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PERFORMANCES AND EMISSIONS OF A 2-STROKE DIESEL ENGINE FUELED WITH BIOFUEL BLENDS

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Abstract

Diesel engines are worldwide used as a primary power source not only in motor vehicles, but also in off-road engine applications. Two-stroke Diesel engine is most commonly seen in applications demanding a large power output, such as ships and electric generation plants. The use of biofuels has increased during the last years in response to concerns about climate change and to increase security of supply.

In this paper some results obtained with a 2-Stroke 6V53 Detroit Diesel (5.22L displacement, 150kW at 2800rpm) fueled with a commercial diesel fuel and biodiesel (100%RME) are discussed.

CO, NO/NOx, CO_2 and particulate matter (PM) have been sampled at 1 Hz in different load conditions and fuel consumption has been measured.

A catalyzed Diesel particulate filter (DPF) has been also installed at the exhaust to reduce PM emissions and the influence of fuel quality on emissions and fuel consumption was analyzed.

The installation of DPF has involved an average of less than 10% fuel economy penalty for both tested fuels.

A passive DPF system can be easily installed at the exhaust of in-use engine and it permits to reduce more than 90% PM emissions.

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1. Introduction

The International Energy Agency (IEA) predicted that, under current policies, in 2030 the global demand for energy will increase by 55% compared to 2005 [1]. In particular the amount of energy used for the mobility has the most important role with, obviously, great repercussions on the environmental impact [2]. In this context the fossil fuels, probably for more decades, will, still, have a prominent role. The continuous increase in demand and the limited resources available has led many researchers to assume that, with such trends in consumption and referring to the typical fuel adopted in mobility, the natural gas reserves will be depleted in about 60 years, while those of oil in just 40 years [3]. The 2014 EC communication on European Energy Security Strategy highlights the need to reduce reliance on fuel imports to the EU [4]. In recent years the EU has adopted measures to encourage the production and use of sustainable biofuels. i.e. such as those made from wastes and algae, provide high greenhouse gas savings with low risk of causing indirect land use change and do not compete directly for agricultural land for the food and feed markets [5]. Biodiesel is, as well known, a fuel deriving, through a process of transesterification, from many different sources including plant oil, animal fats, cooking oil, and algae.

In 2002, EPA published a technical analysis of the effect of biodiesel on exhaust emissions from diesel-powered vehicles with a large amount of emissions data (from the 1980s and early 1990s) comprised many two-stroke engine results [6]. Since four-stroke engines have dominated the vehicular industry during the last decades, two-stroke Diesel engines are nowadays most commonly seen in applications demanding a large power output, such as ships and electric generation plants or in generating power for building roads, mining, aircraft ground support equipment, high-end marine pleasure craft, and in most of the world's armies and navies [7].

The disadvantages of the two-stroke cycle are that emissions are higher than a four-stroke cycle, and fuel efficiency can be marginally poorer. The environmental performance of these engines are also becoming an issue due to difficulty to bring into compliance with modern emission regulations. The use of biodiesel could reduce greenhouse gas emissions and the particulate matter released into the atmosphere. To meet the actual Diesel emissions regulations, many engine manufacturers are using a Diesel Particulate Filter (DPF) integrated into a regeneration system (active or passive type) for particulate reduction, combined with engine tuning for NOx reduction. High efficiency DPF technology can reduce PM emissions up to 90% but some of these systems are known to increase the proportion of NO_2 in the total NOx emission. In fact one of the possibilities for the DPF regeneration is to generate NO_2, by the oxidation of NO, then this reacts with the trapped carbon particles to clean the filter continuously. A critical requirement for the implementation of DPF on a Biodiesel powered engine is the determination of Break-even Temperature (BET) which is defined as the temperature at which particulate deposition on the filter is balanced by particulate oxidation on the filter. This balance point needs to occur at sufficiently low temperatures to fit within the exhaust temperature range of a typical diesel vehicle duty cycle.

The authors of this work have a long experienced [8-9] in the field of applications of biodiesel and its blends with Diesel Fuel. In particular, this study examines the characteristics of 2-stroke diesel emissions using a Detroit 6V53 engine, equipped with a passive DPF system as retrofit application, and 100% rapeseed methyl ester (RME) biodiesel (B100) as fuel. Regulated emissions (CO, CO_2, NOx and Particle Matter) were measured running the engine in various steady state conditions with B100 and diesel fuel. The aim is analysis of the impact of fuel composition on particulate trap efficiency and on the break-even temperature.

2. Experimental Set-Up and engine description

Engine set-up

Tests were performed with a 2-stroke Detroit 6V53 engine (204 CV max output), described in Table 1, connected to a Schenk 550 kW capacity, eddy current absorbing dynamometer. This engine provides power for a