Spray Characteristics in CI Engines Fuelled with Vegetable Oils and Its Derivatives

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Abstract

Even though there is a broad literature in the field of review on production of biodiesels from edible and inedible vegetable oils, performance and exhaust emissions of CI engine fuelled with vegetable oil and its derivatives, spray characteristics is not considered in those reviews. In this article, therefore, spay characteristics in CI engines fuelled with vegetable oils and its derivatives will be reviewed. Of edible vegetable oils, soybean and rapeseed oils were mainly investigated. Of inedible vegetable oils, jatropha and used frying oils were main concern on the research on spray characteristics in CI engines. Spray angle and spray penetration were mainly examined among the macroscopic spray characteristics and Sauter mean diameter was only investigated among the microscopic spray characteristics.

Introduction

Due to the limited fossil fuels, the development of alternative fuels is required. Due to the global climate change, CO_2 emission reduction is required through the use of compression ignition (CI) engine in internal combustion engines. Therefore, the application of vegetable oils (VO) biodiesel, DME and Fischer-Tropsch diesel in CI engine can be solution for the above two problems simultaneously[1,2]. Of four alternative fuels for CI engines, VO can be grouped as edible and inedible oils. The edible VO in use at present soybean (SO), sunflower, rapeseed (canola)(RO), coconut and palm oils. The inedible VO used as feedstock for biodiesel production includes jatropha, karanja, mahua, linseed, rubber seed, cottonseed and neem oil etc.[3-5].

The first review on the combustion of fat and VO derived fuels in CI engines was reported by Graboski and McCormick in 1998 [6]. Even though there are so many articles related to the review on production of biodiesels from edible and inedible VO, performance and exhaust emissions of CI engine fuelled with VO and its derivatives [7-18], spray characteristics was not included in those reviews. In this article, therefore, spray characteristics in CI engines fuelled with VO and its derivatives will be reviewed.

Spray angle, Spray penetration and SMD

The research on the spray angle in the application of VO and its derivatives to CI engines can be classified as seven groups, i.e. neat SO and its blend, neat SO biodiesel and its blend, neat RO and its blend, neat RO biodiesel and its blend, other VO and its blend, other VO biodiesel and its blends, and unknown biodiesel.

The study on the penetration of spray produced from neat VO and its blend, neat VO biodiesel and its blends can be divided by two areas; i.e. vapour phase penetration and liquid phase penetration. However, spray penetration will be used here as the synonym with the vapour phase penetration. The literatures related to spray penetration can be grouped as neat SO and its blend, neat SO biodiesel and its blend,neat RO and its blend, neat RO biodiesel and its blend, other VO and its blends, other VO bidiesel and its blends and unknown biodiesel.

The droplet size distribution is frequently characterized by it Sauter mean diameter (SMD). In turn, SMD is influenced by the properties of the atomized and atomizing fluids, the nozzle design and operating conditions. The study on the droplet size distribution characterized by its SMD was classified as neat SO biodiesel and its blend, neat RO biodiesel and its blend, other VO and its blends, other VO biodiesel and its blends, unknown biodiesel and prediction of SMD by empirical correlation.

Results and Discussion

Compared with diesel fuel, spray angle of neat VO is very small. Spray angles of VO and its blend decreases with increase in fuel temperature and with decrease in fuel viscosity. The effect of VO contents in the blends on spray angle is negligible. The influence of ambient pressure and temperaure, injection pressure and orifice diameter on spray angle for VO and its blends should be examined. It was found that due to the non-axisymmetrical structure of VO and its derivatives, there are six different definitions of spray angle.

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VO and its blend have a longer spray penetration than diesel fuel. An increase in fuel temperature or a decrease in fuel viscosity causes the spray to a decrease in spray penetration of VO and its blend. The research on the effect of ambient pressure and temperature, injection pressure, orifice diameter and VO contents in the blends is required. Biodiesel has a higher spray penetration than diesel fuel and biodiesel blended with diesel fuel shows the similar spray penetration with diesel fuel. Spray penetration of biodiesels and its blends increases with increase in ambient temperature, injection pressure and biodiesel contents in the blends.

VO and its blends have larger SMD than diesel fuel. An increase in fuel temperature or a decrease in fuel viscosity produces a smaller SMD in VO and its blends. The effect of ambient pressure and temperature, injection pressure, orifice diameter, nozzle shape and VO contents in the blends on SMD should b examined. SMD in the biodiesel spray is higher than that in the diesel spray. In the case of biodiesel, an increase in fuel temperature leads to an increase in SMD. The studies on the relation between ambient pressure and temperature, injection pressure, orifice diameter, nozzle shape and biodiesel contents in the blends are required.

References

[1] Demirbas, A., *Energy Sources, Part B.*, 2, 343-351(2007).
[2] Soltic, P. et al., *Fuel*, 88, 1-8 (2009).
[3] No,S.Y., *The 13th Annual Conf. on Liquid Atomization and Spray Systems-Asia*, Wuxi, P.R.China, Oct. 15-17, 2009, pp.8-25 – 7 inedible oils.
[4] No,S.Y., *Journal of ILASS-Korea*, 14(2):49-58 (2009).
[5] No,S.Y., *Journal of ILASS-Korea*, 14(4):153-162 (2009).
[6] Graboski, M.S. and McCormick,R.L., *Progress in Energy and Combustion Science*, 24: 125-164 (1998).
[7] Babu,A.K and Devaradjane,G., *SAE paper* 2003-01-0767 (2003).
[8] Ramadhas, A.S. et al., *Renewable Energy*, 29:727-742 (2004).
[9] Altin,R. et al., *Energy Conversion and Management*, 42:529-538 (2001).
[10]Agarwal,A.K., *Progress in Energy and Combustion Science*, 33:233-271 (2007).
[11]Shahid,E.M. and Jamal,Y., *Renewable and Sustainable Energy Reviews*, 12(9): 2484-2494 (2008).
[12]Lapuerta,M. et al., *Progress in Energy and Combustion Science*, 34:198-223 (2008).
[13]Basha,S.A. et al., *Renewable and Sustainable Energy Reviews*, 13:1628-1634 (2009).
[14]Hossain,A.K. and Davies,P.A., *Renewable Energy*, 35:1-13 (2010).
[15]Saka, S., *All about biodiesel*, IPC, 2006(in Japanese).
[16]Demirbas, A., *Biodiesel*, Springer, 2008.
[17]Soetaert W. and Vandamme, E.J., *Biofuels*, Wiley, 2009.
[18]No, S.Y., *Bioenergy Engineering*, Somoon Graphics Art, 2009(in Korean).

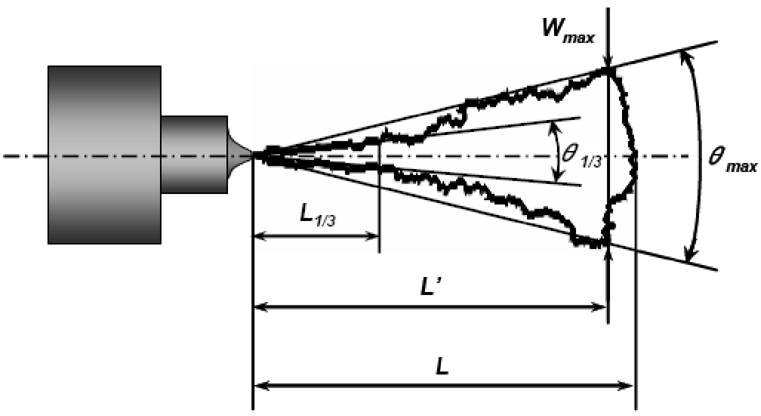

Figure 1. Definition of spray penetration, spray angle and spray cone angle by Senda et al.[36]