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AN INVESTIGATION INTO HOW DIFFERENT BLENDS OF BIO-DIESEL AT A RANGE OF TEMPERATURES AFFECT ENGINE HORSEPOWER, TORQUE AND EMISSIONS

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Abstract

The report aims to show how horsepower torque, & emissions from bio-diesel manufactured from waste vegetable oil are affected by the temperature of the mixed blends of biodiesel that are being fed into the engine. Using bio-diesel manufactured from waste vegetable oil this project aims to see how the engine horsepower, torque and emissions on a 7.5L, 6 cylinder turbocharged Fiat/New Holland tractor engine are affected by the multiple blends of bio-diesel (B10, B30, B50, B70 & 100% mineral diesel), which will be fed into the engine at a range of temperature's (+30°C, + 15°C, -5°C & -10°C).

INTRODUCTION

The global price of fuel has increased especially over the last few years and the effects of global warming are becoming apparent it is necessary to look for fuel elsewhere. Biofuels are an alternative to petroleum based fuels and have become more of a viable option over the last few years. Biofuels can consist of the following bio ethanol, vegetable oils and bio-diesel. These are agricultural crops such as wheat, rape seed and corn that require high quality agricultural land for growth [3]. Bio-diesel is made essentially from plants and when they are burnt it leads to a complete recycle of CO_2 emissions [2].

Bio-diesel is one alternative of renewable energy; however bio-diesel is not a new alternative in relation to fossil diesel [1]. The effects that bio-diesel fuels have on modern engines is still relatively unknown, and with the uncertainty, there is much speculation to what effects the fuels have on engine power and torque, the environmental health (emissions) and differences in fuel consumption compared to the industry accepted fossil diesel.

There is a great deal of interest in biodiesel in the agricultural sector as biodiesel is renewable and therefore will never run out, it is also cheaper than mineral diesel at just 0.89 pence per litre (PPL).

Considerable waste vegetable oil from commercial food producing companies (e.g. McDonalds) needs to be disposed of or recycled; the concept of converting it into bio-diesel.

Bio-diesel manufacturing can easily be carried out by the small user, for example a small farmer. The Etruk 100 biodiesel processor used in this research programme can produce 2 X 100 litres of bio-diesel per day and requires very little supervision.

MATERIALS AND METHODS

Test Equipment

Dynamometer: The horse power from the Fiat/New Holland engine rig will be calculated from the Power take off (PTO). The PTO power is measured using a dynamometer coupled to the PTO shaft. The data is displayed via the dynamometers own onboard hand held computer, this can also be used to print off the power and torque graphs produced from the engine tests (figure 1).

Fig. 1. Fromet Sigma 5 pto dynamometer

Emissions Analyser: The emissions analyser used was a Testo 350 XL (figure 2), this was hired in for the duration of the testing. The Testo 350 XL is capable of reading the following exhaust gasses; Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Oxygen (O_2) and the exhaust temperature. These gasses are needed to properly analyse the engine emissions.

Fig. 2. Testo 350 XL emissions analyser

Heating and Cooling the Fuel: To heat the fuel an Etruk 100 biodiesel processor (Eco2tec Resources UK Ltd) provided a thermostat temperature range from 0 –

50°C. The temperature is easily adjusted by turning the thermostat to give an accurate reading (figure 3).

Fig. 3. Etruk 100

To cool the fuel a domestic freezer was used, this provided a temperature range, adjustable between -3°C to -25°C.

RESULTS AND DISCUSSIONS

Out of the fuels that were tested B70 at -10 °C was unable to be tested because of the properties that it consists of at low temperatures. At -10°C the blend turned into a very thick liquid which is not suitable to be used in an internal combustion engine. Figure 4 shows the B70 blend at -10°c, waxing into a 'gel like' state.

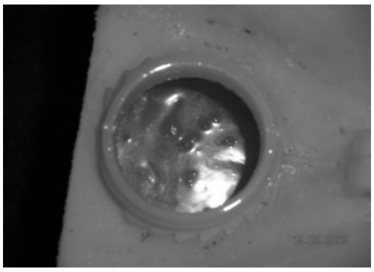

Fig. 4. The "gel like" B70 blend at -10ºC

Table 1 shows the maximum horsepower from each blend of biodiesel, each blend achieved its maximum horsepower at -5°C; this is a positive result to show that the temperature of the fuel effects engine horse power. In each blend of biodiesel the horsepower decreases with the increase in percentage of biodiesel.

Maximum torque has been achieved at -5°C in every blend of biodiesel; this is consistent with the horsepower results, table 2 below shows the maximum torque achieved at -5°C.

NOx and CO_2 emissions increase the colder the bio-diesel temperature becomes, which matches with the effect on horsepower at this temperature, as it is also the highest.

Table 1

The maximum horsepower of tested biodiesel blends

Fuel Blend	Temperature (°C)	Maximum Horsepower Blended bio-diesel	Maximum Horsepower 100% fossil diesel	Revs/min max power achieved
10%	-5	160.8	163.8	964
30%	-5	159.2	163.8	965
50%	-5	157.0	163.8	974
70%	-5	155.6	163.8	968

Table 2

The maximum torque of tested biodiesel blends (at -5ºC)

Fuel Blend	Temperature (°C)	Maximum Torque Nm Blended bio-diesel	Maximum Torque Nm 100% fossil diesel	Revs/min max power achieved
10%	-5	1304.5	1340.9	820
30%	-5	1304.5	1340.9	768
50%	-5	1234.0	1340.9	809
70%	-5	1239.0	1340.9	789

Table 3 shows the percentage increase of CO_2 emissions between 100% fossil diesel at 30°c and at -10°c. Due to the high content of oxygen in bio-diesel this lead to a reduction of CO emissions. Also it was found that the exhaust temperatures decreased with the amount of bio-diesel in the blend. Further testing is needed with a full analysis of blended fuel properties to see if this has any effect on the emissions.

Analysing both the NOx and the CO_2 emissions results shows that they both have the highest emissions at -5 and -10°C. This coincides with the horsepower results gained from the testing as Burland. M (2009) found that at -5°C the NHER produced the most horsepower at every blend and indeed the highest horsepower overall. Coincidently at maximum horsepower the engine requires more fuel to be burnt so in turn increases the amount of NOx and CO_2 produced.

Table 3

The increase of CO_2 emissions

Blend Percentage (%)	**CO_2 Emission Percentage (%)**	**Temperature (°C)**	**Percentage CO_2 Increase (%)**
100% Fossil Diesel	9.68	30	13.2
100% Fossil Diesel	10.96	-10	

CONCLUSIONS

1. The first clear conclusion that can be drawn is the effect -10°C had on the blended biodiesels with horsepower's dropping down to 85.3 HP this equated 92.4% loss in horsepower from the 100% benchmark mineral diesel which produced164.2 HP. The second result is that in every blend -5°C produced the highest power and torque.
2. As the B70 blend was not suitable for use in an engine at -10°C or below. It is recommended that a tank or fuel line heater needs to be fitted, so bio-diesel can be used in colder conditions. This in turn would decrease the viscosity of the bio-diesel.
3. The results show there is a close relationship between bio-diesel and the temperature at which the fuel is entering the engine at, because both affect each other's parameters. It can be confirmed that the following occurrences happened during testing:

- The exhaust temperatures dropped the more bio-diesel that was added to the blend due to lower combustion temperatures;
- The NOx and CO_2 content is highest at -5 and -10°C due to the oxygen content at these temperatures;
- The oxygen content in the emissions is higher in bio-diesel which promotes the oxidation of carbon in the fuel leading to lower CO emissions in comparison to fossil diesel [4].

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