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AN INVESTIGATION INTO HOW DIESEL FUEL ADDITVES AFFECT EXHAUST GAS EMISSIONS, POWER, TORQUE AND FUEL CONSUMPTION

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Abstract

The report aims to show how horsepower, torque, emissions, temperature and fuel consumption are affected by the addition of aftermarket fuel additives, which are claimed to improve exhaust emissions, engine performance and fuel economy. Four different diesel fuel additives and one blend of "super diesel" were critically evaluated and compared with the data obtained from conventional low sulphur road diesel used as the bench mark. Using a Fendt 415 fitted with a four cylinder, sixteen valve turbo charged common rail, tier III, diesel engine and a Fromet Sigma 5 power take off (PTO) dynamometer a series of controlled tests were carried out to determine the effects of fuel additives.

INTRODUCTION

Global warming and climate change is a world wide issue, the latest G8 Conference (7^{th}-18^{th} December 2009), representing the richest nations, also agreed for the first time that it should collectively cut emissions by 80% by 2050, and that the world should be able to cut its emissions by 50% by the same date. It is alleged that burning fossil fuels (coal, oil, gas) produces carbon dioxide (CO_2); CO_2 acts as a blanket, which traps more of the sun's energy and warms the earth's surface and modern day power and transport needs contribute to the increased levels of CO_2 in the atmosphere[1].

The reason why fuel additives are becoming more noticed in industry is because manufacturers both of the vehicles and the fuel companies are being enforced by the government to reduce the carbon footprint in accordance with the European emission laws. Fuel additives are one way in which the manufacturers can achieve this. (Emission standards, 1997)[2].

The range of additives selected was based on price[3], availability and alleged reputation[4]. It was important that these additives were related to the power output of the engine, the specific fuel consumption and exhaust gas emissions.

MATERIAL AND METHODS

Test Equipment

Dynamometer: A Fromet Sigma 5 PTO dynamometer fitted with an on board computer, programmed to carry out a test cycle which could be replicated for each fuel sample under test[5].

Emissions Analyser: The emissions analyser was a Testo 350XL hired in for the duration of the test. The Testo 350XL is capable of reading the following exhaust gases; Nitrogen Oxide (NO), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Oxygen (O_2) and the exhaust temperature[6].

Method: Fuel for testing was accurately made up into 10 litre samples following the fuel additive manufacturer's recommendations for concentration; the tractor fuel system (Fendt 415)[7] was adapted to use the fuel directly from the containers, a separate sample of the fuel was run through the fuel system prior to commencing the test. Three test runs were made for each fuel sample and an average reading calculated. The fuel samples consisted of four commercially available additives and a super diesel, which all manufacturers claim to improve economy, performance and reduce emissions.

Test results were bench marked against low sulphur diesel EN 590[8].

The dynamometer was programmed to load the tractor engine from maximum revolutions per minute to engine stall; power and toque data was automatically recorded at 30 second intervals. The exhaust gas was monitored in the exit point of the exhaust pipe on the tractor, the data being collected at regular intervals throughout the cycle. The collected data was analysed and compared to the data collected when standard low sulphur diesel fuel was used.

It was difficult to identify the chemical content of the additives used; however, extensive research identified the use of the chemical cerium oxide as one of the additives and according to G. Wakefield and M. Gardener[9] the addition of cerium oxide at a concentration of 5-8 ppm has the effect of improving fuel economy between 5-8%

RESULTS AND DISCUSSIONS

All tests were carried out without any problems occurring and the data collected proved an interesting comparison to claimed performance.

From the available data not one of the fuel samples provided an overall improvement on economy, power and torque; for the emission additive "A" provides the most significant improvement.

All additives provided an increased economy with very little change to power and torque figures and the cost effectiveness of using additives for economy need to be compared to litres of fuel used per hour or in the case of road going vehicles litres used per 100km.

Additive "A" reduced the impact of CO_2, whereas additives "B" and "E" increased the levels.

Table 1

The maximum PTO horse power produced from test samples

	Power outputs (HP)			
	Test 1	**Test 2**	**Test3**	**Average pto/hp**
Additive A	150.4	150.9	151.2	150.86
Additive B	150.9	151.6	151.6	151.36
Additive C	150.6	151.4	151.1	151.03
Additive D	150.9	151.5	151.9	**151.43**
Additive E	150.9	151.7	151.2	151.26
EN509 Diesel	150.7	151.5	151.3	151.16

Table 2

The maximum torque produced from test samples

	Power outputs (Torque Nm)			
	Test 1	**Test 2**	**Test 3**	**Average**
Additive A	1282.60	1279.89	1277.18	1279.89
Additive B	1281.25	1288.03	1285.32	1285.32
Additive C	1279.89	1281.25	1279.89	1279.89
Additive D	1286.67	1281.25	1290.74	**1286.67**
Additive E	1288.03	1281.25	1281.25	**1286.67**
EN509 Diesel	1282.60	1283.96	1281.25	1282.60

Table 3

The amount of fuel used during each test run

	Fuel consumed during each specific test (litres)
Additive A	5.4
Additive B	5.15
Additive C	**5.05**
Additive D	5.25
Additive E	5.2
EN509 Diesel	5.5

Table 4

Exhaust gas emissions and temperature

Average emissions and temperature during each test						
	O_2%	**CO ppm**	**CO_2%**	**NO ppm**	**NO_2 ppm**	**FT ºC**
Additive A	11.07	**55.33**	**5.88**	**521.76**	40.11	**309.29**
Additive B	10.77	65.52	6.14	537.76	**38.39**	322.74
Additive C	10.79	60.76	5.97	547.33	39.23	318.94
Additive D	**10.70**	67.86	6.01	542.43	40.00	317.6
Additive E	10.99	55.71	6.94	535.00	39.93	314.38
EN509 Diesel	10.91	58.71	5.92	530.24	38.26	316.82

Table 5

Analysis of available data

Analysis of test results: percentage change									
	Econom y	**Power**	**Torqu e**	**O_2%**	**CO ppm**	**CO_2%**	**NO ppm**	**NO_2 ppm**	**FT ºC**
	%	%	%	%	%	%	%	%	%
Additive A	*+1.81*	*-0.20*	*-0.21*	*+1.57*	**-5.76**	**-0.68**	**-1.6**	*+4.83*	**-2.38**
Additive B	*+6.36*	*+0.13*	*+0.21*	*-1.28*	*+11.60*	*+3.7*	*+1.42*	**+0.34**	*+1.97*
Additive C	**+8.18**	*-0.09*	*-0.21*	*-1.09*	*+3.49*	*+0.84*	*+3.22*	*+2.54*	*+0.67*
Additive D	+4.55	**+0.18**	**+0.32**	**-1.92**	*+15.58*	*+1.52*	*+2.30*	*+4.55*	*+0.25*
Additive E	+5.55	+0.07	**+0.32**	*+0.73*	*-5.10*	*+17.23*	*+0.90*	*+4.36*	*-0.77*
EN509 Diesel	100	100	100	100	100	100	100	100	100

CONCLUSIONS

1. The improved economy, which is in line with Wakefield and Gardner's research, is of a significant impact to consider using an additive, providing it is cost effective
2. The effect on power and torque is unlikely to be noticed by the operative.
3. The effect on emissions is negative in all but two examples.
4. The tractor engine is a current tier III, future legislation is for tier IV and V to be introduced into the agricultural sector. Future research needs to focus on the effects of fuel additives on the more sophisticated engines

5. The format of the test may need to be revised, the current test measured the results from a programmed power/torque test, it is suggested that a series of programmed working cycles would give a more accurate data profile.

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