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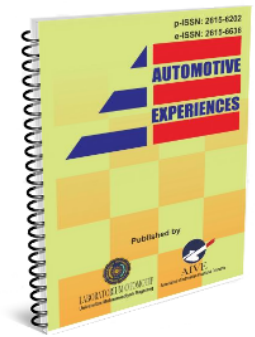

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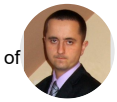

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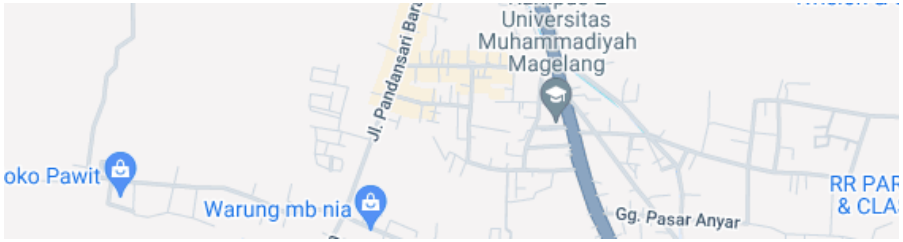

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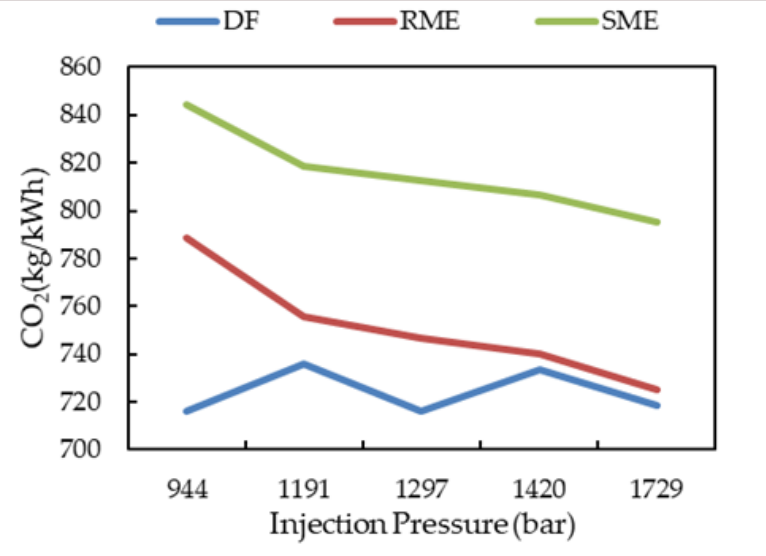

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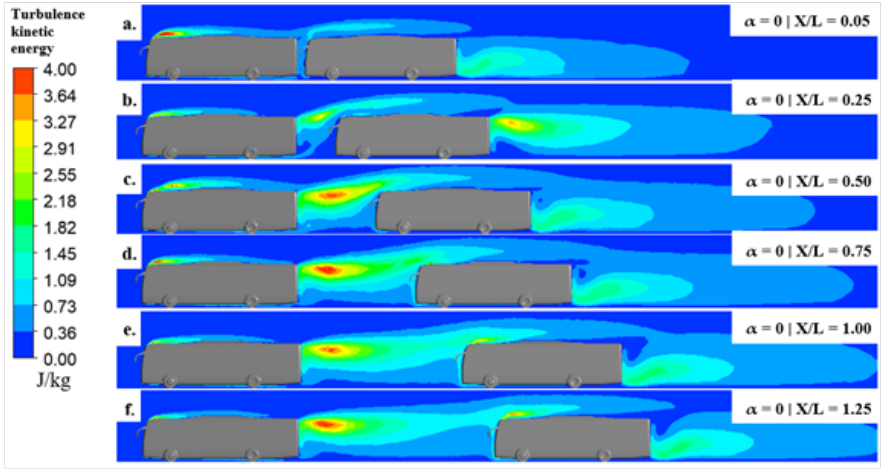

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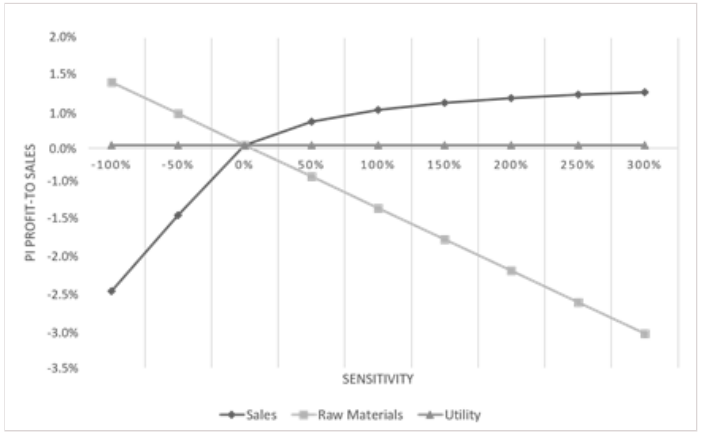

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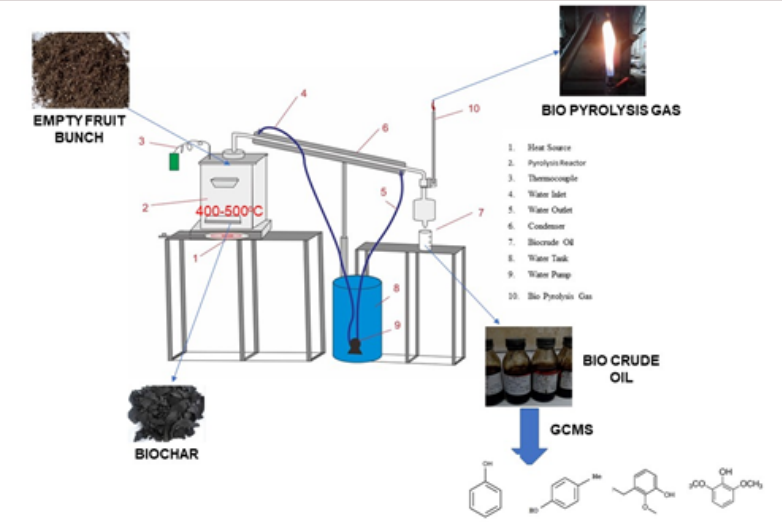

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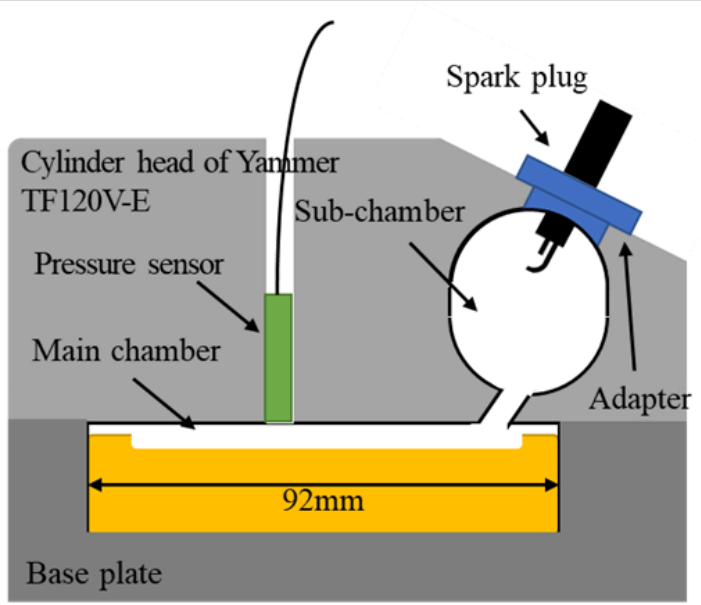

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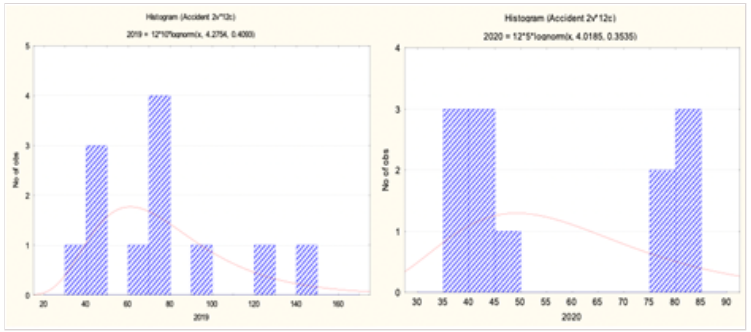

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Automotive Experiences
Vol. 4 No.3 (2021) pp. 112-118
p-ISSN: 2615-6202 e-ISSN: 2615-6636

Research Paper

The Simulation of Performance and Emissions from Rapeseed and Soybean Methyl Ester in Different Injection Pressures

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https://doi.org/10.31603/ae.4682

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Article Info
Submitted:
15/02/2021
Revised:
10/05/2021
Accepted:
25/05/2021
Online first:
08/09/2021

Abstract

Biodiesel is one of the promising alternative fuels of the future that is environmentally friendly. Biodiesel can be produced from rapeseed, soybeans, coconut oil, jatropha and many others. It is important to analyze the effect of comparison between diesel fuel and biodiesel to study the effect of combustion and emissions of these fuels. In this research, the simulation of combustion and emission is done with Diesel RK. Three fuels are studied; diesel fuel, rapeseed methyl ester (RME) and soybean methyl ester (SME). The engine was simulated at 2000 rpm and the injection pressures were 944, 1191, 1297, 1420 and 1729 bar respectively. The results show that the specific fuel consumption (SFC), particulate matter (PM), and CO_2 emissions of diesel fuel are relatively the same for different injection pressures. However, the SFC, PM and CO_2 emissions for rapeseed methyl ester and soybean methyl ester decrease with increasing injection pressure. These results can prove that higher injection pressures in diesel engines can improve combustion and reduce emissions of biodiesel fuel as compared to diesel fuel.

Keywords: Diesel RK; Emissions; Diesel fuel; Injection pressures; Rapeseed methyl ester; Soybean methyl ester.

1. Introduction

The demand for fossil fuels has been increasing for the past decades. However, the supply of fossil fuels is decreasing every year. This leads the researchers to find alternative fuels to replace fossil fuels. Biodiesel is one of the alternative fuels that can replace fossil fuels. The use of biodiesel has been researched for many decades and it has been proved that it can be used in diesel engine without some modifications. Biodiesel is produced through a trans-esterification process using alcohol and catalyst. Biodiesel can be produced from jatropha [1], rapeseed [2], carbera mangas [3], coconut oil [4] and many others including waste cooling oil [5], [6]. Biodiesel can be one of the alternative fuels that can reduce some emissions such as HC, SOx and some particulate matter (PM) [7]. However, the high viscosity and density of biodiesel can cause some difficulties in fuel atomization and injection. Moreover, the sauter mean diameter (SMD) in biodiesels is affected at high and low injection pressures. The SMD of biodiesel is higher than that of diesel fuel and is affected by evaporation in the chamber [8]. However, these problems can be minimized by blending with diesel fuel and using some additives in the fuels [9]–[11].

The discussion of biodiesel production has been going on for almost 50 years [12]. Ramadas, et al. [13] investigated that the fuel properties in biodiesels can affect the combustion in the diesel engines. Bhikuning, et al. [14] studied that viscosity, density and surface tension in biodiesel can have effects on spray penetration, spray angle and sauter mean diameter in a constant volume chamber. Shroder, et al. [15] analyzed the emissions of soybean methyl ester compared to diesel fuel. The NOx emissions from soybean are higher than diesel fuel. However, CO_2 emission can be reduced due to oxygen content in biodiesel. Al_Dawody and Bhatti [16] investigated the combustion and emissions of soybean methyl

ester (SME) experimentally and computationally with diesel RK. The results show that SME can reduce smoke opacity up to 48.23% and has higher brake specific fuel consumption (BSFC) than diesel fuel. The simulation results show good agreement between with two fuels. Qi, et al. [17] investigated the atomization and combustion of SME and rapeseed methyl ester (RME). The results show that the liquid length and droplet size are higher for biodiesel than diesel fuel. This happened due to the surface tension and lack of evaporation due to lower vapor pressure. This can be influenced to slow down the evaporation rate in the atomization process. Aldhaidhaw, et al. [18] investigated the effect of a 20% blend of rapeseed methyl ester (B20) and diesel fuel. The results show that the brake specific fuel consumption of B20 was higher than that of diesel fuel. However, carbon monoxide and smoke emissions were lower than diesel fuel. Nevertheless, the NOx emissions were higher than diesel fuel.

In this study, the combustion and emissions of biodiesel fuels are investigated by using Diesel RK simulation. The biodiesel fuels are produced from pure rapeseed methyl ester (RME) and soybean methyl ester (SME). The objective of this study is to understand the specific fuel consumption (SFC), sauter mean diameter (SMD) and brake mean effective pressure (BMEP) as well as some emissions of RME and SME in Diesel RK simulation and compare with diesel fuel (DF).

2. Materials and Methods

2.1. Diesel RK software model

Diesel RK is a simulation software for the analysis of the thermodynamic full cycle engine. The advantage of using diesel RK is that it can calculate thermodynamic diesels running on diesel fuel, methanol, and biodiesel. In addition, it can analyze thermodynamics in SI engines, including pre-chamber fueled with natural gas, pipeline gas, wood gas, etc [19]. The RK model is capable of analyzing the piston shape and fuel injection system. Moreover, it can develop common rail control together with EGR (Exhaust Gas Recirculation) in the system [20].

2.2. Simulation method

In order to simulate the diesel RK, general parameters must be input for engine specification. **Figure 1** shows the diesel RK proceeds, first, a new project must be created by entering the engine specification. Then, the project has to be saved. After that, the operating regimes must be saved, in this section, setting the RPM in the engine, setting the ambient temperature condition, etc. Then, check the correctness of the nozzle configuration and the shape of the combustion chamber. The combustion chamber must be set and the actual piston bowl configuration entered for the engine under study. After that, the correctness of the injection characteristics must be checked. **Figure 2** shows the spray visualization at 2000 rpm and an injection pressure (P_{inj}) of 944 bar. Then, calculate the simulation and analyze the parameters.

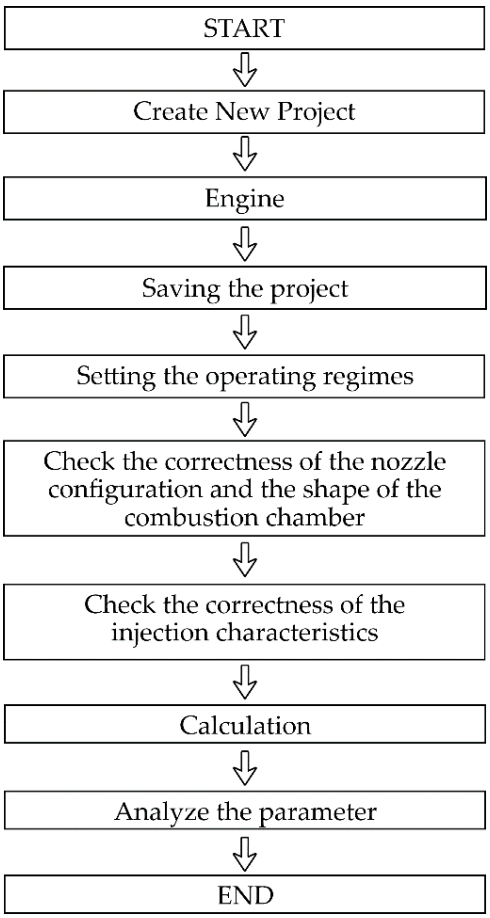

Figure 1. Diesel RK simulation

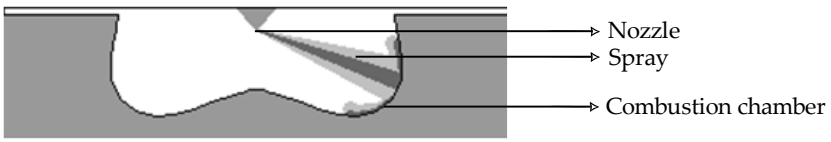

Figure 2. Spray visualization in diesel engine at 2000 rpm and P_{inj} of 944 bar

2.3. Material

Four fuels were tested in this study; diesel fuel (DF), 100% rapeseed methyl ester (RME) and 100% soybean methyl ester (SME). The fuel properties can be seen in Table 1. Density, viscosity, cetane number and surface tension of SME and RME are higher than those of diesel fuel. However, diesel fuel has a higher LHV than SME and RME. Oxygen content in diesel fuel is not present, however, RME and SME have some oxygen content which would be beneficial for biodiesel to reduce emissions.

2.4. Engine specification

In this study, the simulations were performed using the engine specification in Table 2. The engine was running at 2000 rpm and the injection pressures (P_{inj}) were simulated at 944, 1191, 1297, 1420 and 1729 bar and the injection nozzle bore was 0.123 mm.

3. Result and Discussion

3.1. Sauter Mean Diameter (SMD)

The Sauter Mean Diameter (SMD) is defined as the diameter of a sphere having the same volume and surface area ratio of small particles [21]. The SMD can be specified for spray atomization characteristics in the chamber. As can be seen in Figure 3 that the SMD for DF, RME and SME decreased with increasing injection pressure. These results are in agreement with those of Qi et al. [17] and Mahanggi et al. [22]. For comparison, at 944 bar, the SMD of RME and SME are 10,922 and 11.78 microns, respectively. At 1191 bar, the SMD of RME and SME decrease to 10.833 and 10.922 microns, respectively. And at 1729 bar, the SMD of RME and SME decreased to 9.6428 and 9.7214 microns. A small size of SMD in fuel can make evaporation in the combustion chamber easier than a large size. This is because a small size of SMD can vaporize more easily than a large size [14]. Higher SMD for RME and SME than DF due to higher viscosity, surface tension and density in biodiesel than DF. Higher viscosity may make it difficult to atomize the fuel. Therefore, spray atomization can be improved by in high injection pressures due to the small size of the fuels.

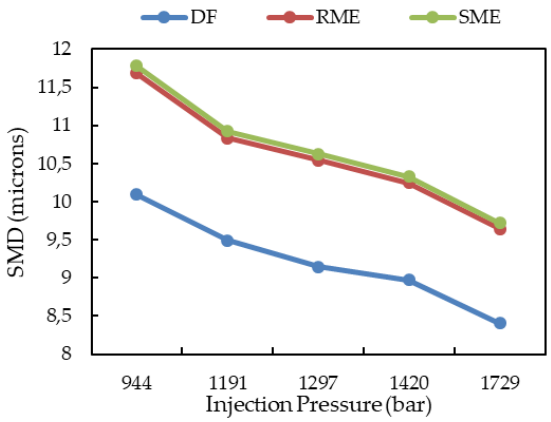

Figure 3. Sauter mean diameter (SMD) from all fuels

Table 1. Fuel properties from all fuels [20], [23]

Properties	Units	Diesel Fuel (DF)	Soybean Methyl Ester (SME)	Rapeseed Methyl Ester (RME)
LHV	MJ/kg	42.5	36.22	39.45
Density (323 K)	kg/cm^3	830	885	874
Viscosity (323 K)	PaS	0.00463	0.00692	0.00692
Cetane Number	-	48	51.3	54.4
Surface Tension (323 K)	N/m	0.028	0.0433	0.0315
Carbon Content	%	0.87	0.7731	0.77
Oxygen Content	%	0	0.1081	0.109
Hydrogen Content	%	0.126	0.1188	0.121

Table 2. Engine specification [7]

Type		Supercharged direct-injection single cylinder, 4 stroke
Bore x Stroke	[mm]	85 x 96.9
Displacement	[cm^3]	550
Compression ratio		16.3
Fuel injection system		Common rail
Number of holes		7
Injection nozzle hole	[mm]	0.123
Injection pressure	[bar]	944, 1191, 1297, 1420, 1729
Engine speed	[rpm]	2000

3.2. Engine performance

3.2.1. Specific fuel consumption

The specific fuel consumption (SFC) of all fuels can be seen in **Figure 4**. It can be shown that the specific fuel consumption for diesel fuel in does not show too many differences at injection pressures. These results are in agreement with those of Bakar et al. [24]. This is due to the fact that the density and viscosity of diesel fuel is lower than that of biodiesel fuel. However, the specific fuel consumption for DF may decrease to 0.23% when the injection pressure ranges from 1420 bar to 1729 bar. This is because the higher Injection pressures can make the particles of the fuel smaller and facilitate evaporation. Moreover, the specific fuel consumption for RME and SME decreased with increasing injection pressure. These results are consistent with those of other studies from Mahanggi e al. [22] and Kim et al. [25]. At low injection pressure (944 bar), the specific fuel consumption of SME and RME are higher than DF. This is due to the fact that viscosity and density of SME and RME are higher than those of DF. Higher viscosity and density can cause the particles of the fuels to be larger and difficult to evaporate. This can cause the engine to have low power and higher specific fuel consumption. At an injection pressure of 1729 bar, the specific fuel consumption for RME and SME decreased by up to 8.03% and 5.78%, respectively, compared to an injection pressure of 944 bar. This is due to the fact that as the injection pressure increases, the particles of the fuels are smaller and can cause better the combustion due to good atomization in the engine.

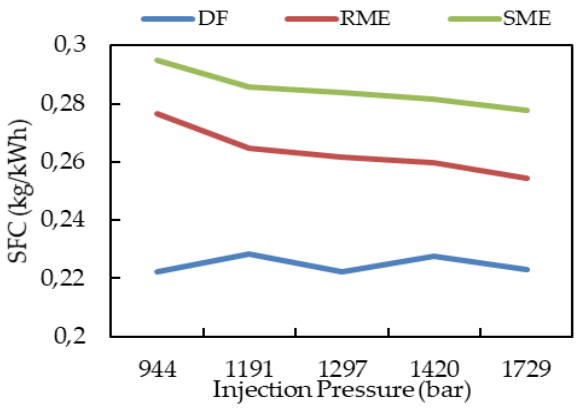

Figure 4. Specific fuel consumption from all fuels

3.2.2. Brake Mean Effective Pressure

Figure 5 shows the brake mean effective pressure (BMEP) of all fuels. It can be seen that the BMEP of DF remained constant with increasing injection pressures. Nevertheless, the BMEP for RME and SME increased with increasing injection pressure. These results are in agreement with those of Kim et al. [25] and Bakar et al. [24]. This happened because by increasing the injection pressures, the diameter of the fuels (SMD) becomes smaller, this can improve the fuel -air mixing in the combustion chamber [17] and the fuels can be burnt more easily. Compared with the injection pressure of 1729 bar, the BMEP of RME and SME was increased up to 7.67% and 5.42% from the injection pressure of 944 bar, respectively. The increase in BMEP value at high injection pressure is due to the improved combustion as the SMD of RME and SME can be easily vaporized.

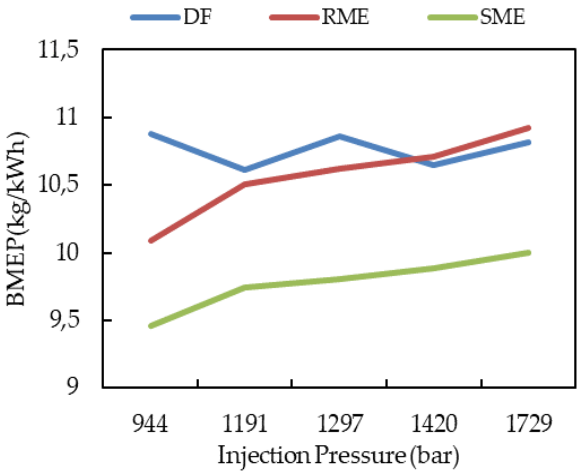

Figure 5. Brake mean effective pressure from all fuels

3.3. Emissions

3.3.1. CO_2

The CO_2 emissions of all fuels can be shown in **Figure 6**. Diesel fuel has the lowest CO_2 emission than RME and SME. However, in this study, RME and SME are 100% biodiesel without blending with DF. Therefore, the values of CO_2 emissions of pure RME and SME are still high compared to DF. In addition, CO_2 emission are not legally required emissions, but are usually counted in regular engine emissions tests to understand the fuel consumption in the engine [26].

As can be seen in **Figure 6**, the value of CO_2 emission remained constant for diesel fuel, which shows that higher injection pressures have no effect for DF. On the other hand, for RME and SME, the value of CO_2 decreased with increasing injection pressure. These results are in agreement with other studies by Kim et al. [25], Canakci et al.

[27], and Yoon e al. [28]. The value of CO_2 emissions of RME decreases up to 8,03% from injection pressure 944 bar to 1729 bar. Moreover, the CO_2 emissions of SME are reduced by up to 5.78% from injection pressure 944 bar to 1729 bar. The reduction in CO_2 emissions is due to the oxygen content in RME and SME. The oxygen content in biodiesel can cause complete combustion, which can prolong the mixing in the combustion chamber [29]–[31].

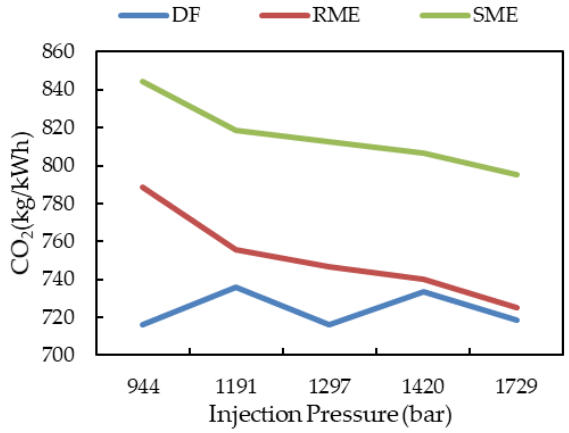

Figure 6. CO_2 emissions from all fuels

3.3.2. Particulate Matter (PM)

Particulate emissions in this study can be seen in **Figure 7.** As the injection pressure increased, the PM emissions decreased. This study is in agreement with Yoon et al. [28] and Kim et al. [25]. The SMD and viscosity of RME and SME are larger than those of diesel fuel. However, as the injection pressure increases, the diameter of the fuels of RME and SME becomes smaller. This phenomenon is due to the fact that when the diameter of the fuels is smaller, the atomization is improved, and the fuels vaporize more easily, leading to faster combustion, which decreases the PM emissions. The faster vaporization rate may cause a lower ignition temperature as the thermal energy is converted to latent heat for phase change during vaporization [32]. PM emissions for RME at an injection pressure of 1729 bar can be down up to 30.45% than at injection pressure of 944 bar. In addition, PM emissions of SME at an injection pressure of 1729 bar can decrease to 32.9% compared to the injection pressure of 944 bar.

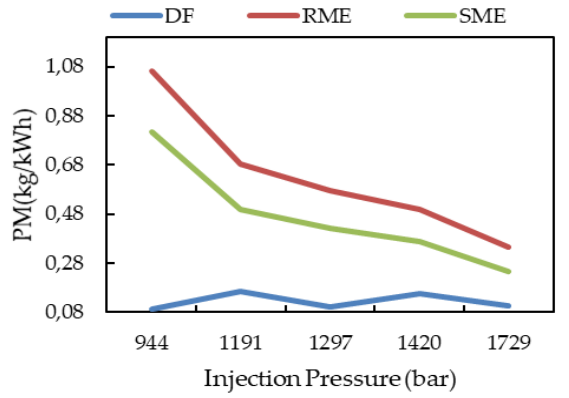

Figure 7. Particulate matter in all fuels

4. Conclusion

In this study, the simulation between DF, RME and SME was investigated by using Diesel RK. The result shows that as the injection pressure increases, the spray atomization can be improved. This happened because at higher injection, the fuel droplet diameter decreased. Therefore, the small fuel droplets can evaporate easily, resulting in faster combustion during combustion process. Pure biodiesel without blending RME and SME has good results in engine performance and emissions when injection pressures are increased. Therefore, it is recommended to run biodiesel fuel at higher injection pressure to improve atomization and combustion when operating in diesel engines.

Acknowledgement

The author would like to grateful for Mechanical Engineering Department, Trisakti University for their support.

Author's Declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

Funding

No funding information from the author.

Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interest.

Additional information

No additional information from the authors.

References

[1] A. Bhikuning, E. Matsumura, and J. Senda, "A review: non-evaporating spray characteristics of biodiesel Jatropha and palm

oil and its blends.," *International Review of Mechanical Engineering*, vol. 12, no. 4, pp. 364–370, 2018.

[2] M. Aldhaidhawi, R. Chiriac, and V. Badescu, "Ignition delay, combustion and emission characteristics of Diesel engine fueled with rapeseed biodiesel–A literature review," *Renewable and Sustainable Energy Reviews*, vol. 73, pp. 178–186, 2017.

[3] A. Bhikuning and M. Hafnan, "Biodiesel Production from Cerbera Manghas Using Different Catalyst; NaOH and Zeolite," *Journal of Clean Energy Technologies*, vol. 7, no. 2, 2019.

[4] A. Bhikuning, "Analisa performa mesin dengan biodiesel terbuat dari virgin coconut oil pada mesin diesel," *Jurnal Energi dan Manufaktur Vol*, vol. 6, no. 2, pp. 95–200, 2013.

[5] D. Ayu, R. Aulyana, E. W. Astuti, K. Kusmiyati, and N. Hidayati, "Catalytic Transesterification of Used Cooking Oil to Biodiesel: Effect of Oil-Methanol Molar Ratio and Reaction Time," *Automotive Experiences*, vol. 2, no. 3, pp. 73–77, 2019, doi: 10.31603/ae.v2i3.2991.

[6] A. Kolakoti, M. Setiyo, and B. Waluyo, "Biodiesel Production from Waste Cooking Oil: Characterization, Modeling and Optimization," *Mechanical Engineering for Society and Industry*, vol. 1, no. 1, pp. 22–30, 2021.

[7] A. Bhikuning, X. Li, S. Koshikawa, E. Matsumura, and J. Senda, "An experimental investigation of bio-hydro fined oil and waste cooking oil in direct injection diesel engine," *Harris Sci. Rev. Doshisha Univ.*, vol. 60, no. 3, pp. 133–140, 2019.

[8] H. K. Suh and C. S. Lee, "A review on atomization and exhaust emissions of a biodiesel-fueled compression ignition engine," *Renewable and Sustainable Energy Reviews*, vol. 58, pp. 1601–1620, 2016.

[9] S. Pambudi, N. Ilminnafik, S. Junus, and M. N. Kustanto, "Experimental Study on the Effect of Nano Additives γAl2O3 and Equivalence Ratio to Bunsen Flame Characteristic of Biodiesel from Nyamplung (Calophyllum Inophyllum)," *Automotive Experiences*, vol. 4, no. 2, pp. 51–61, 2021.

[10] H. Y. Nanlohy, H. Riupassa, I. M. Rasta, and M. Yamaguchi, "An Experimental Study on the Ignition Behavior of Blended Fuels Droplets with Crude Coconut Oil and Liquid Metal Catalyst," *Automotive Experiences*, vol. 3, no. 2, 2020.

[11] E. Marlina, M. Basjir, M. Ichiyanagi, T. Suzuki, G. J. Gotama, and W. Anggono, "The Role of Eucalyptus Oil in Crude Palm Oil As Biodiesel Fuel," *Automotive Experiences*, vol. 3, no. 1, pp. 33–38, 2020.

[12] G. Knothe, J. Krahl, and J. Van Gerpen, *The biodiesel handbook*. Elsevier, 2015.

[13] A. S. Ramadhas, S. Jayaraj, and C. Muraleedharan, "Use of vegetable oils as IC engine fuels—a review," *Renewable energy*, vol. 29, no. 5, pp. 727–742, 2004.

[14] A. Bhikuning, R. Sugawara, E. Matsumura, and J. Senda, "Investigation of spray characteristics from waste cooking oil, bio-hydro fined diesel oil (BHD) and n-tridecane in a constant volume chamber," *Case Studies in Thermal Engineering*, vol. 21, p. 100661, 2020.

[15] O. Schröder *et al.*, "Emissions from diesel engines using fatty acid methyl esters from different vegetable oils as blends and pure fuel," in *Journal of Physics: Conference Series*, 2012, vol. 364, no. 1, p. 12017.

[16] M. F. Al_Dawody and S. K. Bhatti, "Experimental and computational investigations for combustion, performance and emission parameters of a diesel engine fueled with soybean biodiesel-diesel blends," *Energy Procedia*, vol. 52, pp. 421–430, 2014.

[17] W. Qi, P. Ming, A. Jilani, H. Zhao, and M. Jia, "A comparison of spray and combustion characteristics of biodiesel (soy methyl ester, rapeseed methyl ester) with diesel," *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, vol. 233, no. 7, pp. 1712–1723, 2019.

[18] M. Aldhaidhawi, L. Miron, R. Chiriac, and V. Badescu, "Autoignition process in compression ignition engine fueled by diesel

fuel and biodiesel with 20% rapeseed biofuel in diesel fuel," *Journal of Energy Engineering*, vol. 144, no. 5, p. 4018049, 2018.

[19] V. V Pham, "Research on the application of Diesel-Rk in the calculation and evaluation of technical and economic criteria of marine diesel engines using the unified ULSD and Biodiesel blended fuel," *J. Mech. Eng. Res. Dev*, vol. 42, no. 2, pp. 87–97, 2019.

[20] M. F. Al-Dawody and S. K. Bhatti, "Effect of soybean oil biofuel blending on the performance and emissions of Diesel engine using diesel-rk software," *International journal of engineering science and technology*, vol. 3, no. 6, pp. 4539–4555, 2011.

[21] D. Wang and L.-S. Fan, "Particle characterization and behavior relevant to fluidized bed combustion and gasification systems," in *Fluidized bed technologies for near-zero emission combustion and gasification*, Elsevier, 2013, pp. 42–76.

[22] A. A. K. Mahanggi, B. Sudarmanta, and H. Soebagyo, "Experimental Study on Effect of Injection Pressure to Spray Characteristics, Performance and Emissions of DieselEngine DI 20 C Using Biodiesel Fuel," *The International Journal of Mechanical Engineering and Sciences*, vol. 2, no. 1, pp. 18–25, 2018.

[23] M. F. Al-Dawody, A. A. Jazie, and H. A. Abbas, "Experimental and simulation study for the effect of waste cooking oil methyl ester blended with diesel fuel on the performance and emissions of diesel engine," *Alexandria Engineering Journal*, vol. 58, no. 1, pp. 9–17, 2019.

[24] R. A. Bakar, S. Ismail, and A. R. Ismail, "Fuel injection pressure effect on performance of direct injection diesel engines based on experiment," *American Journal of Applied Sciences*, vol. 5, no. 3, pp. 197–202, 2008.

[25] H. Y. Kim, J. C. Ge, and N. J. Choi, "Effects of fuel injection pressure on combustion and emission characteristics under low speed conditions in a diesel engine fueled with palm oil biodiesel," *Energies*, vol. 12, no. 17, p. 3264, 2019.

[26] P. McCarthy, M. G. Rasul, and S. Moazzem, "Comparison of the performance and emissions of different biodiesel blends against petroleum diesel," *International Journal of Low-Carbon Technologies*, vol. 6, no. 4, pp. 255–260, 2011.

[27] M. Canakci, C. Sayin, A. N. Ozsezen, and A. Turkcan, "Effect of injection pressure on the combustion, performance, and emission characteristics of a diesel engine fueled with methanol-blended diesel fuel," *Energy & Fuels*, vol. 23, no. 6, pp. 2908–2920, 2009.

[28] S. K. Yoon, J. C. Ge, and N. J. Choi, "Influence of fuel injection pressure on the emissions characteristics and engine performance in a CRDI diesel engine fueled with palm biodiesel blends," *Energies*, vol. 12, no. 20, 2019, doi: 10.3390/en12203837.

[29] 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," *Egyptian journal of petroleum*, vol. 28, no. 2, pp. 183–188, 2019.

[30] K. Muralidharan, D. Vasudevan, and K. N. Sheeba, "Performance, emission and combustion characteristics of biodiesel fuelled variable compression ratio engine," *Energy*, vol. 36, no. 8, pp. 5385–5393, 2011.

[31] A. Bhikuning, X. Li, S. Koshikawa, E. Matsumura, and J. Senda, "The Experimental Investigation of the Performance and Emissions Characteristics of Direct Injection Diesel Engine by Bio-Hydro Fined Diesel Oil and Diesel Oil in Different EGR," SAE Technical Paper, 2020.

[32] E. Marlina, W. Wijayanti, L. Yuliati, and I. N. G. Wardana, "The role of pole and molecular geometry of fatty acids in vegetable oils droplet on ignition and boiling characteristics," *Renewable Energy*, vol. 145, pp. 596–603, 2020.