Tạp chí Khoa học và Công nghệ, Số 40, 2019

SPRAY VISUALIZATION OF HYDROTREATED VEGETABLE OIL UNDER SIMULATED DIESEL ENGINE CONDITION

VO TAN CHAU
Industrial University of Ho Chi Minh City
votanchau@iuh.edu.vn

Abstract. The diversity of alternative fuels and the corresponding variation in their physical and chemical properties, coupled with simultaneous changes in advanced techniques for CI-engine, needed to improve engine efficiency and emissions. Hydrotreated Vegetable Oil (HVO), seen as a promising substitution for petrol-diesel, and diesel fuel (mixed of 7% palm-biodiesel or B7) were analyzed on fuel properties. Then, the influence of these fuel properties on spray characteristics in constant volume combustion chamber were evaluated under conditions of single hole injector of 200μm diameter, injection pressure of 100MPa, constant back pressure of 4.0MPa and energizing time of 2.5ms. The results show that HVO had smaller in viscosity (18.48%), density (5.52%), sulfur content, distillation under T50, T90 and higher in derived cetane index (27.2%), heating value (2.2%), respectively, compared to diesel. Spray characteristics of HVO had the same propensity with diesel fuel. HVO revealed a slightly shorter in penetration length (5%) during fully developed zone, a larger spray cone angle (from 0.2 to 1.1 degree wider in quasi-steady state). Both fuels had a similar maximum spray velocity reaching at 5mm to 10mm from nozzle orifice. Also observed was an increase in spray volume of HVO.

Keywords. Hydrotreated vegetable oil, Common-rail, Diesel engine, Spray characteristics, Diesel exhaust emissions.

1 INTRODUCTION

Diesel exhaust gas emissions contribute to environmental contamination, especially NO_x and soot emission. To meet the emission assessment standards that most countries are applying, the reduction of diesel emissions is considered as priority requirements in diesel engine studies. The fuel injection process is one of many factors poses major influence on the fuel dispersion of the fuel droplet, the fuel spray formation, the mixing and development of the charge gas mixture then the combustion process in cylinders and the forming process of emissions which are released to the environment. Therefore, diesel injection features studies provide a basic and in-depth understanding about the impact of fuel properties (viscosity, molecular density, surface tension, fuel bulk modulus of compressibility, etc.), the injector geometry (the nozzle diameter of injector, the number of nozzle holes, the geometry of nozzle hole, etc.), the operating parameters of the spraying process (fuel injection pressure, injection quantity, injection timing, injection strategy in a cycle, etc.) to the formation and development of fuel spray in the combustion chamber (spray penetration, angle fuel spray, volume of spray, velocity of fuel spray, etc.). Thereby affecting the formation of the mixture of charge gas in the engine cylinder [1], [2], [3], [4], [5].

Nowadays, with the diversity of new fuel sources capable of replacing diesel fuels, studies on the use of these fuels demonstrate the possibilities in practical application (issues on the energy crisis, environmental pollution, engine performance) [6]. In this aspect, the combination of using new fuels and advanced technologies developed on diesel engines is perceived to be a potential solution to reduce emissions that pollute the environment while using the diesel engine. Hydrotreated vegetable oil (HVO) is one of the most promising and prominent biofuels when applied to this solution. HVO is classified as the second generation biofuel, with outstanding fuel properties, can overcome the defects of the first generation biofuels (causing abrasion and deposits in fuel pipes, fuel filters, fuel injectors, starter difficulties in low temperature, high NO_x emissions, inefficient oxidation stability, the limited mixing ratio with diesel fuel, etc.) [7], [8], [9]. HVO oil is produced from vegetable oils or animal fats through the hydrogenating treatment to remove oxygen in the structure of fatty lipid vessels (triglycerides) and form intermediate chemical chains (monoglycerides, diglycerides, carboxylic acids, etc.). They are then converted into the saturated chemical chain (Alkanes) and are isomerized to enhance fuel properties [10], [11]. Through this technique, HVO oil has many remarkable fuel properties such as high cetane index, non-existence of sulfur content and aromatic content, increasing cold flow fuel properties [12], [13].

Many studies have concluded the possibilities of using HVO as fuel for the purpose of reducing diesel emissions. With low boiling point value along with viscosity and molecular density smaller than diesel fuel, HVO has short penetration of the fuel spray, so there is little impact of the fuel spray on the engine cylinder wall [13]. The potential of using HVO in diesel engines is based on the comparison of proven fuel injection characteristics and the equivalency with diesel fuel [14]. Research on HVO and mixing ratios between HVO and diesel fuel (10%, 20%, 30%), with biodiesel (5%) was evaluated and concluded with a high level of emission reduction, especially soot, less fuel consumption. However, NO_x concentration tends to increase and some problems in cold flow characteristics [11]. The level of emission reduction on the engine is proportional to the amount of HVO used in the mixture with diesel fuel [12], [15]. The level of emission reduction is unstable and tends to increase when using a mixture of 30% HVO with an early injection timing at changing engine speeds [16]. Research on the characteristic of soot formation and surface tension between HVO and diesel fuel is confirmed similar although HVO has chemical compositions (cetane, aromatic) different from diesel fuel [17]. The effects of HVO and biodiesel (FAME) on diesel emissions indicate that HVO has better engine efficiency than FAME while NO_x emissions are equivalent to ultra-low sulfur diesel [18]. A shorter of 6.43% in ignition delay of HVO compared to diesel fuel due to higher cetane number was recorded as well as better evaporation from 0.7ms to 0.9ms after injection in constant volume combustion chamber [19]. The above research studies on the effect of HVO properties on the performance and emissions of diesel engines on the aspect of analyzing the impact of fuel properties on the formation and development of the fuel spray in the combustion chamber affects combustion process is very limited. Therefore, the aim of this research is to analyze the HVO properties and the impact of HVO properties on the formation and development of fuel spray at experimental conditions using common rail injection system with the injection pressure is 100MPa, 21% O_2 at 4.0MPa of ambient pressure in the constant volume combustion chamber. The analytical results of the visualization spray characteristics of HVO can predict the combustion process and form diesel exhaust gas emissions.

2 EXPERIMENTAL PROCEDURES AND RESEARCH METHOD

2.1 Experimental procedures and conditions

Figure 1 illustrates the experimental diagram of the fuel spray measurement. The experiment was carried out in the constant volume combustion chamber with a diameter of 80mm, a depth of 30mm and the two sides of the combustion chamber were installed with a transparent tempered Quartz crystal glass. A static pressure sensor is used to observe the initial ambient pressure value in the combustion chamber. Electronic solenoid-type injector with a nozzle diameter of 200μm is mounted on the top of the combustion chamber and connected to the common-rail system. A water injector cooling system is designed and installed in this experiment. Fuel piezo transducer pressure sensor type Gems 3100 series 3100B2200S2TB000RS is mounted on a high-pressure pipe to monitor fuel pressure before spraying. To create the condition in a combustion chamber similar to a diesel engine condition at the end of the compression stroke and to observe the process of developing the fuel spray under the non-vaporize spray condition, N_2 gas is pumped to the constant volume combustion chamber until the pressure in the combustion chamber reaches 4.0MPa. Then, the fuel pressure at 100MPa is injected into the combustion chamber. At the time of fuel injection, the high-speed Photron FASTCAM mini UX100 camera connected to Nikkon lens 50mm f /1.4 is synchronized with the injector to record the injection process in the combustion chamber at the speed of 10,000 fps. The resolution of the image is 640x480 $pixel^2$. The signals of injectors, high-speed camera, fuel pressure are synchronized and activated by Labview software. After each fuel injection, the Quartz crystal glass is cleaned, the combustion chamber is blown with compressed air and vacuumed to prevent fuel condensation on the crystal glass.

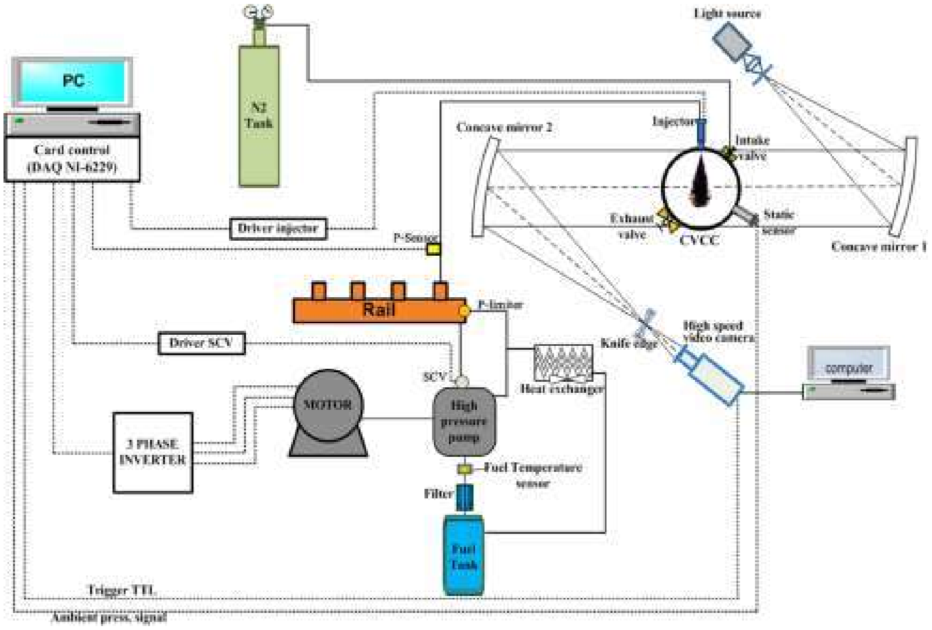

Figure 1. Diagram of experimental set up of fuel spray measurement

Table 1 presents the experimental conditions for fuel spray measurement. The experimental fuel sample is HVO and the diesel (B7) used as the reference sample. The control signal of the injection length is 2.5ms. The number of repetitions at each injection condition is 10 times. When replacing other fuel samples, fuel system (fuel tank, fuel filter, etc.) is renewed to ensure the accuracy of the collected data. The environment temperature is checked regularly and remained constant at 301K ± 2K.

Table 1. Test conditions for fuel spray measurement

Fuels	Diesel (B7), HVO
Ambient pressure (P_a)	4.0MPa
Fuel injection pressure (P_{inj})	100MPa
Injection signal length (T_{inj})	2.5ms
Nozzle diameter	200µm
Camera recording speed	10,000 fps
Number of repetitions / conditions	10 times

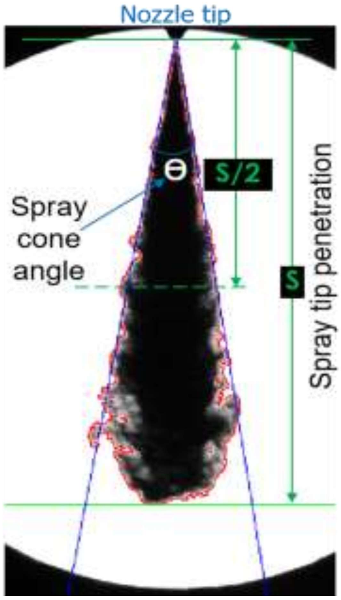

Figure 2. Spray image and fuel spray structure parameters (HVO, Pinj-100MPa, Tinj- 2.5ms, Pa-4.0MPa)

2.2 Research method

Based on the change of gas density in the constant volume combustion chamber, shadowgraph technique was used to observe the development of the fuel spray through the light reflection of the fuel spray on two concaved spherical mirrors [20]. The beam of light reflected from the concaved spherical mirrors will be photographed and recorded by the high-speed camera.

Figure 2 is the shape of the fuel spray captured by this technique. From this figure, the spray penetration (S) is defined as the distance from the nozzle tip exit to spray leading edge. Spray angle (θ) is defined as the intersection between the fuel spray and the injector at a distance of half of the spray penetration (S/2) [21]. The fuel spray velocity is the velocity of the peak developing fuel spray and is determined by two consecutive images taken at a specified time interval. Based on the degree of spray penetration and spray angle, the volume of fuel spray is calculated according to the equation (1) [22].

Fuel spray images results were analyzed by the image processing program [21]. In general, there are 3 steps, the first is to remove the background image from the captured spray image, then convert to a negative value with the pixel values of the fuel spray fixed in the threshold range of picture light intensity. The next step is to convert image values to binary and define the image boundary. Finally, determine the fuel spray structure parameters.

$$V=(\pi/3)S^3[\tan^2(\theta/2)]\frac{1+2\tan(\theta/2)}{[1+\tan(\theta/2)]^3} \qquad (1)$$

3 EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Analysis of experimental fuel properties

Table 2 compares the fuel properties between HVO and B7. From this table, HVO has lower viscosity, molecular density, surface tension of 18.48%, 5.52% and 4.1%, respectively compared to B7. The saturated chemical structure (n-paraffin and iso-paraffin) with short chain-length (fewer carbon atoms) of HVO compared to the complex chemical structure, contains aromatic content and has mixed 7% biodiesel

(biodiesel with unsaturated chemical structure) of B7 makes this difference [10], [23], [24]. In contrast, cetane values, heating value, boiling point of HVO are all higher than B7. With differences in the composition (non-double-connected in chemical structure), especially the chemical structure and the ratio of hydrogen to carbon contribute to this difference [25].

Also, the highlight of the fuel properties of HVO that affect the process of evaporation and forming combustible mixture is the distillation property. With a lower value at a high degree of distillation (T50 and T90), the evaporation characteristics of the fuel lead to a mixture of charge gas become flammable. This is explained by the structure of HVO containing a large amount of the components that easily vaporize at a high degree of distillation compared to B7 (B7 contains heavy compounds, aromatic, sulfur) [14], [15], [24].

Table 2. Fuel properties of HVO and B7

Parameters	**Standard**	**Diesel (B7)**	**HVO**
Cetane index	ASTM D976-06	60.43	76.89
Kinematic viscosity at 40^0C (cSt)	ASTM D445	3.235	2.637
Molecular density (kG/m^3)	ASTM D4052	823.5	776
Surface tension (mN/m)	ASTM D1590	26.7	25.6
Heat value (MJ/kG)	ASTM D240	45.86	46.86
Boiling point (^{o}C)	ASTM D86-11b	157.2	160.8
Distillation at T10 (^{o}C)	ASTM D86-11b	207.7	227.4
Distillation at T50 (^{o}C)	ASTM D86-11b	287.9	278.2
Distillation at T90 (^{o}C)	ASTM D86-11b	352.3	293.2
Carbon content (%wt)	ASTM D5291	86.1	84.2
Hydro content (%wt)	ASTM D5291	15.1	15
Nitrogen content (%wt)	ASTM D5291	0.0014	0.02
Molecular formula	-	$C_{14.28}H_{26.43}$	$C_{14.03}H_{30.1}$
Sulfur content (%wt)	ASTM D2622-16	0.018	0.0001
Flash point (^{o}C)	ASTM D93	61.3	69
Pour point (^{o}C)	ASTM D5950	-2	-6

3.2 The temporal development of fuel spray

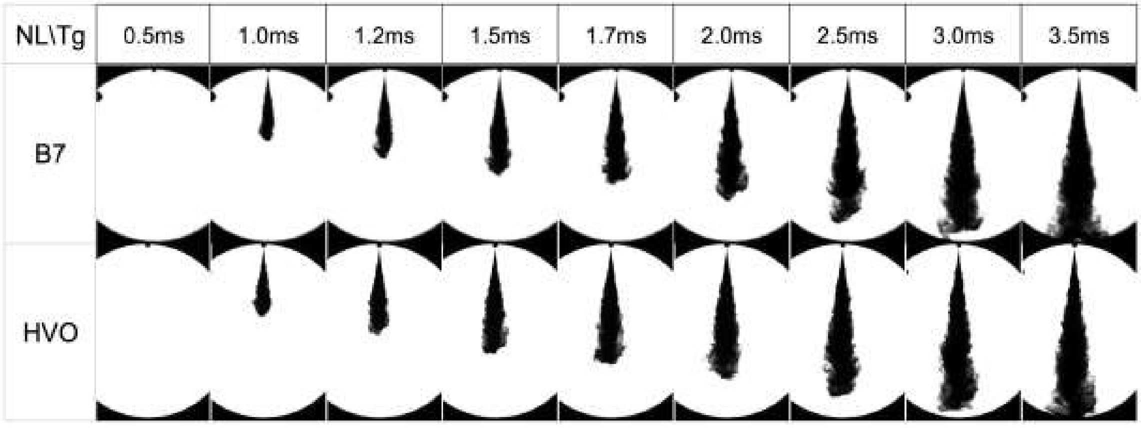

Figure 3. The temporal development of fuel spray of B7 and HVO at Pinj-100MPa, Pa-4.0MPa, Tinj-2.5ms

Figure 3 demonstrates the process of developing fuel spray between B7 and HVO at a fuel injection pressure of 100MPa into the 4.0MPa ambient pressure in the combustion chamber. From the direct observation of this sequence of images, both fuels show the tendency to similarly develop fuel spray. The fuel spray appears after 0.5ms when the fuel injector trigger signal appears. This delay appearance depends on the type of injector, inertia movement of the injector needle, and viscosity of the fuel [13]. The following images demonstrate the development of the fuel spray with increased spray angle, deeper spray penetration and the development of the turbulent flow of the fuel spray. After about 3.0ms, the fuel spray will collide with the bottom of the combustion chamber. The fuel spray structure shows that the spray development angle is conical and stable around up to the center of the spray. Also observed between two types of fuel, HVO has a shorter penetration than B7 at the same time. From the image, it is predicted that HVO has the ability to utilize space and time to mix with the air in the combustion chamber better, which will result in a better combustion process.

3.3 Fuel spray penetration

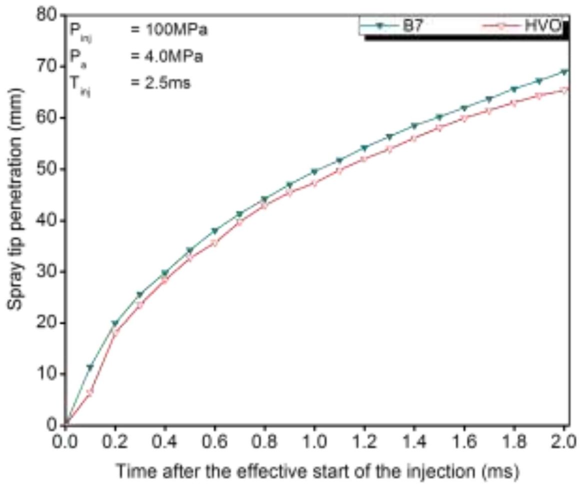

Figure 4. Fuel spray penetration level of B7 and HVO (Pinj-100MPa, Tinj- 2.5ms, Pa-4.0MPa)

The penetration of the fuel spray in the combustion chamber is an important parameter affecting the air utilization and the speed of mixing the air-fuel mixture in the engine. Figure 4 is the fuel spray penetration level of B7 and HVO. From the figure shows that the tendency of penetration of two fuels over time until colliding with the bottom of the combustion chamber. HVO has a shorter penetration than B7. The difference between these two fuels is about 5.1% based on the selected average value at the stable development stage of fuel spray from 1.0ms to 1.5ms. The cause of this difference is because HVO has a value of kinematic viscosity, molecular density and distillation temperature smaller than B7. These properties contribute to making HVO more volatile, smaller HVO molecules will have smaller kinetic energy [26], [27].

3.4 The angle development of fuel spray

Figure 5 is the angle development of fuel spray between B7 and HVO at 100MPa fuel injection pressure measured at a stable development stage from 1.0ms to 1.5ms. It can be seen that the angle development of fuel spray is divided into 2 stages. The first phase of the spray angle rapidly increases to the maximum spray angle and then quickly enters the short-lived oscillation process. This stage is called the acceleration phase (0ms to 0.4ms). Phase 2 is the deceleration stage with stable spray angle. This tendency is consistent with other studies [28], [29]. Figure 5 also shows that HVO has a larger spray angle than B7 from 0.2 degrees to 1.1 degrees. This difference is caused by a smaller in viscosity and molecular density of HVO. This gives HVO in small fuel particle size when spraying and has turbulence greater than B7 at the nozzle out of the spray [13]. With a larger spray angle than B7, HVO has a smaller fuel concentration at the injector hole. This can reduce the formation of soot due to more air exposure.

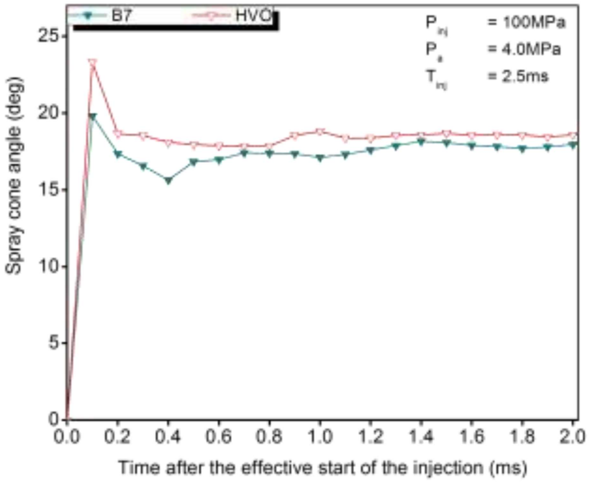

Figure 5. The angle development of fuel spray of B7 and HVO (Pinj-100MPa, Tinj- 2.5ms, Pa-4.0MPa)

3.5 Fuel spray velocity

Figure 6 is the diagram of the fuel spray velocity observed in 3 phases: acceleration, maximum velocity, and deceleration. Maximum velocity is achieved at a distance of 5-10mm from the injector outlet hole which collated from figure 4. HVO has a maximum speed of about 12-18m/s less than B7. This is caused by HVO's molecular density smaller than B7 [22].

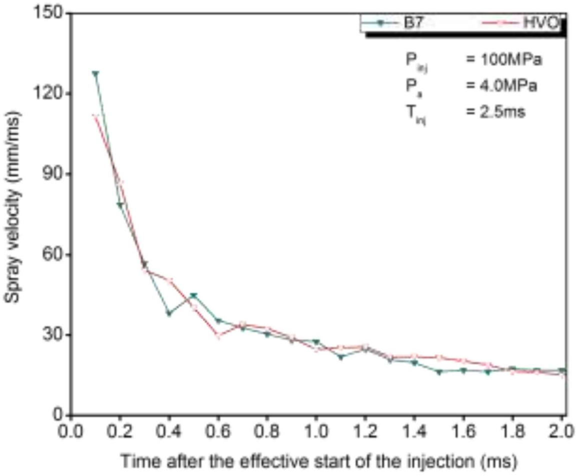

Figure 6. Fuel spray velocity of B7 and HVO (Pinj-100MPa, Tinj- 2.5ms, Pa-4.0MPa)

3.6 The volume development of fuel spray

Figure 7 shows the volume development of fuel spray of HVO and B7. HVO has a larger fuel spray volume than B7. This result is consistent with the results obtained from the fuel spray angle and fuel spray penetration previously. It is also evident from the image of the camera, HVO has a stronger turbulence intensity than B7 which results in better air mixing in the fuel spray lead to the increase in spray volume [30].

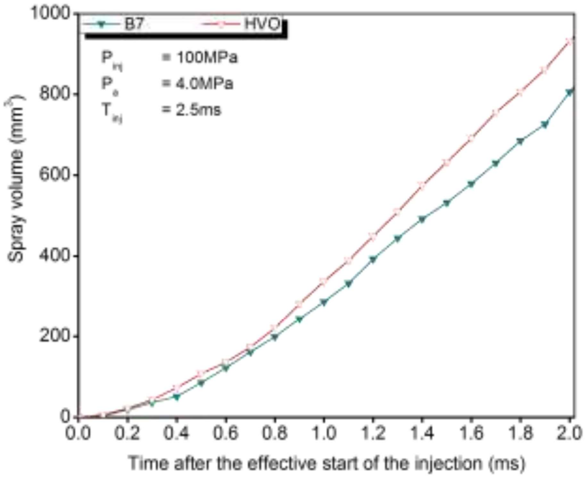

Figure 7. The volume development of fuel spray B7 and HVO (Pinj-100MPa, Tinj- 2.5ms, Pa-4.0MPa)

4 ONCLUSIONS

In this study, the fuel properties as well as spray characteristics under non-vaporized conditions of HVO and B7 in the constant volume combustion chamber were analyzed and evaluated. The conclusions are drawn as follows:

HVO has less viscosity, density, distillation than B7. These factors will affect the fuel injection characteristics, the ability to blend with diesel, the speed of forming charge gas in the combustion chamber. With a very small proportion of sulfur and aromatic as well as high cetane value and high heating value, HVO will contribute to a better combustion process and reduce emissions.

HVO has spraying characteristics with shorter penetration, smaller fuel spray velocity. However, the spray angle develops larger, the volume of the fuel spray is also larger than B7. This predicts that HVO has a process of mixing with air more improved and lead to better combustion as well as less emission than B7.

ACKNOWLEDGMENT

This work is supported by King Mongkut's Institute of Technology Lakrabang Research Fund (Grant No. KREF125615)-Thailand, AUN/SEED-Net program under Japan International Cooperation Agency (JICA). The authors would like to thank National Science and Technology Development Agency (NSTDA) and PTT Research & Technology Institute for their contribution in this work.

REFERENCES

[1] H. Hiroyasu, M. Arai, Structures of Fuel Sprays in Diesel Engines, SAE Transactions Journal of Engines, Paper 900475, Vol 99 (3), 1990.

[2] J. Dernotte, C. Hespel, S. Houille, S. Foucher, C. Mounaim-Rousselle, Influence of fuel properties on the diesel injection process in non-vaporizing conditions, Atomization and Sprays, Vol 22(6), pp. 461-492, 2012.

[3] H. Hillamo, T. Sarjovaara, V. Vuorinen, M. Larmi., et al., Diesel Spray Penetration and Velocity Measurements, SAE Technical Paper, 2008-01-2478.

[4] X. Wang, J. Gao, D. Jiang, Z. Huang, W. Chen, Spray characteristics of high-pressure swirl injector fueled with methanol and ethanol, Energy & Fuel, Vol 19 (6), pp. 2394-2401, 2007.

[5] E. Delacourt, B. Desmet, B. Besson, Characterisation of very pressure diesel spray using digital imaging techniques, Fuel, Vol 84, pp. 859-867, 2005.

[6] Renewables 2016-Global status report, REN 21-Renewable energy policy network for 21st century.

[7] J. Perdiguero, and J.L. Jiménez, Sell or not sell biodiesel: Local competition and government measures, Renewable and Sustainable Energy Reviews, Vol 15, pp. 1525-1532, 2010.

[8] Ng. Jo-Han, Ng. Hoon Kiat, Suyin Gan, Advances in biodiesel fuel for application in compression ignition engines, Clean Technologies and Environmental Policy, Vol 12 (5), pp. 459-493, 2010.

[9] K.P. Rajesh, A. Rehman, R.M. Sarviya, Impact of alternative fuel properties on fuel spray behavior and atomization, Renewable and sustainable energy reviews, Vol 16 (3), pp. 1762-1778, 2012.

[10] Soo-Young No, Application of hydrotreated vegetable oil from triglyceride-based biomass to CI engine-A review, Fuel, Vol 115, pp. 88-96, 2014.

[11] R. Caprotti, T. Tanng, N. Ishibe, R. In-ochanon, C. Tipdecho, S. Silapakampeerapap, Performance of Diesel Containing Bio-Hydrogenated Component, SAE Technical Paper, 2011-01-1953.

[12] M. Kuronen, S. Mikkonen, P. Aakko, and T. Murtonen, Hydrotreated Vegetable Oil as Fuel for Heavy Duty Diesel Engines, SAE Technical Paper, 2007-01-4031.

[13] Tuomo Hulkkone, Harri Hillamo, Teemu Sarjovaara and Martti Larmi, Experimental Study of Spray Characteristics between Hydrogenated Vegetable oil (HVO) and Crude Oil Based EN 590 Diesel Fuel, SAE Technical Paper, 2011-24-0042.

[14] K. Sugiyama, I. Goto, K. Kotano, K. Mogi, M. Honkanen, Effects of hydrotreated vegetable oil (HVO) as renewable diesel fuel on combustion and exhaust emission in diesel engine, SAE paper, 2011-01-1954.

[15] Hannu Aatola, Martti Larmi, Teemu Sarjovaara, Hydrotreated Vegetable Oil (HVO) as a Renewable Diesel Fuel: Trade-off between NOx, Particulate Emission, and Fuel Consumption of a Heavy-Duty Engine, SAE Technical Paper, 2008-01-2500.

[16] J. Somnuek, S. Peerawat, S. Komkrit, T. Manida, C. Nuwon, Effects of GTL and HVO Blended Fuels on Combustion and Exhaust Emissions of a Common-rail DI Diesel Technology, SAE Technical Paper, 2014-01-2763.

[17] H. Matti, L. Tero, E.M. Maria, S. Teemu, L. Martti, W. Reine, V. Annele, and K. Jorma, The comparison of particle oxidation and surface structure of diesel soot particles between fossil fuel and novel renewable diesel fuel, Fuel, Vol 89, pp. 4008-4013, 2010.

[18] N. Mizushima, D. Kawano, H. Ishii, Y. Takada, et al., Evaluation of Real-world Emissions from Heavy-duty Diesel Vehicle Fueled with FAME, HVO and BTL Using PEMS, SAE Technical Paper, 2014-01-2823.

[19] M. Sombat, E. Pop-Paul, S. Prathan, C. Chinda, K. Preechar, T. Manida, K. Hidenori, Combustion characteristics of hydrotreated vegetable oil-diesel blends under EGR and low temperature combustion conditions, KSAE, Vol. 20, pp. 569-578, 2018.

[20] S.G. Settles, Schlieren and shadowgraph techniques: Visualizing phenomena in transparent media, Springer, ISBN: 978-3-642-63034-7, 2002.

[21] J. Dernotte, C. Hespel, F. Foucher, C. Mounaim-Rousselle, Influence of physical fuel properties on the injection rate in a diesel injector, Fuel, Vol 96, pp. 153–160, 2012.

[22] C.P. Chen, C.W. Wang, and T. Fang, Spray and atomization of diesel fuel and its alternatives from a single-hole injector using a common rail fuel injection system, Fuel, Vol 103, pp. 850-861, 2013.

[23] B. Morteza, K. Preechar, T. Manida, C. Nuwong, Comparison study on fuel properties of biodiesel from jatropha, palm and petroleum-based diesel fuel, SAE Technical paper, 2014-01-2017.

[24] M. Lapuerta, M. Villajos, R.A. John, L.B. Andre, Key properties and blending strategies of hydrotreated vegetable oil as a biofuel for diesel engine, Fuel Processing Technology, Vol 92, pp. 2406-2411, 2011.

[25] P. Hellier, M. Talibi, E. Aaron, and N. Ladommatos, An overview of the effects of fuel molecular structure on the combustion and emissions characteristics of compression ignition engines, J. of Automobile Engineering, Vol. 232, pp. 90-105, 2017.

[26] A. Ghurri, D. J. Kim, G. H. Kim, Y. J. Jung, K. K. Song, The effect of injection pressure and fuel viscosity on the spray characteristics of biodiesel blends injected into an atmospheric chamber, J. Mechanical Science and Technology, Vol 26 (9), pp. 2941-2947, 2012.

[27] S. Lee, S. Jeong, O. Lim, An investigation on the spray characteristics of DME with variation of ambient pressure using the common rail fuel injection system, J. Mechanical Science and Technology, Vol 26 (10), pp. 3323-3330, 2012.

[28] P. Tinprabath, C. Hespel, S. Chanchaona, and F. Foucher, Influence of Biodiesel and Diesel Fuel Blends on the Injection Rate and Spray Injection in Non-Vaporizing Conditions, SAE Technical Paper, 2013-24-0032.

[29] K. K. Song, C. S. Sim, K. B. Jung, G. H. Kim, H. J. Kim, Effect of the injection parameters on diesel spray characteristics, KSME Int. J., Vol. 19 (6), pp. 1321- 1328, 2005.

[30] X. Wang, Z. Huang, A. Kuti, Experimental and analytical study on biodiesel and diesel spray characteristics under ultra-high injection pressure, Int. J. Heat fluid flow, Vol 31, p.659-66, 2010.

QUAN SÁT CHÙM TIA PHUN CỦA DẦU HYDROTREATED VEGETABLE OIL TẠI MÔ PHỎNG ĐIỀU KIỆN CỦA ĐỘNG CƠ DIESEL

Tóm tắt. Sự đa dạng của các nguồn nhiên liệu thay thế cho nhiên liệu lỏng động cơ Diesel và theo đó là sự thay đổi tương ứng trong các đặc tính vật lý và hoá học của các nhiên liệu này kết hợp đồng thời với sự phát triển các kỹ thuật hiện đại trong động cơ Diesel là giải pháp cần thiết để tăng hiệu suất và giảm khí thải của động cơ. Nhiên liệu có nguồn gốc từ thực vật đã qua xử lý tách mạch bằng hydro (Hydrotreated Vegetable Oil-HVO) được nhận thấy là một sự thay thế đầy tiềm năng cho việc sử dụng dầu Diesel. Nghiên cứu này tập trung vào việc phân tích tính chất nhiên liệu giữa dầu HVO và dầu Diesel (dầu Diesel đã được hoà trộn thêm 7% dầu Diesel sinh học sản xuất từ palm oil-B7). Sự khác nhau trong tính chất giữa 2 nhiên liệu sẽ ảnh hưởng đến quá trình phun, phát triển chùm tia nhiên liệu trong động cơ Diesel và từ đó đặc tính phun nhiên liệu được đánh giá so sánh. Thí nghiệm sử dụng buồng cháy đẳng tích, kim phun điện tử solenoid một lỗ tia phun có đường kính 200μm, áp suất phun nhiên liệu là 100MPa vào trong buồng cháy đẳng tích có áp suất ban đầu là 4.0MPa, thời gian tín hiệu điều khiển phun là 2.5ms. Kết quả thí nghiệm cho thấy dầu HVO có độ nhớt thấp hơn 18.48%, mật độ phân tử nhiên liệu nhỏ hơn 5.52%, hàm lượng lưu huỳnh rất thấp, nhiệt độ chưng cất tại khoảng nhiệt độ cao (T50 và T90) nhỏ hơn khi so sánh với dầu Diesel. Bên cạnh đó, HVO có chỉ số cetan cao hơn 27.2%, nhiệt trị toả ra cao hơn 2.2%. Trong kết quả đánh giá đặc tính phun của chùm tia nhiên liệu, cả 2 loại nhiên liệu này có xu hướng phát triển chùm tia phun giống nhau. Cụ thể hơn, dầu HVO có độ xâm nhập tia phun ngắn hơn khoảng 5% trong khu vực phát triển chùm tia phun, và góc phun dạng hình nón rộng hơn khoảng từ 0.2 đến 1.1 độ trong giai đoạn phát triển ổn định của chùm tia phun. Vận tốc đạt giá trị cực đại khi phun 2 loại nhiên liệu này vào khoảng 5mm tới 10mm tính từ vị trí lỗ ra kim phun. Cũng được quan sát trong thí nghiệm này là một sự tăng lên của thể tích chùm tia phun khi sử dụng dầu HVO.

Từ khóa. Dầu sinh học Hydrotreated vegetable oil, Phun dầu điện tử Common-rail, Động cơ diesel, Đặc tính tia phun, Khí thải động cơ diesel.

Ngày nhận bài: 242/09/2019

Ngày chấp nhận đăng: 07/01/2020