biodiesel oil will mix and mix with petroleum diesel (DO) according to a certain ratio and supply it into the engine. Depending on the mixing ratio, there will be different types of biodiesel blends: B5, B10, B20, ..., B100 (in which: 5%, 10%, 20%, ..., 100% are components of biodiesel in the mixture) [3]. Current studies mainly focus on developing and applying mixes B5 to B20 in diesel engines equipped on road vehicles, especially in cars. Because biodiesel oil FAME acts as a soluble solvent, at a rate of 20%, this oil is not compatible with some types

of synthetic resin and natural rubber. Therefore, if using this type of mixture in diesel engines, it is necessary to replace rubber tubes and gaskets with other materials compatible with it. In 1997 the first standard for biodiesel FAME was born and in 2003 the quality of biodiesel in Europe allowed B5 application on all engines[16].

2) Research and install additional conversion devices so that diesel engines can work directly with vegetable oil or a mixture of them with a traditional fuel without processing into biodiesel:

This technology is called SVO (Straight Vegetable Oil). SVO oil for diesel engines in the world is extracted from mustard seeds, sunflower seeds, soybeans, palm, coconut, etc. [7]. This SVO technology is mainly based on the principle of heating and dilution so that vegetable oil achieves the equivalent viscosity of DO oil because SVO oil at normal temperature has a very high viscosity. This helps to improve the quality of misting and improve combustion efficiency. There are a number of manufacturers and suppliers around the world for some types of engines. The main part of the main converter is the heating unit for SVO using heat from the engine coolant system. There are 2 popular options for using SVO on diesel engines:

Simultaneous use of SVO and DO in the process of diesel engine exploitation: DO oil will be used in the process of starting and stopping engines. When the engine is working stably, the engine temperature and cooling water are high enough to switch to SVO oil.

Only use SVO: The engine's fuel system needs to be converted and the installation of separate SVO oil supply equipment as well as the addition of oil refining pots. In addition, fuel nozzles are also converted to ensure the quality of misting as when the engine works with DO oil.

For biodiesel, trials of extracting this fuel from *Jatropha curcas* L. of TS. Thai Xuan Du - The Institute of Tropical Biology recently showed positive results with the extract rate of up to 32-37%. In 2007, the National Biofuel Company investigated the production of biodiesel from materials such as cottonseed, fish fat, dry palm oil, ... and successfully ran tests on some diesel engines. Road transport vehicles with the use of B5 mixed fuel (5% biodiesel and 95% traditional diesel). In addition, in the south, a number of small-scale production facilities have been built to utilize fish fat (especially basa fish) to produce biodiesel fuel. The use of biodiesel has only a few researches applied to the above-mentioned engines as the subject of Assoc. Dr. Nguyen Thach uses the homogeneous solution of "water - fuel" emulsion for coconut oil to apply directly to static diesel engines. The project tested B5 mixed fuel from fish fat for D243 engine at Polytechnic University laboratory of Assoc. Dr. Le Anh Tuan. Research on the use of mixed fuels (B10 and B20) for military vehicles of Assoc. Dr. Nguyen Hoang Vu; ... In the maritime field, in 2006, TS. Phung Minh Loc has started to mention applications for diesel engines installed on fishing vessels through the study of experimental vegetable oil as fuel for small-sized diesel boat engines. The research direction of this topic is to heat down the viscosity of vegetable oil to diesel equivalent and directly to the engine. However, the topic has not considered the factors affecting the long-term storage process on the ship, the life expectancy, corrosion of the details of the

engine, the impact of soot at the nozzle and on the wall of the cylinder.

IV. POTENTIAL APPLICATION OF BIODIESEL ON MARINE DIESEL ENGINES IN VIETNAM

Our country with oil and gas potential is not large, the annual exploited reserves according to Vietnam Oil and Gas Group's data are 15-17 million tons of oil and about 8-10 billion m³ of gas. In the next 15 years, we will have to import fuel (currently importing petroleum and gas from abroad), forecasting the import rate of about 11-20% by 2020, increasing to 50 - 58% in 2050 - not to mention nuclear energy. In 2003, commercial energy consumption was 205 kg OE / person (equal to 20% of the world average). According to calculations by energy experts, if no new energy sources are found to balance supply and demand, the rate of dependence on foreign energy will be up to 28.2% by 2020. Gasoline used for delivery Transportation often accounts for 30% of the country's needs and must now be fully imported. In 2010, oil imports were 2.1 million tons, and is expected to continue at 2020 to 4-5 million tons / year. When the first refinery in Dung Quat was put into operation in 2008, it only provided about 5.3 million tons of gasoline and diesel for transportation in the total demand of 15.5-16 million tons (34%). Before 2020, when all 3 refineries with a total capacity of 20-22 million tons of crude oil put into operation will provide 15-16 million tons of gasoline and diesel in the total demand of about 27-28 million tons (56%). The amount of fuel consumed per capita in 2020 is only equal to 65% compared to Thailand in 2005 [2]. The necessity of finding a kind of energy to support the current fuel demand is an inevitable trend to ensure national energy policy in the next few decades, gradually reducing the dependence on fuel and oil. from abroad.

The maritime industry is one of the economic sectors affected by fluctuations in the oil market. Along with the strong development of the economy, the demand for transporting goods, especially shipping by sea is growing[24]. According to the latest statistics of Vietnam Maritime Administration, there are 1,445 ships with a total tonnage of up to 5,579,523 DWT[28]. The number of ships increased rapidly, especially the fleet of specialized vessels (container ships, oil tankers), with an average growth rate of about 17% per year, the average age of Vietnamese fleets is 12.77 [1]. Most of these vessels are equipped with diesel fuel powered by diesel fuel. Meanwhile, diesel fuel prices are on the rise due to growing demand. With such a large number of ships, annual fuel consumption of up to thousands of tons will be consumed and a lot of toxic substances as well as greenhouse effects will be released to the environment[29]. If the use of biodiesel and its mix of engines on these vehicles will help shipping companies significantly reduce their reliance on fuel imports and reduce emissions. Toxic substances cause environmental pollution[30].

Since the past 10 years, our government has oriented and has policies to develop biofuels in the country, and most recently, in November 2007, the Government approved the Project "Development of biofuels. by 2015, vision to 2025 ", facilitating and opening up mechanisms for agencies,

organizations and individuals in the transportation, industry and energy sectors to study biofuels. On that basis, a number of companies, institutes and universities have been experimenting with gasoline ethanol and biodiesel. Lam Son Sugar Company (Thanh Hoa), Saigon Petro, Binh Tay Wine Company, Chi Hung Company also had a project to produce ethanol as fuel. Recently, a number of companies in An Giang, Can Tho and Long An like AGIFISH Company have invested in biodiesel production from basa fat with a total capacity of about 40,000 tons / year. Tests of biodiesel extraction from *Jatropha curcas* L. of TS. Thai Xuan Du - Institute of Tropical Biology, and TS. Le Vo Dinh Tuong - City Institute of Natural Products Chemistry Ho Chi Minh ... recently all showed positive results with oil extraction rate up to 32-37%. In 2007, the National Biofuels Company researched the production of biodiesel from materials such as flakes, fish fat, dry palm oil, ... and successfully ran tests on diesel engines of some Road transport vehicles with the use of B5 biodiesel blends (5% biodiesel and 95% traditional diesel). With the initial successes as well as research on the use of biodiesel and its mixes in the world, there is a great prospect in the application of biodiesel on marine diesel engines in country.

Due to specific characteristics, diesel engines equipped on water transport vehicles have relatively strict operating modes and are controlled by a lot of regulations related to maritime safety and environmental pollution prevention. Without adequate research on biofuel, it is very easy for incidents for diesel engines in the exploitation process as follows:

- First of all, because biodiesel has the chemical properties of a softener (this substance is also in the material composition of fuel pipes, gaskets, rubber seals), it will replace the substances soft in these tubes and gaskets. The material will initially inflate and when using petroleum-derived diesel will wash biodiesel. Without softeners, the material will become hard and absorb water.

- Second, it is the structural destruction of engine lubricating oil. In the process of working motors, especially small load modes, transitional modes, non-combustible fuel droplets form on the combustion chamber wall. These biofuel droplets will destroy lubricant film on the mirror surface of the cylinder, increasing the level of abrasion of shirts and cuffs. In some cases, it may cause jamming in the shirt due to increased friction. In addition, sticking on the cylinder mirror surface of the biofuel droplets will increase the level of fuel leakage to the crankcase, damaging the lubricating oil, causing abrasion of bearings.

- Thirdly, biodiesel is harder to burn than diesel diesel, so how to use it, how much is the mixing ratio on marine diesel engines with very changing characteristics of continuous working regime. Specific and thorough research and testing is required.

V. CONCLUSION

Vietnam is a country that is endowed by nature with sufficient energy resources. However, the ability to exploit, process and use energy resources is limited. According to the analysis of the situation of economic development and energy supplies, it is expected that in the coming time (by

2020) our country will continue to import petroleum products, while oil prices are always under pressure. great to economic development.

Biofuel with its own characteristics has become a clean energy alternative to oil in the future, especially biodiesel in the field of water transport. The potential of biodiesel application in the country is huge but how to effectively apply this energy source for marine diesel engines, it is necessary to have technical solutions attached to exploit the engine one Safe, effective way. This really has important implications for the fleet of Vietnam and is consistent with the trend of using biofuels and clean fuels in the world.

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