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A Simulated Research on the Characteristics of Diesel Engines When Using Biofuels Extracted from RSO

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***Abstract*—** *Before the situation of traditional energy reserves on ports decreased, people now focus on researching, exploiting and applying new energy sources. These energy sources are considered clean, renewable energy and they do not pollute the environment. The paper studies the power and exhaust of RT125 diesel engine when using biodiesel. This fuel is made from rubber seed oil with variable mixing ratios B0, B5, B10 and B20, with loading modes of 50%, 80% and 100%. The study was carried out in revolutions of 1600 rpm, 2000 rpm and 2400 rpm. Simulation results by KIVA-3V software show that when changing from diesel (B0) to biodiesel (B5, B10, B20) engine power does not change much, but soot emissions decreased significantly while NOx increased.*

***Keywords*—** *Biodiesel, rubber seed oil (RSO), biodiesel production KIVA-3V.*

I. INTRODUCTION

Facing the instability of oil prices, the anticipated exhaustion of fossil fuel resources around the world, forewarned environmental disasters, countries and scientists are trying to find solutions. New method to put renewable energy into use. Among these types of energy, bioenergy is considered one of the most reliable sources of energy because of the CO_2 cycle it produces. Biofuels can be produced from a variety of fuels: starch, synthetic gas, Cellulose (ethanol, butanol), oil, fat, microalgae (biodiesel), animal waste, ... in which starch and cellulose are believed to be the most potential in terms of reserves and applicability of the product[1].

For many countries including Vietnam, starch is still considered an important food source. The tradition of using starch in many places does not agree with the use and use of them as industrial fuels. However, the use of starch produced into fuel is relatively easy, the product cost is low[2]. Vietnam is a developing country mainly based on agriculture and forestry, so the potential of energy from biomass is very diverse and has a large reserve[3]. Therefore, in Vietnam, the research on the use of energy from biomass gradually replaces fossil energy sources that are of interest to state agencies and scientists[4].

According to statistics of the Vietnam Rubber Association, in 2015 Vietnam had 600,000 hectares of rubber being harvested with an output of about 1,017,000 tons. With this output, each year, there will be about 180,000 tons of rubber seeds. Rubber Seed Oil (RSO) is currently a source of raw materials for biodiesel fuel production in India, Malaysia and Indonesia and reported in some Vietnamese studies[5].

In recent years, the issue of fuel prices, the environment and the decline of fossil fuel sources has provided an important incentive for scientists towards finding an alternative source of raw materials. Fossil fuel source. Biodiesel is produced from vegetable oil and animal fat can replace fossil fuel sources, because of its similar properties to fossil fuels[6]. In many countries, biodiesel is produced from edible oils such as sunflower oil, coconut oil, and soybean oil. The price of edible oil is many times higher than that of non-edible oil. Inedible oil is also a potential for biodiesel production. Biodiesel produced from non-edible oil will reduce the price of products and abundant supplies[7].

Rubber tree is native to the Amazon rainforest (Brazil). Today, rubber is present in many parts of the world, including most of Southeast Asia and some tropical climates in Africa. Mature rubber trees can grow up to 30 m. The life of each rubber tree lasts from 30-40 years. Rubber trees start bearing fruit after four years[8]. The tree produces two fruits a year and each fruit contains 3-4 seeds, when ripe they fall to the ground and the seeds are separated[9]. Oil is extracted from the seed. The oil content of seeds depends on the climate and soil of each place where they live, however, the seed contains about 40% of the average oil. According to the Vietnam Rubber Group, our country currently has more than 500,000 hectares of rubber tree growing area. If including the land area that the group rented for rubber plantations in Laos and Cambodia, the total area of rubber trees may be more than one million hectares, correspondingly this year the group may have 17,600-330,000 tons. rubber seed oil[10].

In order to evaluate the performance of diesel engines when using RSO without renovating the engine, the authors conducted combustion simulation on Kubota RT125 engine when using biodiesel fuel from RSO with the Different mixing ratios, under different load conditions and revolutions. The obtained results contribute to the orientation for the gradual replacement of diesel fuel by biodiesel according to "Project of developing biofuels to 2015, vision to 2025" for biofuel to reach the output 1.8 million tons, meeting 5% of the country's gasoline demand by 2025.

II. SIMULATION CONDITIONS

2.1. Math simulation model

KIVA-3V is an open source fluid dynamics simulation software, developed by scientists at Los Alamos National Laboratory, USA, which is commonly used in the world for simulation too. combustion engine internal combustion. The turbulent flow is modeled by the improved RNG k-ε model The main models in KIVA 3V are Wave breakup jet decay model, Shell late fire model, fire model Abraham himself, NOx Zel'dovich formation model, Foster soot oxidation formation and oxidation.

2.2. Create mesh and simulation parameters

The engine is a RT125 single cylinder Kubota engine

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which is widely used in many fields such as agriculture, construction, power generation, etc. The main specifications of the engine are shown in Table 1. RT125 engine has an eccentricity-controlled directly burning chamber. The Kubota RT125 is a horizontal, water-cooled, four cycle diesel engine. With a capacity of 12.5HP at 2400RPM, the Kubota RT125 is renowned for its reliability and durability. To increase the simulation accuracy, the eccentric combustion chamber model was reproduced with 24 cells in the direction of the glass, 36 cells in the tangent direction, 29 cells in the axial direction (Figure 3), with a total of 21420 cells.

Figure 1. Kubota RT125

TABLE 1. RT125 Specifications

Type	Water Cooled Horizontal Diesel Engine
Number of Cylinders	1
Bore & Stroke	94mm x 96mm
Total Displacement (cc)	666
Combustion System	Direct Injection
Intake System	Naturally Aspirated
Max Output kW/rpm (hp/rpm)	9.2/2400 (12.5/2400)
Cont Output kW/rpm (hp/rpm)	8.1/2400 (11.0/2400)
Starting System	Manual/Electric

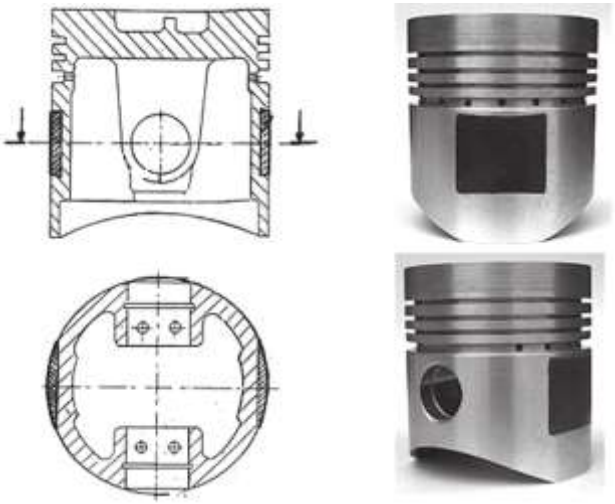
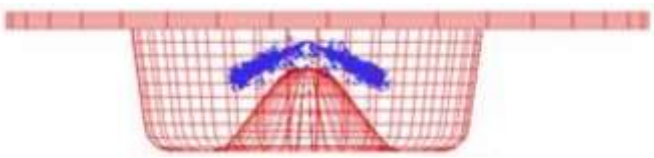


Figure 2. View cross-section of piston



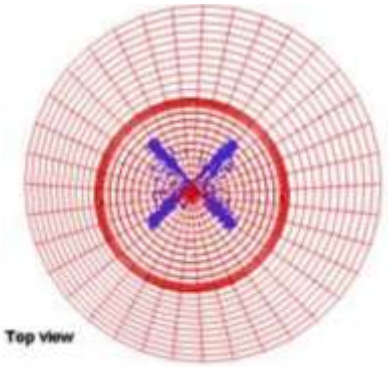


Figure 3. Grid simulating combustion chamber at the time of -12°ATDC with spraying

Simulations were conducted for four different fuels: DO (100% diesel), B5 (5% RSO + 95% diesel), B10 and B20. For each type of fuel, conduct simulations in three load modes of 50%, 80% and 100%. In each load mode, the number of engine revolutions change respectively 1600rpm, 2000rpm and 2400rpm. RSO rubber seed oil is synthesized at VNU-HCM Key Laboratory of Chemical Technology and Petroleum under two-stage method, and then sent to Center for Standards, Metrology and Quality 3 to identify parameters. These parameters are used as input parameters for simulating the mixture of B5, B10, B20.

III. Results and Discussion

The first step in the simulation process is to check the accuracy of the input parameters, shown by simulation and experimental chamber pressure graphs. Figure 4 and Figure 5 compare the pressure variation in the engine combustion chamber in turn without fuel injection and with diesel fuel injection at revolutions of 2000 rpm. The results show a very good similarity between the two non-flammable and fire pressure curves between simulation and experiment. This proves a reliable set of simulation parameters.

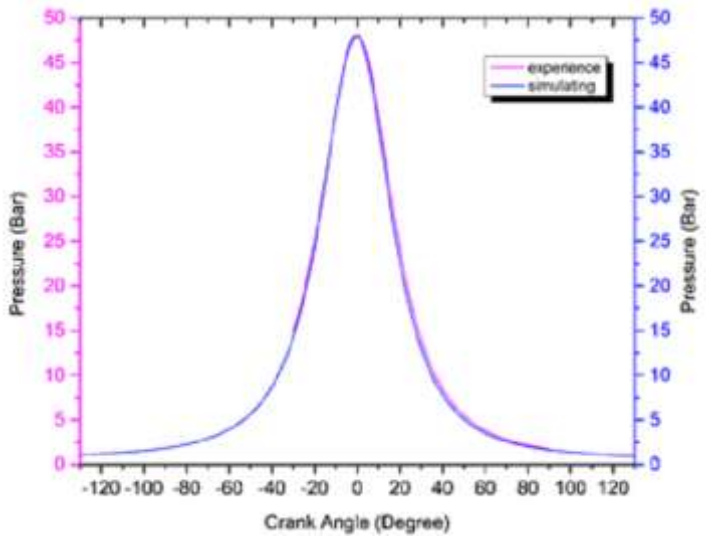


Figure 4. Comparison of combustion chamber pressure when simulated and experimented, no fuel injection

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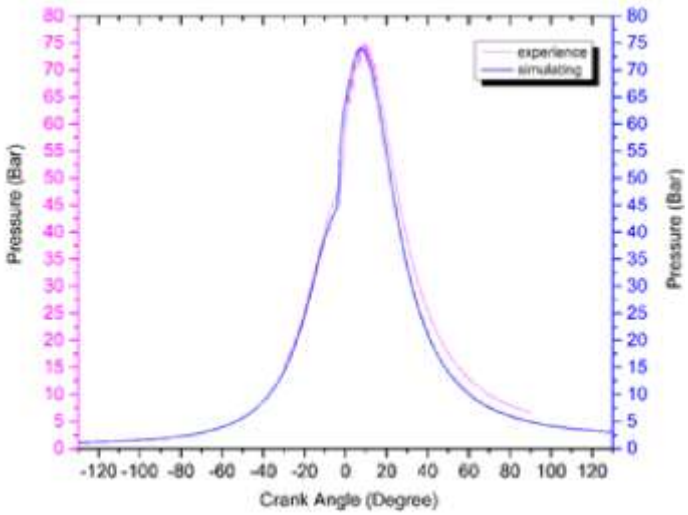


Figure 5. Comparison of combustion chamber pressure during simulation and experiment, with fuel injection

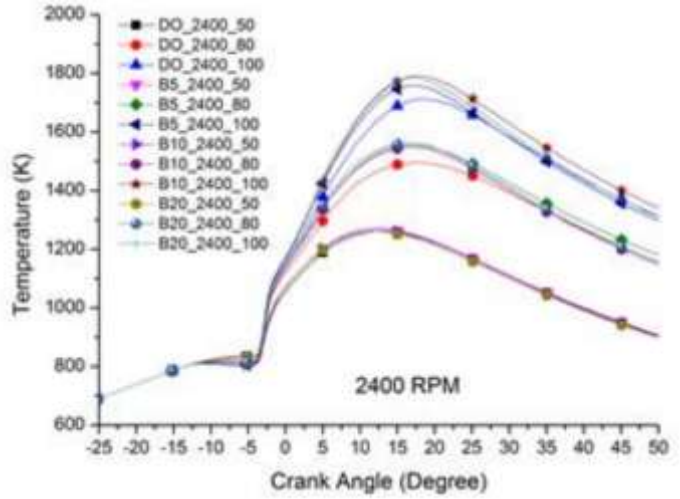
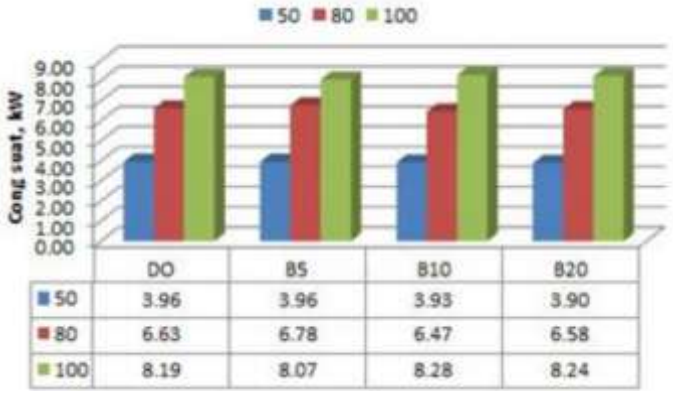


Figure 6. Compare chamber temperature at 2400rpm

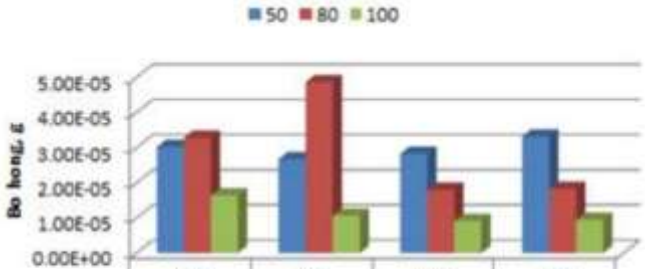


	DO	B5	B10	B20
50	3.96	3.96	3.93	3.90
80	6.63	6.78	6.47	6.58
100	8.19	8.07	8.28	8.24

Figure 7. Compare NOx emissions at 2400rpm

In each load mode and corresponding engine speed, the combustion chamber pressure when using RSO fuel tends to be higher than when using DO fuel. In addition, the oxygen component available in the RSO fuel also helps improve combustion, increasing combustion chamber pressure as well as combustion chamber temperature (Figure 6). However, this increases the NOx emission in the exhaust gas because NOx is very sensitive to temperature. Figure 7 shows the NOx emissions in the engine revs reaching the highest power of 2400 rpm, with load modes of 50%, 80% and 100%, respectively. Due to the higher combustion temperature of RSO, in all modes, especially when the load is high, NOx emissions of biodiesel fuels are higher than traditional fuels.

However, NOx disadvantages are offset by significantly reduced soot emissions when using RSO-blended fuels. Figure 7 shows the soot emissions of different fuels at 2400 rpm. The amount of soot is significantly reduced in full-load mode of the engine.



	DO	B5	B10	B20
50	3.02E-05	2.67E-05	2.83E-05	3.32E-05
80	3.28E-05	4.87E-05	1.80E-05	1.83E-05
100	1.64E-05	1.06E-05	9.16E-06	9.44E-06

Figure 8. Comparison of soot emissions at 2400rpm

Especially can be found in 80% load mode, when using B5 soot amount increased compared to DO. To understand, Figure 8 shows the soot transformation according to crankshaft rotation inside the combustion chamber of DO and B5 fuels. Emissions soot is the difference of soot formed and soot burned in the combustion chamber. In the case of B5, due to the higher combustion chamber temperature than DO, the amount of soot formed and oxidized is higher. However, the effect of these two processes is greater, resulting in higher soot emission of B5.

IV. Conclusion

By simulation, the parameters of combustion chamber pressure, combustion chamber temperature, engine power and exhaust components have been evaluated when changing diesel fuel with biodiesel mixture from rubber seed oil (RSO). The simulation results are summarized as follows:

When using RSO fuel, the engine power varies but not much. In terms of exhaust characteristics, at most engine speeds and loading modes, RSO fuel models have higher NOx emissions than DO fuel due to the pressure and temperature of combustion chamber when using RSO fuel higher than DO. However, due to the better combustion of RSO fuel, soot volume in exhaust gas is lower than DO fuel. In terms of power and emissions overall, the two fuel samples B5 and B10 have advantages over the B20 fuel model in terms of NOx emission characteristics, while the other characteristics are almost equivalent.

References

[1] Y. Chen et al., "Emissions of automobiles fueled with alternative fuels based on engine technology: A review," Journal of Traffic and Transportation Engineering (English Edition). 2018.

[2] A. Datta and B. K. Mandal, "Effect of compression ratio on the performance, combustion and emission from a diesel engine using palm biodiesel," in AIP Conference Proceedings, 2016, vol. 1754, no. 1, p. 50005.
[3] W. Zhao, Z. Luan, and C. Wang, "Parametric optimization of novel electric–hydraulic hybrid steering system based on a shuffled particle swarm optimization algorithm," J. Clean. Prod., vol. 186, pp. 865–876, 2018.
[4] A. Datta and B. K. Mandal, "Numerical investigation of the performance and emission parameters of a diesel engine fuelled with diesel-biodiesel-methanol blends," J. Mech. Sci. Technol., vol. 30, no. 4, pp. 1923–1929, 2016.
[5] U. Rajak and T. N. Verma, "A comparative analysis of engine characteristics from various biodiesels: Numerical study," Energy Convers. Manag., vol. 180, pp. 904–923, 2019.
[6] M. H. Mat Yasin, T. Yusaf, R. Mamat, and A. Fitri Yusop, "Characterization of a diesel engine operating with a small proportion of methanol as a fuel additive in biodiesel blend," Appl. Energy, 2014.
[7] Ö. Can, E. Öztürk, H. Solmaz, F. Aksoy, C. Çinar, and H. S. Yücesu, "Combined effects of soybean biodiesel fuel addition and EGR application on the combustion and exhaust emissions in a diesel engine," Appl. Therm. Eng., vol. 95, pp. 115–124, 2016.
[8] S. M. Palash, M. A. Kalam, H. H. Masjuki, B. M. Masum, I. M. Rizwanul Fattah, and M. Mofijur, "Impacts of biodiesel combustion on NOx emissions and their reduction approaches," Renewable and Sustainable Energy Reviews. 2013.
[9] A. Anderson, Y. Devarajan, and B. Nagappan, "Effect of injection parameters on the reduction of NOx emission in neat bio-diesel fuelled diesel engine," Energy Sources, Part A: Recovery, Utilization and Environmental Effects. 2018.
[10] K. A. Abed, M. S. Gad, A. K. El Morsi, M. M. Sayed, and S. A. Elyazeed, "Effect of biodiesel fuels on diesel engine emissions," Egypt. J. Pet., 2019.
[11] Nguyen Thi Bich Ngoc, Nguyen Thi Hoa, Phan Thi Thuy Hoa, "Development of Biomass Resource Conversion Technology in Vietnam," EJERS, European Journal of Engineering Research and Science, Vol. 4, No. 8, 2019.