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Short note regarding Pure Plant Oil, PPO, as engine fuel

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My background for writing this note is 8 years working intensely to convince the Danish and European systems to accept that PPO engine technology, and PPO as a fuel, is 100% reliable. I have learned that the "old system" including Energy Agencies, Institutes specialised in engine and combustion technologies etc, know little or nothing about PPO technology, but they do not hesitate to talk about it as if they knew everything.

I wrote the first version of this note back in June 2004, as an reaction to the UK report *"UK Department for Transport Biofuels Evaluation - Final Report of Test Programme to Evaluate Emissions Performance of Vegetable Oil Fuel on Two Light Duty Diesel Vehicles, 7 November 2003, by Diance Lance, Jon Anderson, Ricardo Consulting Engineers"*. The Ricardo report concluded that PPO is not suitable as fuel in diesel engines. In my opinion this conclusion was based on fundamental mistakes made regarding combustion of PPO in diesel engines and by ignoring requirements to PPO fuel.

It is common knowledge that basically all diesel engines will run on PPO for a short while even without conversion, but that is far from optimised and no solution. Then you can compensate for cold start problems with a 2-tank system, and compensate for the higher viscosity by heated fuel system and larger fuel pipes, but this is not all that you will need for a real optimised solution where the original engine is optimised for the specific fuel - PPO. What I call a real conversion also includes injectors, injection parameters, glow plugs, and a lot of simple and practical considerations regarding the fuel supply.

To obtain good emissions results, it is essential to have a real conversion, including optimisation of the engine performance, and to have a good quality fuel which meets the limits specified in fuel standards developed for that specific fuel.

Our experiences in Denmark are as good as the thousands German examples, where here it is common to run round the year always on "PPO100", without additives, 2-tank diesel start, or other help - the cold engine starts well on cold PPO in cold weather. Personally, I have completed more than 7 years with my VW Golf 1.9 IDI, literally always on PPO100, and never filled a single drop of fossil diesel or other additives. We have also converted the more modern VW TDI engines with direct injection with 1-tank system, and even where it is not optimal, they can start the cold engine on cold PPO100 in cold weather. To protect the engine, reduce emission etc., the TDI models should preheat a little before cold starts below 5-10 deg C. That can be done by a comfort heater, which also starts to come in new diesel cars. Alternatively 10-15% diesel could be added in the cold season to ensure a prompt cold start. IDI engines do not need to be preheated to start on 100% PPO even down to -10 deg C.

PPO Fuel quality

Rapeseed oil as created by nature is an excellent fuel, but can easily be spoiled by wrong processing, handling and storing. Fuel analysis according to fossil diesel standards does not include important fuel parameters for PPO, so therefore PPO should be analysed according to PPO fuel standard. Here we can all benefit from very fine German research work on PPO fuel quality, ending up with the German RK-standard for rape seed oil as engine fuel in 1999. In 2006 the RK standard was upgraded to a draft DIN Norm, DIN V 51605. The Norm describes both characteristic properties and variable properties. The first group of properties is created by nature, so it makes no sense to check the PPO e.g. for density, viscosity and sulphur. The really important properties are the variables, which are influenced by processing, handling and storing.

One of the important parameters regarding emissions from PPO, is the phosphorus (P) content, which I will compare with the Sulphur (S) content in fossil diesel. It is well known that sulphur in fossil diesel creates SO_2 and particle emission, and that the fossil industry fights to reduce sulphur. In Denmark the fossil industry convinced the government at least once, to reduce the mineral oil tax on low sulphur diesel, to compensate for the expenses to reduce sulphur content. In 2003 they tried again because of the new requirements from EU. PPO contains from nature no sulphur.

Both phosphorus and sulphur are "strangers" to the combustion process, which itself only includes C, H and O. If you study the final report from the German research on SVO fuel quality, Gelbes Heft 69, you will find

that the phosphorus reduces the combustion temperature, and that it will create phosphorus layers in the engine. Reduced temperature could reduce the combustion efficiency leading to more unburned fuel and thereby more emissions. Phosphorus layers are naturally harmful to the engine, and the reduced temperature/combustion efficiency can also lead to coking and polymerisation in the engine.

Industrially produced non refined rapeseed oil can easily contain 20 times the phosphorus limit specified in the RK-standard. Only cold pressed rapeseed oil, or fully refined industrially produced rapeseed oil, can meet the phosphorus limit of 12ppm.

Emission parameters

NO_x emission: The NO_x emission is more related to the combustion technology than the fuel, and an important factor is the combustion temperature. The source of the NO_x generated is the surplus of combustion air, in combination with the high combustion temperature, which is present in the diesel engine.

PM: There is often a reverse relation between NO_x and PM emission. I believe that it is related to engine load and combustion efficiency, which can be adjusted by optimisation. The logic is, that adjustment for higher combustion temperature gives higher efficiency, more complete combustion and therefore less particles, but more NO_x.

T.HC: T.HC is unburned fuel and related to the above mentioned.

CO_2: The direct CO_2 emission is normally proportional to the fuel consumption.

Other studies

You can find hundreds of studies, which have used unconverted or badly converted engines, with undefined or badly defined PPO fuel. The worst case I know is the Swedish study, which did not even test in an engine, but in an oven, and also used non-defined PPO. The press release from the Chalmers University was later retracted by the university, and Volvo UK, which had used the Swedish results to promote their Natural Gas Cars, also had to send out a new press release with retractions.(read more here)

Other emission tests

Through my work during the last 8 years, first of all trying to convince the Danish and European Systems that PPO is a reliable technology when used in proper vehicles, I have had unofficial emission tests from different vehicles converted to and running on PPO. The first one is a test of a VW Golf, 1.6 (IDI) from 1984, tested according to the EURO1 norm. The results are all very fine, and shows that the vehicle after the conversion could even meet the EURO2 limits.

The other is a test of a VW LUPO 1.2 (PDI) 3L, which shows very fine results for particles (PM) of 86% of EURO3 limit, but the NO_x emission exceeded the EURO3 limit by 80%. It corresponds with the reverse relation between PM and NO_x emission. The test shows a consumption of 3.6 liters/100km, but the test was by mistake carried out with too high rolling resistance for the converted car (Fa(80km/h)=3,53kW) compared to the reference test with a non-converted car (Fa(80km/h)=2,93kW). Therefore emissions and consumption was relatively higher for the converted car than for the reference car. If the numbers for consumption and CO_2 emission is corrected with factor 2,93/3,53, both the consumption and CO_2 emission matches the numbers for the reference car. The test results are available here.

Fuel and emission standards

As described above, PPO fuel should be tested according to PPO fuel standards, and not to fossil diesel standards. Therefore larger attention should be paid to develop PPO fuel standards further, and take care that these standards are followed by the producers and consumers.

An example where standards are developed to the purpose, is the special EURO2 limits developed for DI(direct injection) engines in the 90´ties, which allowed larger emissions for DI than for IDI(indirect) engine, due the beginner problems for DI engines.

Future

In May 2003 the EU biofuel directive was adopted, including PPO as one of the options as biofuel. The first draft of the directive (naturally) did not include PPO, but an informal international group including Denmark, Holland, France, Germany, Belgium, Ireland etc., succeeded in convincing first the Parliament, and later the European Commission, that PPO belonged to the list of Biofuels mentioned in the directive. The greatest challenge was to convince the officials of the Commission, who naturally had to take care that PPO was a serious option, if they should include it in the directive. They were only convinced by references to a lot of well functioning examples in Germany, Denmark etc., and by documentation from literature. This literature is

usually not found through traditional sources, you have to search for them in the quite limited numbers of research environments, such as in Germany. The PPO sector is in a large vacuum of research money, but has a huge potential, and deserves more attention and financial support. PPO accepted in the EU Biofuel directive confirms that we can count on that technology, but it needs much more attention and financial sources for relevant studies done by qualified institutions. It's an illusion to believe that the existing institutions linked to the fossil sector, can and will think alternative, and come out with qualified studies.

Request
Let us all spend our efforts to present convincing results with PPO engines and PPO fuel, rather than spend the time to discuss bad results from useless studies. Convincing results requires large attention to engine conversion and optimisation, and to the quality of the PPO fuel. Both things are quite simple, but they need attention and require discipline. Let's move the attention and money from the fossil and nuclear sectors to the future sector, Renewable Energy.

best regards
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