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An Empirical Research Evaluating the Technical Characteristics and Particulate Emissions of Diesel Engines Using Biofuels

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Abstract— *Among the sources of air pollution in urban areas across the country, emissions from transportation activities rank first. Of the total emissions that pollute the urban air environment, emissions from motorized road vehicles take the leading position. Among the types of transport vehicles, motorcycles and mopeds account for the largest proportion and are also the largest source of pollutant emissions. The burning process does not run out of fuel also emits particle emissions. This PM emission source is often deposited on the road, or following the vehicle and often entrails the tires when the car runs. The paper presents the results of research on renovating the engine - generator cluster using diesel fuel to use palm oil biodiesel fuel. Study on physical and chemical properties of vegetable oil fuel, biodiesel and waste oil. Methods of processing vegetable oil, waste oil into biodesel and the ratio of mixing biodiesel into fuel for engines. Analysis of B25 diesel and biodiesel fuel system characteristics in Mazda WL engine. Calculate heat for engine when using biodieselt.*

Keywords— *PM emission, biodiesel, palm oil, diesel engines.*

I. Introduction

The use of biodiesel from vegetable oil has contributed significantly in reducing environmental pollution and reducing dependence on imported raw materials. The amount of waste cooking oil is mainly discharged into the external environment causing water pollution [1]. Therefore, the study of usability from waste cooking oil is necessary because it will contribute to reducing environmental pollution from this waste oil. This is also the direction and is being applied in many countries around the world. In a developed society, internal motivation plays a very important role in all fields, industry, agriculture, economy as well as meeting life's needs. The benefits of internal combustion engines bring a lot, but their exhaust sources also cause major pollution in the atmosphere, causing the greenhouse effect. It is estimated that the engine's emissions causing the atmosphere are about 80% CO, 60% HC, and 40% Nox [2].

Air pollution is the result of activities of modern life such as: increase in energy consumption, development of key industries:

Metallurgy, chemistry, road and aviation, etc. The search for clean fuels and energy not only solves the problem of air pollution but also can actively control fuel sources, limiting the dependence on fluctuations in the world. Therefore, the thesis chooses to study the solution of applying biodiesel fuel instead of fuel used for diesel engine today. Besides, environmental pollution is the top concern of mankind. In particular, the transport sector is a significant source of pollution due to engine exhaust as well as noise[3]. Currently, according to statistics, the fuel that the vehicles consume only accounts for 1/3 of the global energy but discharges into the environment a toxic gas accounting for 70% of the emissions[4]. The scarcity of fossil fuels in addition to the increased demand for fuel leads to an increase in the quality of petroleum and the backward structure and technology of automobile engines making the environment more and more polluted. more important[5]. To cope with that situation, the study of finding other types of fuels to replace each part to completely replace fossil fuels will be exhausted in the future and environmentally friendly due to internal combustion engines because It is an urgent and important issue. Environmentally friendly biodiesel due to its low sulfur content can be extracted from Jatropha tree seeds (Porridge), a plant that grows wild in our northern provinces. The world's Biodiesel school is estimated to reach 37 billion gallons or 140 billion liters in 2016, an annual growth rate of 42%. The EU will continue to be the largest biodiesel market in this decade, followed by the US market. In addition, India plans to replace 50% of fuel oil by 2030[6].

In Vietnam, Petro Vietnam plans to bring 10% Bio-Diesel (B10) into diesel components to circulate on the market. According to the proposal of the Ministry of Industry and Sojitz Company Office in Hanoi, August 3, 2005, the Ministry of Natural Resources and Environment, as the focal point of the Government of Vietnam, participated and carried out Kyoto letter has confirmed the PIN project to develop biodiesel according to the clean development mechanism (CDM) in Binh Dinh province.

The most important finding from Jatropha is to get seeds to produce biodiesel. Jatropha seeds have an oil content of over 30%, from crude oil pressed seeds. Although Biodiesel is produced from a variety of materials: canola, sunflower, soybean, palm oil, animal fat ..., but produced from Jatropha still has the cheapest price, good quality, equivalent to traditional fossil diesel oil[7]. The use of traditional fuels is now being encouraged to switch to using clean (new) fuels to address fuel, environmental pollution, the two biggest concerns today in the world[8]. Therefore, Research on the effect of Jatropha - Diesel mixing ratio on the formation of soot in exhaust gas is true to the development trend of the area. In order to contribute to the general trend in the world and Vietnam in particular in finding alternative fuel sources, solving the problem of energy exhaustion (petrol, oil, gas, etc.) and pollution environment[9]. Through the study of the theory of Biodiesel fuel (Jatropha oil) as well as the formation of

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pollutants in engine exhaust when using fuel, it helps to better understand the process of forming pollutants when used. Biodiesel-Diesel mixture. In addition, the effect of engine characteristics (basically the moment and heat consumption) will be the parameters that help the author to analyze more objectively[10].

The evaluation of criteria of economic and technical features of diesel engines in experiment is through quantities of power, torque, fuel consumption and other equivalent quantities. So the theoretical basis of the chapter is the foundation, which is the scientific basis not only to guide the organization of experimental practice, but also to analyze and evaluate scientifically the results obtained on the test bench.

II. Materials and Experimental Set-Up

A. Test Equipment

The test subject was Hyundai D4CB 2.5 TCI-A diesel engine using fuel systems type CR (CP1-H) above with the principle diagram as shown in Figure 2, with basic specifications as shown in Table 1. This type of engine is being used quite commonly in Vietnam (mounted on cars, light trucks, passenger cars, ambulances ...) due to the appropriate level of technology and cost. During the test, 2.5 TCI-A engine was controlled by ECM-0565-128.

Through the theoretical study of Biodiesel fuel as well as the formation of pollutants in engine exhaust when using fuel, it helps to understand in depth the processes of forming pollutants when using Biodiesel-Diesel mixture. In addition, the influence of motor characteristics (basically torque and heat consumption) will be the parameters that enable the author to analyze more objectively. The dynamometer consists of a shaft/rotor assembly mounted within a casing supported on a rigid baseplate. The Opus 40 is a device that analyzes the contaminants in engine exhaust. The components of measured emissions include: HC, CO, CO2, O2, NOx. AVL DiSmoke 4000 Diesel Tester analyzes% soot in exhaust component. Through OPAC value [%]. Displays engine speed and lubrication temperature through sensors attached to the engine of the device. AVL 733S is a measure of fuel consumption and temperature regulation of liquid fuel. Set Opus 40 is a device to analyze the composition of pollutants in engine exhaust. Measured emissions components include: HC, CO, CO2, O2, NOx. DiLmoke 4000 Diesel Tester analyzes% soot in the exhaust composaition.

TABLE 1. Specifications of Mazda WL engine

Model	**EV2600N**
Type	4 cycle, 1 cylinder, horizontal
Bore x Stroke (mm)	118 x 108
Displacement (cm3)	1181
Continuous output (HP/r.p.m) Maximum output	20/2200 25/2400
Maximum torque (kgm/rpm)	8.92/1400
Compression ratio	16.5
Fuel	Light diesel oil
Fuel tank capacity (l)	16
Specific fuel consumption (g/HP/hr)	165
Nozzle opening pressure(Kg/cm^2)	-
Lubricating oil	SAE30,20,10w-30
Lubricating oil capacity (l)	5
Combustion system	Direct injection
Starting system	Speed doubling handle by hand
Lamp	-
Cooling system	Radiator
Cooling water capacity (l)	4.7
Weight (kg)	192
Dimensions:L x W x H (mm)	943 x 453 x 667

B. Install Test Bench and Engine

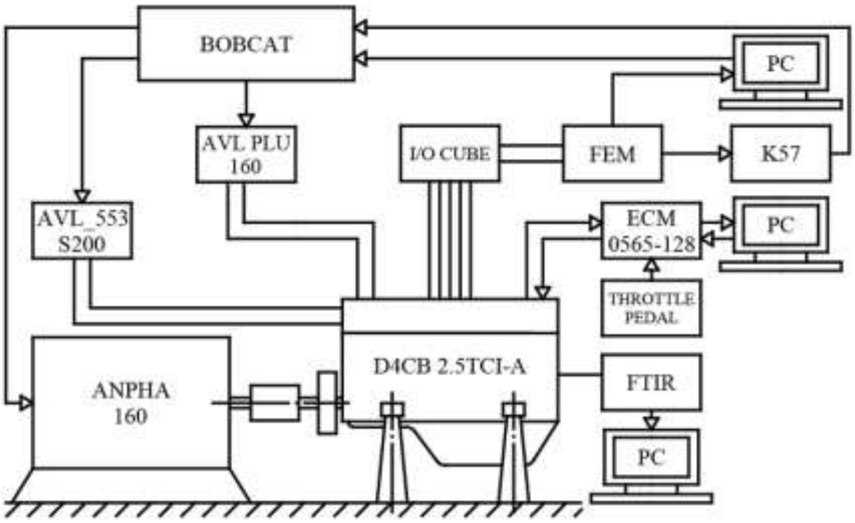

Fig. 1. Schematic diagram of the engine test bench

C. Testing Process

The testing was conducted on the AVL engine test bed located at the Internal Combustion Engine Laboratory - University of Transport Technology with the equipment layout shown in Figure 1. The engine is placed on the high dynamometer Alpha 160 comes measurement devices including: AVL PLU 160 fuel consumption meter; FTIR emission analyzer; measuring and calibration equipment coolant temperature. SCV and RPCV valves are controlled by Woodward's ECM MotoHawk ECM-0565-128. ECM-0565-

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128 uses a high-speed 32-bit microcontroller with large memory, combined with the Motohawk translator that allows translation from Matlab Simulink to Assembler microcontroller language. Thanks to this advantage, the designer can optimize the driver program on Matlab Simulink and send it directly to ECM-0565-128 without the need for an intermediary to write code, helping to make the chapter real-time. The process is guaranteed. ECM can operate accurately under harsh conditions, is capable of controlling complex signals, high frequencies and allows connecting to computers, diagnostic devices and other ECUs in the vehicle through CAN 2.0B port.

III. RESULTS AND DISCUSSION

A. *The engine speed curve with traditional diesel fuel*

TABLE 2. Experimental data of diesel fuel DO-30% of the gear position

n[rpm]	P[kW]	M[N.m]	ge[g/kW.h]	Q[KJ/KW.h]
1200	3.77	29.67	231.64	9992.51
1400	5.31	35.91	193.82	8361.19
1600	5.45	32.21	216.07	9320.65
1800	6.58	34.59	223.22	9629.09
2000	7.38	34.84	223.26	9631.10
2200	7.41	32.00	259.73	11204.15

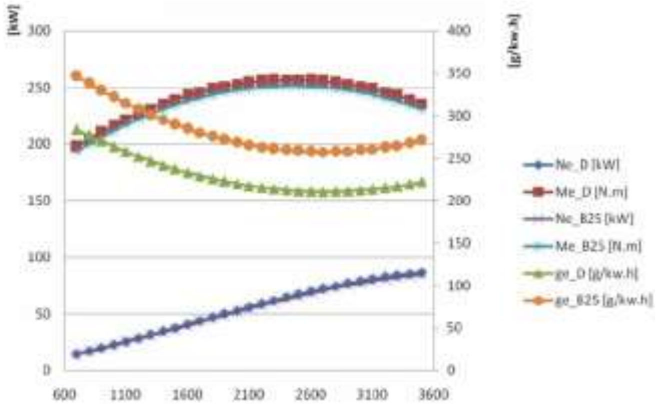

Fig. 2. Comparison of engine speed characteristics when using diesel and biodiesel

Experimental results of building Vikyno EV2600 engine load characteristics using diesel DO at 1200 rpm are shown in Table 2. The experimental engine has been removed the speed regulator, so the experimental process according to the speed characteristics has obtained the following results: Table of engine test results when using Diesel fuel at 30% of the gear rack. Through the characteristic of engine speed, the engine's capacity and engine moment are greater than the remaining fuels. In addition, during the experiment, the engine worked better, the lowest fuel consumption at the speed of 1400rpm is similar to the maximum engine torque generated.

B. *The diesel engine speed curve with B5*

TABLE 3. Experimental data of B5-30% of the gear position

n[rpm]	P[kW]	M[N.m]	ge[g/kW.h]	Q[KJ/KW.h]
1200	2.35	18.52	351.78	14959.17
1400	2.96	23.29	324.15	13784.24
1600	5.17	30.57	251.55	10696.76
1800	4.16	21.69	349.75	14872.75
2000	5.90	27.37	271.75	11556.14
2200	6.25	26.85	284.78	12110.22

C. *The diesel engine speed curve with B10*

TABLE 4. Experimental data of B10-30% of the gear position

n[rpm]	P[kW]	M[N.m]	ge[g/kW.h]	Q[KJ/KW.h]
1200	3.35	26.03	292.76	12359.60
1400	4.10	27.21	47.33	1998.17
1600	4.56	26.92	247.50	10448.81
1800	3.88	20.15	372.35	15719.64
2000	8.53	40.63	230.78	9742.72
2200	5.92	25.71	273.71	11555.30

Through the graph, we see that, at 1800-2000rpm, the motor works less stable, so the generated moment has a big jump. Even so, the fuel consumption of the engine is still lower than when the engine uses B5 fuel. The process of preparing experiments and experiments, collecting experimental data. Built motor speed characteristics through the relationship between torque, power and fuel consumption compared to engine speed at different load levels.

D. *Consumption of heat in 30% of the rack position*

Through the engine power generated and the amount of heat consumed we can grasp the combustion process in the engine. Thereby, most of the causes of forming polluting substances are created. The heat consumption of the engine when using B5, B10, and B15 fuels is larger than when using Diesel fuel. This shows that the thermal efficiency of the engine when using B5, 10, and 15% fuel is smaller than when using Diesel.

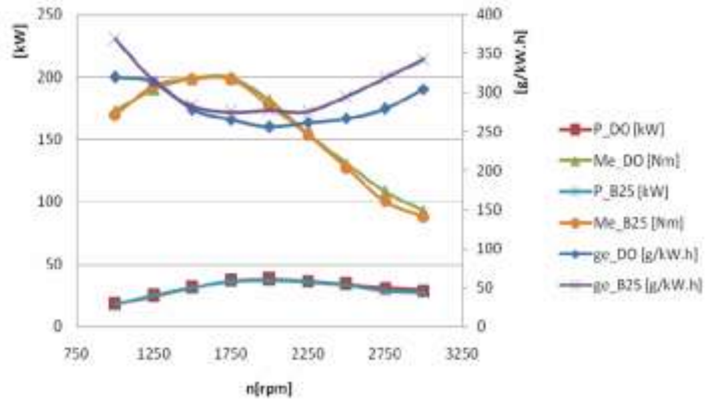

Fig. 3. Compare engine speed when using diesel / biodiesel, at 50% load

E. *Power at 30% of the rack position*

As shown in the Figure 3, we can see that: with a 30% load of Diesel fuel use, it benefits economically and technically. The generation of engine power has a great influence from the source of fuel. With the low heat of Bio fuel is lower than Diesel fuel, the viscosity is higher but especially the fuel itself has no molecular oxygen, so the burning process of the fuel still has no big impact from the above properties. Through the graph shown in Figure 4, we can calculate the average increase and decrease level of the concentration of PM emissions in engine exhaust when using the four above fuels as follows: The concentration of PM in engine exhaust when using Bio fuel is 5%, 19% lower than Diesel fuel. The concentration of HC in engine exhaust when using Bio fuel 10% increased 29% compared to Diesel fuel. The concentration of PM in engine exhaust when using Bio fuel is 15%, 11% lower than Diesel fuel.

IV. CONCLUSION

The paper presents the results of empirical research assessing the impact of biodiesel blends B10, B20 on economic indicators (useful fuel consumption, ge), energy (useful torque, Me; utility power, Ne), environment (NOx emission level; smoke level, k) of B2 engine at AVL-ETC Heavy-duty engine test room (HeavyDuty Engine TestCell) of the National Center for Emission Test of Road Motor Vehicle (NETC), with advanced equipment and technology system of AVL List GmbH (Austria). The economic, energy, and environmental indicators of the engine are the most basic parameters to evaluate the engine's perfection level as well as the impact of the use of alternative fuels. These indicators can be determined through theoretical or experimental calculations. The use of simulation software has the advantage of saving money and research time, but the calculation results need to be evaluated and verified experimentally, especially when the object of the research is the engine being used (technical condition has decreased compared to the original design). The project has studied the conversion of diesel fuel to B25 biodiesel fuel derived from waste cooking oil for diesel engines. The use of Biodiesel B25 fuel has significantly reduced the harmful gases in exhaust fumes of the engine, contributing to protection and human health.

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