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ScienceDirect

Energy Procedia 81 (2015) 942 – 949

Energy Procedia

69th Conference of the Italian Thermal Machines Engineering Association, ATI2014

Vegetable oils as fuels in Diesel engine. Engine performance and emissions

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Abstract

The EU new energy strategy represents a challenge and a boost for industries and researchers pushing them to find new solutions to supply the energy demand complying with new environmental requests. The transport sector is one of the most addicted to oil product and then pollutant. A new bio-fuels generation is being studied, but the use of the ones already available should be increased. The use of vegetable oils (VO) and waste cooking oils (WCO) could represent interesting alternative fuels for Diesel engines in some specific applications (i.e., public transportation, hybrid or marine propulsion, etc.). Moreover, VO can be produced almost everywhere in the world in relatively small plants, and WCO would represent the use of a waste material which otherwise should be disposed. However, operating a Diesel engine (DE) with a different fuel might results in some problems. Indeed VO and WCO have different characteristics compared to Diesel fuel (i.e, a smaller heating value, a larger density and viscosity), and this can affect the operation of a DE. In particular the DE is expected to have some problem at the injection system and power loss.

In this work different vegetable oils (both straight and waste) are used to fuel a DE in automotive configuration and study its behavior. Tests are performed using a turbocharged, four stroke, four cylinders, water cooled, common-rail multijet DE. The influence of fuel used on engine power, specific consumption, efficiency, and exhaust opacity, are compared with those obtained fuelling with Diesel fuel.

Peer-review under responsibility of the Scientific Committee of ATI 2014

Keywords: Straight vegetable oil; waste cooking oil; common-rail Diesel engine; bio-fuels.

1. Background

The new energy strategy adopted by EU (see the Directive 2009/28/EC [1]) represents a challenge for scientists and industry. As a matter of fact it fixes three main objectives which should be accomplished by 2020: to reduce the greenhouse gas (GHG) emissions by 20 %; to reduce the final energy consumption by 20 % (improving energy effi-

Peer-review under responsibility of the Scientific Committee of ATI 2014
doi:10.1016/j.egypro.2015.12.151

Nomenclature

BD	Bio-diesel
DE	Diesel engine
DF	Diesel fuel
RO	Rapeseed oil
SVO	Straight vegetable oil

ciency); to provide 20 % of European energy consumption using renewables. The same Directive also fixes at 10 % the minimum consumption of renewable fuel in transports by 2020. This is pushing the development of a new generation of bio-fuels. However, in the meanwhile, the use of the already available biofuels should be widen and efficiently increased in order to achieve the 2020 targets. Nowadays Diesel fuel (DF) can be replaced by bio-diesel (BD), which can be used alone or in blend with DF ([2]-[6]), however its production requires big plants and large energy consumption. For this reason in the last years there is a growing interest on other bio-fuels such as straight vegetable oils (SVO) in order to widen the available alternatives to DF. Actually, the land requested to oilseed crops does not allow to look at SVO as a global alternative to DF. However it can be used in blend with gasoil, bio-diesel (BD) or also alone in some niche applications, such as public transport, hybrid and marine propulsion, electricity generation units, etc. The situation may change with the use of oil from algae which seems to be very promising ([7]-[10]). Notwithstanding the several advantages in using SVO as fuel, some technical problems (i.e., power and engine efficiency losses, feeding system malfunctions, etc.) should be faced.

The present work aims at studying the behavior of a common-rail DE in automotive configuration when fuelled with SVO in comparison with DF and BD.

The interest in using SVO as fuels in automotive applications is growing day by day and there are several small companies producing kits to switch from DF to vegetable oils. Some of them propose their products also for common-rail engine, but so far the number of studies on this kind of engines are not very common. Good reviews can be find in [11] and [12]. Labeckas and Slavinskas [13] reported on the experiments performed on a direct-injection off-road DE fuelled with RO, but it was a low speed, naturally aspired, not common-rail engine. Rakopoulos and coworkers [14] studied the performance of a bus engine operating with several vegetable oils in blend with DF. Fontaras et al. [15] used a Renault Laguna 1.9 dCi passenger car for their tests, but it was fuelled with a RO-DF blend (10% of RO). In a previous work the authors studied the use of RO and waste cooking oil in a common-rail DE [16]. To better understand the effects of the use of SVO in DE more experiments and studies have to be done.

2. Materials and methods

2.1. Fuel properties

In the present work three different fuels are used to feed the DE: rapeseed oils (RO), BD produced from waste cooking oils, and a standard DF. BD and DF have very similar characteristics, conversely vegetable oils are quite different from them ([11], [12]). In the present work, the main characteristics of the fuels used to feed the DE are reported in Table 1. As reported RO has a net heating value smaller than that of DF and a bit larger than that of BD. Density of BD is similar to that of DF, and both are smaller than RO. The viscosity is the physical properties which more affects the engine operation, since a larger fuel viscosity may provoke failures in the feeding system, and deposit formation within the combustion chamber, the feeding channels, the filters, etc.

Viscosity may remarkably vary with temperature, hence in order to avoid problems with the pumping system, its variation with temperature has been measured. It is found that to have a viscosity comparable to that of DF, RO has to be heated up to about 90 °C, as can be found in literature ([11]-[19]), thus this is the temperature we adopted in our tests.