Effects of Injector Nozzle Geometry on Engine Parameters for a Diesel Engine Fueled with Preheated Pure Biodiesel

Menelik Walle Mekonen [a,*], Niranjan Sahoo[b] and Santosh Kumar Hotta [c]

[a,c] Research Scholar, Indian Institute of Technology Guwahati (IITG), Guwahati – 781039, Assam, India
[b] Professor, Indian Institute of Technology Guwahati (IITG), Guwahati – 781039, Assam, India
*Corresponding author: menelik@iitg.ernet.in

1. INTRODUCTION & OBJECTIVE

Recently, biodiesel from non-edible vegetable feed stocks are getting strongly attention for substitute of mineral diesel fuel partly or totally due to the high demanded of rapidly depleted limited mineral fossil fuel and also due its environmental concerns [1, 2]. Nevertheless, direct use of pure biodiesel B100 in existing compression ignition engine is currently limited due to the existing biodiesel problems such as high viscosity and density, poor cold flow properties, and lower heating value than diesel fuel [3, 4]. In turn, the high viscosity and poor flow properties biodiesel affects the fuel atomization and combustion characteristics of diesel engines [5, 6]. In order to use them directly, the properties have to be improved.

The performance, combustion and emission parameters of the recent variable compression ratio (VCR) direct injection (DI) compression ignition (CI) engines are strongly influenced on fuel spray parameters and the quality of fuel injection process. The major parameters which influence the pure biodiesel atomization, spray and combustion characteristics, are the shape and size of injector nozzle holes, preheating temperatures and fuel injection pressure. The primary goal of this experimental work is to examine the effects of these parameters with pure biodiesel B100 with respect to mineral diesel fuel. For this study, three different type of injector nozzles are used i.e. (DLLA 110S1030, DLLA 142S1256 and DLLA 150S187) of hole size and number of holes (300 μm × 3; 320 μm × 4; 340 μm × 5), respectively. All the experiments are performed with two test fuels of Palm Oil Methyl Ester (POME) B100 biodiesel and high speed diesel fuel (Baharat stage –III).

2. EXPERIMENTS & RESULTS

In this study, among a few techniques, preheating option is applying for improving the existing problems of pure biodiesel for reducing the viscosity and density, and improving cold flow property and lower hating value. For this reasons, a simple shell and tube type preheating device is attempt to design and fabricated. This device consists of a single pass of inner copper tube and an outer shell of galvanized iron as shown in Fig. 1. Baffle plates of mild steel were fixed to inner tubes for enhancing the heat transfer area between the two fluids. For a requirement of better transfer heat well, thermal conductive, corrosion resistant and extreme temperature resistance a copper tube material is considered. Important design factors such as pressure drop, fouling factor and resistance, available sizes of the materials are considered during design and fabrication of the preheating device and also while choosing the diameter, thickness and length of tube, TEMA and ASME standards are followed. Additionally, the experimental work on atomization and mixing problems of pure biodiesel also attempted at varied fuel injection pressures at (224, 212, 200 and 188 bar). During analysis of the experiment, the pure biodiesel (B100) at different inlet temperature of exhaust gases (66, 78, 90, 102, 114, 126 and 138^{0}C) is considered to find out the optimum preheating temperatures of pure biodiesel as compared to mineral diesel fuel. The experiments were conducted on a single cylinder, four stroke, water cooled research diesel engine rated at constant speed of 1500 RPM and 3.5 kW power output. An eddy current dynamometer is used for loading engine crankshaft. The required injection pressure of fuel was changed by adjusting the fuel injector locking nut, screw and spring tension mechanisms, and rotating the screw clock wise (reducing the pressure) or counter clockwise (increasing fuel injection pressure) The setup also consists cooling systems, lubrication systems and fuel supply system for diesel fuel and biodiesel separately. In addition to the above operating conditions, the experiments were conducting with a variations of engine load from no-load (0 kg) to full- load condition (12 kg) with an increment of 2.4 kg (20 %) while engine speed is kept constant. The standard diesel specification is kept as, compression ratio 17.5, injection pressure 200 bar and injection timing of 23^0BTDC, for baseline experimental comparison with biodiesel. The experimental results indicate that increase in number of holes of injector improved pure biodiesel atomization, faster evaporation and better mixing. It leads to significant improvement in engine performance parameters such as brake thermal efficiency (BTE), brake specific fuel consumption (BSFC) and emission characteristics such as unburned hydrocarbon (HC), carbon monoxide (CO) whereas NOx emission and exhaust gas temperature is found to be increased. The variation of injections pressure also plays a vital role fuel atomization and evaporation of biodiesel. An increase injection pressure improved the combustion efficiency compared with diesel fuel, however its effects are negligible if injector nozzle has more number of holes and smaller orifice diameter. The investigated results of property of preheated pure biodiesel also highlights the fact that, increase of heating temperature (102 to126^0C) improves the viscosity (5.62-4.32 cSt) and density 868-862 kg/m^3) of the oil. More details will be elaborated in the final manuscript.

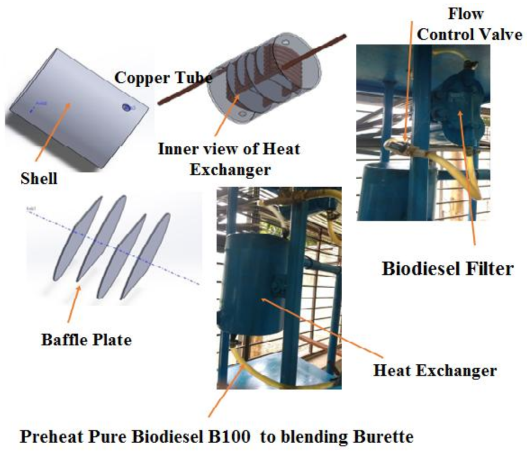

Fig. 1: Three dimensional sectional and photographic view of preheating assembly device.

REFERENCES

1. Rimos, S., Hoadley, A.F. and Brennan, D.J., 2014. Environmental consequence analysis for resource depletion. *Process Safety and Environmental Protection*, *92*(6), pp.849-861.
2. Nogueira, L.A., 2011. Does biodiesel make sense?. *Energy*, *36*(6), pp.3659-3666.
3. Ramadhas, A.S., Jayaraj, S. and Muraleedharan, C., 2004. Use of vegetable oils as IC engine fuels—a review. *Renewable energy*, *29*(5), pp.727-742.
4. Joshi, R.M. and Pegg, M.J., 2007. Flow properties of biodiesel fuel blends at low temperatures. *Fuel*, *86*(1), pp.143-151.
5. Kegl, B., 2006. Numerical analysis of injection characteristics using biodiesel fuel. *Fuel*, *85*(17), pp.2377-2387.
6. Wu, Z., Zhu, Z. and Huang, Z., 2006. An experimental study on the spray structure of oxygenated fuel using laser-based visualization and particle image velocimetry. *Fuel*, *85*(10), pp.1458-1464.