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RESEARCH ARTICLE

EFFECTS OF AMBIENT PRESSURE IN A CONSTANT VOLUME SPRAY CHAMBER ON THE CHARACTERISTICS OF BIODIESEL-MIXED SPRAYS

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ABSTRACT

The output of diesel engine combustion is strongly influenced by the characteristics of the fuel spray. An important role in the process of forming a mixture of fuel and air is to develop the characteristics of fuel spray, which will directly affect the combustion and emissions process. The characteristics of fuel spray depend on fuel injection pressure, fuel viscosity, fuel density, ambient pressure, and temperature. Among the parameters that are very important and directly affect the shape of the spray is ambient pressure. With injection pressure set at 200 Bar and all experiments with spray pressure chamber 1 Bar, 4 Bar, 7 Bar and 9 Bar. This study investigated the effect of ambient pressure on spray characteristics such as spray tip penetration, cone angle, spray time and spray area in constant volume spray chamber by using spray visualization. Biodiesel from nyamplung oil was varied in this study BD 20 (20% nyamplung oil, 80% diesel oil), BD 40 (40% nyamplung oil, 60% diesel oil), BD 60 (60% nyamplung oil, 40% diesel oil) and pure diesel D 0. The record of fuel mixture was immortalized using a high-speed camera, iso speed 800, exposure time 1/125 sec. The results fo the macro-analysis showed that with increasing spray pressure level will cause spray tip penetration decreases but cone angle and spray area will increase. BD 60 gives penetration of the longest spray tip, cone angle and spray area widest while BD 20 and D 0 diesel have similar sprayed characteristics.

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INTRODUCTION

Diesel oils as fossil fuels are limited in number and non-renewable, not because of the high demand of the market, but also because the rate of oil formation is very long, takes millions of years and long will run out (Prasodjo *et al*., 2016). Seed nyamplung (Calophyllum inophyluum) is selected as an alternative fuel and renewable as a substitute for fossil fuels The selection of nyamplung seeds as a fuel (biodiesel) in its utilization does not compete with food/food security (Kartika, 2013). weakness nyamplung seed oil has a high viscosity of 5.88 mm^2/s compared to diesel oil 4.5 mm^2/s. Seed nyamplung oil from 12 populations in Indonesia has high rendemen variation between 37-58% (Leksono *et al*., 2014), compared tojatropha curcas25-40%, forest saga 14-28%, kepuh 24-40% , kesambi 30-40% and kelor 39-40% (Sudrajad, 2005). Seeds of nyamplung 2-2.5 kg can produce a liter of nyamplung oil, while the jatropha curcas to produce one liter of oil requires 4 kg (Sudrajat, 2010b). Fuel spray characteristics are a consequence of the two-phase complex process flow when fuel is injected (Nanthagopal *et al*., 2016).

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Fuel spray experiments are visualized and captured in high volume constant pressure chambers. A macroscopic analysis of spray images was performed to investigate the characteristics of sprays such as spray tip penetration, cone angles, and spray areas. Spray tip penetration is defined as the spray length between the nozzle and the farthest spray tip. The position of the nozzle can be known then the extreme point of the spray tip penetration can be found (Park *et al*., 2009). The spray angle is defined as the angle between two nozzle tips connecting lines with two spray tip penetration points. The spray area is defined as an area covered by fuel spray in the combustion chamber (pressure spray chamber and high temperature) (Jing *et al*., 2016). Investigator effects of fuel injection pressure increased then spray tip penetration also increased (Park, 2003). A similar study was conducted on the in-cylinder pressure effect of Dimethyl ether (DME) and diesel with high ambient pressure as a result of decreasing spray tip penetration and wide spray angle due to high density (Suh, 2008). The reduced spraying momentum causes slowing of spray development due to the effects of ambient temperature and pressure on the spray tip is fuel injection pressure resulting in longer spray tip penetration and width (Lee, 2017).

Research on the characteristics of karanja biodiesel (KB) biodiesel blends with diesel in high volume constant spray chamber with the result of increased ambient pressure penetration of spray tip decreased and cone angle and spray area increased. Due to the difference in fuel density KB100 provides penetration of spray tip, cone angle and highest spray area whereas KB20 spray characteristics resemble solar (Agarwal, 2012). The characteristics of spray granules of biodiesel blends which are not purified by diesel show the same pattern, regardless of the biodiesel blending ratio. The performance of the biodiesel blend of biodiesel grains is lower than diesel fuel because of the relatively higher surface tension of biodiesel (Gao *et al*., 2009). High viscosity fuels tend to form larger droplets at the tip of the injector causing poor fuel spray grains to increase in the tip of the spray penetration and decrease of the spray angle, resulting in poor combustion which ultimately increases the exhaust emissions and smoke opacity tends to form engine precipitates (Fatah *et al*., 2014).

Research Objective

Knowledge of the spray characteristics of biodiesel and its mixtures so far has long been known but limited. One of the difficulties of spray biodiesel characterization experimentation is a very dynamic phenomenon such as biodiesel feedstock, high injection pressure, temperature conditions and spray room pressure. This study investigated the effect of ambient pressure on spray characteristics such as spray tip penetration, cone angle, spray time and spray area in constant volume spray chamber by using spray visualization.

RESEARCH METHODOLOGY

The preparation of spray visualization experiments to investigate the form of biodiesel spray is shown in Figure 1. Materials needed for this research seed nyamplung oil and diesel oil (Pertamina production is solar dex) are already known for its nature.

long steel strip length 60 cm, High-speed camera used to record images at 60 fps (maximum) with F image -stop 1 / 1.8, Exposure time 1/125 sec, Focal length 50 m (640 - 480 pixels), USB cable and computer. Biodiesel from nyamplung oil and diesel oil mixed with a variation of BD 20 (20% nyamplung oil and 80% diesel oil), BD 40 (40% nyamplung oil and 60% diesel oil), BD 60 (60% nyamplung oil and 40% oil diesel fuel) and pure diesel fuel D 0. The fuel is supplied from the fuel tank to the nozzle using a fuel pump with an injection pressure set at 200 bar (standard 1 cylinder diesel engine). All spray experiments were performed on the visualization box with spray pressure chamber of 1 Bar, 4 Bar, 7 Bar and 9 Bar. The injector used in the experimental setup is a mechanical nozzle. The fuel is injected by the injector into the spray visualization box toward the axial at a constant volume. The spray chamber is designed to withstand air pressure up to 9 Bar obtained from air compressors.

The compression tester is mounted above the visualization box to measure the pressure of the visualization space. The visualization box has two windows made of clear acrylic material. The first window is used for spray visualization spray lighting. While the second window is used to capture images in various experimental conditions. A halogen white light source is used as a light source in the spray visualization room. A white light source is placed on top of the box on one of the windows, so that very intense light rays can illuminate the desired area in the spray room. The steel ruler is placed in front of the second window as a spray length guide. The camera is placed in front of the visualization box at a distance of 1.5 m right at the centerline of the optical window, precisely 90 degrees from the window with a white light source. Images captured with high-speed cameras and stored in micro SD memory. The camera is also connected to the data acquisition system with the help of a USB cable to the computer. The "Streampix v.3" mode software, used for processing images in single shot mode or video mode. The time interval between images is 0.01 ms, all images were taken after 1/60 ms.

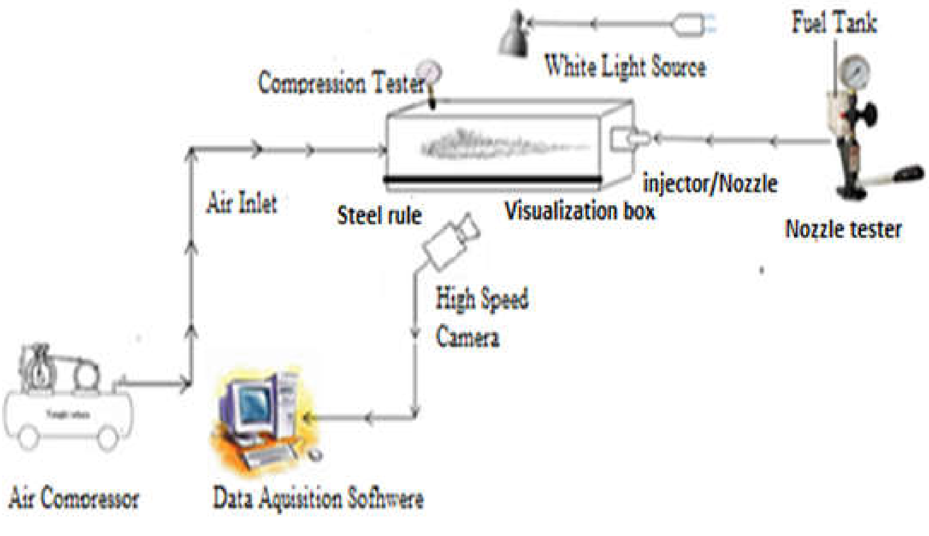

Figure 1. Experiment setup scheme

Tools for experimenting; simple fuel pump (Nozzle Tester), spray visualization box (length 60 cm x 15 cm width and plate thickness 2 mm), injector/mechanical nozzle with three holes (0.29 mm diameter) located 120 degrees and nozzle tip diameter 26 mm, air compressor ¼ HP Gasoline, Compression tester, clear acrylic 5 mm thick, halogen lamp (45 Watt), 2 cm

Three pictures are recorded for each occurrence once the injection pressure into the computer device. Experiments were carried out at four different chamber pressures (1, 4, 7 and 9 bars) to observe effect of chamber pressure spray tip penetration, spray cone angle, and spray area Figure 2. Before the experiment to know the physical properties of fuel that is density and kinematic viscosity should be measured, because it is very critical and affect the spray characteristics in Table 1.

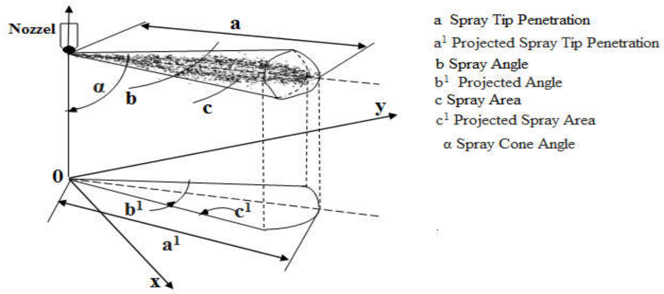

Figure. 2. Investigation of (a) spray tip penetration, (b) spray cone angle, (c) spray area (Park, 2009; Jing *et al*., 2016)

RESULTS AND DISCUSSION

Spray penetration

The determination of a spray tip is the maximum penetration length obtained from the tip of the spray after the commencement of the injection. The speed of the camera determines the focus of the image from the tip of the spray penetration.

Table 1. Fuel characteristics of biodiesel and fossil diesel mixtures

Type of Fuel	Density (mPa/s) at 40^0C	Kinematic viscosity (mm^2/s) at 40^0C
Solar D 0	2,5501	3,0738
BD 20	2,8956	3,4956
BD 40	2,8992	3,5034
BD 60	2,9128	3,5142

(Source: (14))

The spray length comparison with spray time is shown in Figure 3. Spray penetration for biodiesel blends under experimental conditions with the same injection pressure. Penetration of the spray tip rises as the spray ambient pressure increases for all test fuel (Figure 4).

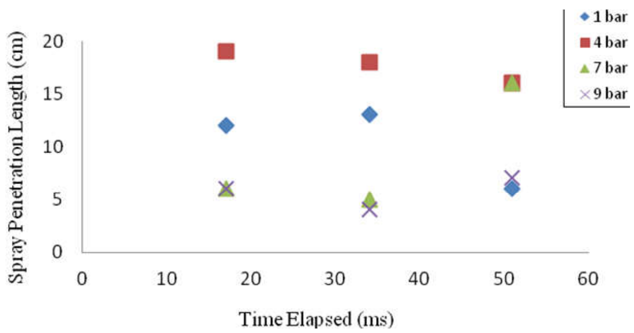

Figure 3. Length of spray evolution for Solar Dex of different chamber pressure

The spray pressure increase from 1 Bar to 9 Bar increases the air density in the spray chamber. Biodiesel BD 60 penetration of the longest spray tip while diesel D 0 shortest. The fuel spray at the tip of the nozzle gets a higher shear resistance due to the denser air pressure in the spray chamber. Spray velocity initially increases while at the end of the spray is hampered because spray pressure increases, resulting in decreased spray time.

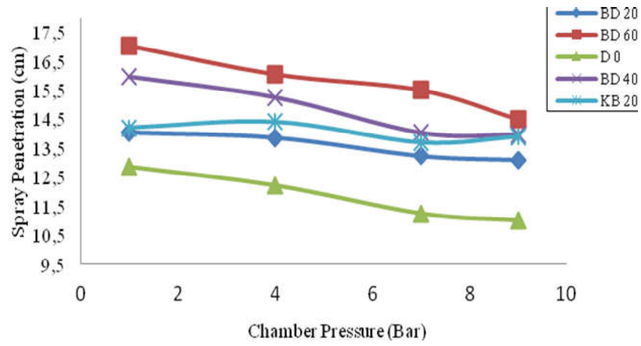

Figure 4. Comparison of spray length of nyamplung and diesel fuel biodiesel with spray pressure chamber 1Bar, 4 Bar, 7 Bar and 9 Bar

Spray tip penetration for all experiments means decreases at all spray chamber pressure (Figure 4). Biodiesel nyamplung D 60 is the slowest spray time, because of the density and viscosity of the largest biodiesel among all test fuels, so the atomization at D 60 is slower than that of other test fuels. D0 diesel oil has the fastest spray tip penetration followed by, BD 20 and BD 40 under ambient spray ambient pressure conditions. The largest viscosity of BD 60 biodiesel mixture does not affect the spray length, but it affects the longest spray time. The mixture of biodiesel nyamplung BD 20 and karanja biodiesel KB 20 (12) at the same spray pressure spray found penetration spray tip almost the same as diesel D 0.

Spray cone angle

The conical angle is defined as the largest angle formed by two straight lines from the nozzle end to the spray boundary. The spray cone angle for biodiesel and mixtures under experimental conditions is shown in Figure 5.

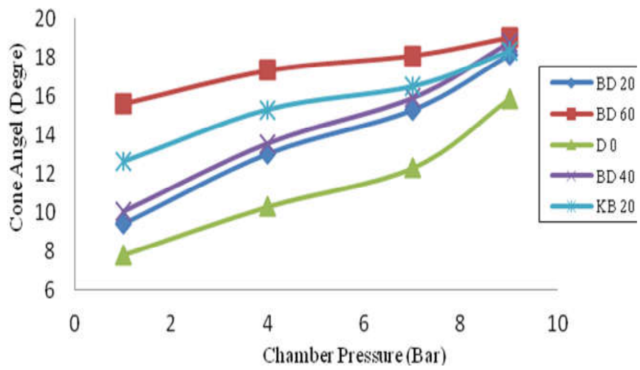

Figure 5. Comparison of spray angle of a mixture of biodiesel and solar nyamplung with spraychamber pressure1 Bar, 4 Bar, 7 Bar and 9 Bar

The results show that the spray angle widens as the spray pressure increases. At the 9 Bar spaces pressure spray (Figure 5), the ambient spray ambient density is very high resulting in an enlarged spray angle. Fuel sprays have very high initial speed due to lower resistance of the surrounding environment. The fuel spray is faster along the radial axis and this is the reason why the small spray angle for all fuel tests is at 1 Bar spray chamber pressure. Spray chamber pressure increases the spray density as well as rises near the midline of the spray. Increased shear resistance in the spray chamber as a result of spray chamber pressure the fuel spray pressure so that it will affect the enlarged spray angle in proportion to the increased spray chamber pressure.

Figure 5 At spray chamber pressure 1Bar spray BD 60 most wide while the smallest spray angle is D 0. Solar D 0 has the lowest viscosity compared to the other test material. The greater viscosity affects the enlarged spray angle shape. The ambient pressure of the spray chamber is increasing as the larger spray angle for all the biodiesel blends. Biodiesel nyamplung BD 20 compared to the karanja biodiesel KB 20 (Agarwal, 2012) at ambient pressure spray chamber 9 Bar spray angle form the same.

Spray area

The spray area is defined as an area covered by fuel spray in the combustion chamber (high-pressure spray chamber). The spray area for mixed nyamplung biodiesel with diesel in spray experiment with spray chamber pressure varies. shown in Figure 6.

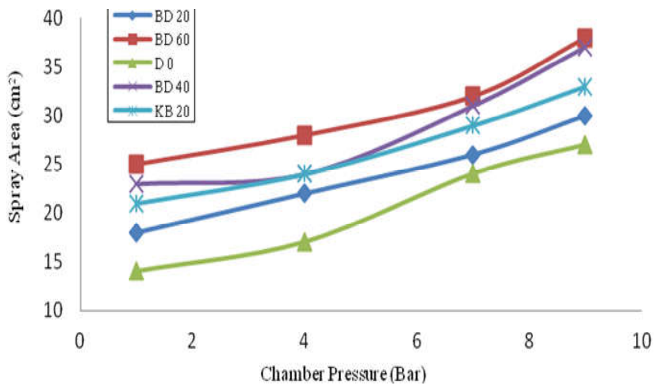

Figure 6. Spray area for biodiesel BD 20, BD 40, BD 60 and diesel D0 at spray chamber pressure 1 Bar, 4 Bar, 7 Bar and 9 Bar.

As the spray angle increases, the spray area is larger, except for BD 40 biodiesel. The lowest solar spray area is compared to other test fuels. The reason for this is the same as described earlier for the spray angle. At the spray bar pressure of 1 Bar, the spray area of BD 60 biodiesel mixture of long and wide spray area (penetration of long spray tip and wide spray angle), compared to diesel D 0 small angle and short spray tip penetration (Figure 6), due to solar density and the viscosity is relatively low. The higher density and viscosity of the biodiesel blends lead to larger spray formations, which affect the higher inertia causing poor atomization compared to diesel. Increased spray chamber pressure. The amount of fuel droplets increases concentration near the end of the spray. Fuel sprays face higher shear resistance due to higher room pressure and higher spray momentum forcing the fuel to move radially outward. As spray pressure increases from 1 Bar to 9 Bar, the fuel spray experiences a higher force that presses air into the pressurized space. As a result, the spray moves forward (elongated), the spray is concentrated in the center. At the end of the spray begins to move out radially because of the shear resistance that occurs on the surface, the spray tends to rupture and is converted to fine droplets thus increasing the number of droplets widening in the spray end. The results are shown at the injection pressure of 200 bar BD 40 spray width area (penetration of long spray tip and small spray angle), compared to BD 20 and D 0. Higher viscosity effect on spray area, according to the above explanation related to injection pressure. Biodiesel nyamplung BD 20 and karanja biodiesel KB 20 (Agarwal, 2012) spray area resemble with diesel D 0 at all ambient spray pressure chamber due to low mixed viscosity.

Conclusion

The characteristic of spray is strongly influenced by two main properties of fuel that is density/density and viscosity. Before experiments variation of biodiesel mixture with diesel must be seen its nature that is viscosity and density so that result of spray fuel mixed characteristic in chamber pressure (ambient spray) influence or not. Spray visualization experiments were performed with constant fuel injection pressure at 200 Bar. Whereas spray visualization pressure spaces from (1 Bar to 9 Bar). Spray characteristics investigated where spray tip penetration, spray cone angle and spray area at ambient spray. It was concluded that the penetration of the spray tip decreased with increasing ambient pressure. BD 60 nyamplung biodiesel has the longest spray penetration tip followed by BD 40 and BD 20 under spray chamber pressure conditions that are varied.

At the same spray pressure spray biodiesel, BD 20 spray penetration is almost the same as diesel D 0. The conical spray angle increases as spray pressure increases as the resistance of droplets from ambient air increase. The speed of the spray is determined by the viscosity of the fuel mixture. Solar D 0 has the lowest viscosity compared to other test materials. At the same ambient pressure spray, the BD 20cone angle of the graph resembles diesel D 0. At 1 Bar spray pressure, wide spray area at BD 60 when compared to pure diesel D 0 has the smallest spray area. Higher viscosity and increased ambient pressure greatly affect the spray tip penetration characteristics, spray cone angle and spray area.

REFERENCES

Agarwal, A. K., Chaudhury, V. H. 2012. “Spray characteristics of biodiesel/blends in a high pressure constant volume, spray chamber” Experimental Thermal and Fluid Science (42): 212–218

Fatah, L.M.R., Marjuki, H.H., Kalam, M.A., Wakil, M.A., Ashraful, A.M., Shahir, S.A. 2014. “Experimental investigation of performance and emissions of a diesel engine with Calophyllum inophyllum biodiesel blends accompanied by oxidation inhibitoer” Energy Conversion and Management, (83): 232 – 240.

Gao, Y., Deng, J., Li, C., Dang, F., Liao, Z., Wu, Z., Li, L. 2009. “Experimental study of the spray characteristics of biodiesel based on inedible A” Biotechnology Advances, (27): 616–624.

Jing, W., Wu, Z., William L. Roberts, T. Fang, 2016. “Spray combustion of biomass-based renewable diesel fuel using multiple injection strategy in a constant volume combustion chamber,”Fuel, (181): 718–728.

Kartika, I.K., Fathiyah, S. Desrial, 2013. “Pemurnian Minyak Nyamplung dan Aplikasinya Sebagai Bahan Bakar Nabati,” Skripsi, Bogor, Fakultas teknologi pertanian IPB Bogor

Lee, S., Lee, C. S., Park, S., Gupta, J. G., Maurya, R. K., Agarwal, A. K. 2017. “Spray characteristics, engine performance and emissions analysis for Karanja biodiesel and its blends,” Energy, (119): 138 – 151.

Leksono, B., Windyarini, E., Hasnah, T. M. 2014. “Budidaya Nyamplung (Calophyllum inophyllum L.) Untuk Bioenergi Dan Prospek Pemanfaatan Lainnya”Penerbit IPP Press, Kampus IPB Taman Kencana, Kota Bogor-Indonesia KEMENTERIAN KEHUTANAN, c1/11

Nanthagopal, K. Ashok, B., Raj, R.K.2016. “Influence of fuel injection pressures on Calophyllum inophyllum methyl ester fuelled direct injection diesel engine,”Energy Conversion and Management,(116): 165–173.

Park, S.H., Hyung, J.K., Suh, H.K., Lee, C.S. 2009. “A study on the fuel injection andatomization characteristics of soybean oil methyl ester (SME)”Heat and Fluid Flow.(30): 108–116.

Park, S.W., Lee, C.S. 2003. ”Macroscopic structure and atomization characteristics of high-speed diesel spray” Automotive Technology, (4): 157–164.

Prasodjo, E., Nurzaman, H., Walujanto, D. Rosdiana, P. Ismutadi, C. Malik, J. Santosa, A.Nurrohim, K. D. Widiastuti, S. H. Pambudi, J. L. Wibowo, A. Sauqi, 2016. “Outlook Energi Indonesia” Sekretariat Jendral Dewan Energi Nasional.

Sudrajad, R., Setiawan, D. 2005. “Biodiesel dari tanaman jarak pagar sebagai energi alternatif untuk pedesaan. Seminar Hasil Litbang Hasil Hutan,” Pusat Litbang Hasil Hutan. Bogor. Hal. 207-219.

Sudrajat, R., Pawoko, E., Hendra, D., Setiawan. D. 2010b. “Pembuatan biodiesel dari biji kesambi (Schleichera oleosa L),” Jurnal Penelitian Hasil Hutan, , Vol.28 (4): 358-379.

Suh, H.K., Lee, C.S. 2008. “Exsperimen taland analytical study on the spray characteristics of dimethyl ether (DME) and diesel fuels within a commonrail injetion system in a diesel engine,” fuel, (87) : 925 – 932

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