EXHAUST GAS EMISSIONS OF RAPESEED OIL FUELLED TRACTORS

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ABSTRACT: The use of rapeseed oil fuel in adapted tractors has environmental benefits and increases agricultural value added. However, the compliance with exhaust gas emission regulations is not known sufficiently. Thus, it is the aim of a present research project, to determinate emission characteristics by recurrent measurement. The measurement takes place at the TFZ test stand according to the EU-Directive 2000/25/EG. With the Deutz-Fahr tractor the relevant exhaust gas stage II is proven to be fulfilled with rapeseed oil fuel for CO, HC and particle mass, but not for NO_X. For the Fendt Farmer Vario 412 the fulfilment of exhaust gas stage I with rapeseed oil fuel could be verified. Apart from NO_X, rapeseed oil fuel operation has significant advantages for limited emission compounds over diesel fuel, in particular for HC. The emission characteristics of both tractors hold stable over a long operating time. Further tests will be conducted, focussing also on “stage III tractors” and other emission compounds.

Keywords: rapeseedoil, liquid biofuels, emissions

1 INTRODUCTION AND PROBLEM

Rapeseed oil fuelled tractors gain more and more importance in Germany. The use of rapeseed oil fuel in these machines has environmental benefits and increases agricultural value added. Additionally, a reduction of fuel costs can be achieved in many cases. Uncertainties, inhibiting higher market relevance, are long term operation reliability, loose of engine warranty agreements for adapted engines and compliance with exhaust gas emission regulations. Thus, the Technology and Support Centre in Straubing is investigating together with the LVFZ Kringell, financed by the Bavarian State Ministry for Agriculture and Forestry, two rapeseed oil fuelled tractors in practical use. The objective is, besides continuous monitoring of operational characteristics as well as engine oil and fuel quality, to determinate emission characteristics by recurrent measurement to see if the emission behaviour is affected due to rising operating hours.

2 APPROACH

Objects of investigation are a Deutz-Fahr Agrotron TTV 1160 and a Fendt Farmer Vario 412 tractor. All limited exhaust gas components, as there are: carbon monoxide (CO), nitrogen oxides (NO_X), hydrocarbons (HC) and particle mass (PM), are recorded. Important data of the tractors are shown in Table I.

The measurement of exhaust gas emissions takes place at a test stand according to EU-Directive 2000/25/EG [1] with a power take-off dynamometer. Thereby, eight test stages within the engine operating map are run through (Figure 1). The results of every single test stage are added up with specified weighting factors. Emission results are stated in g/kWh, assuming a power loss for transmission between engine and power take-off of 10 % [3]. The first particle mass measurements were conducted according to directive VDI 2066 (undiluted hot exhaust gas), which leads to 10 to 25 % lower particle mass [4], due to less particle-bound hydrocarbons, than with the subsequent used method described in DIN EN ISO 8178 [2] (diluted exhaust gas, filtered at a temperature range between 42 and 52 °C). Result discussion is done in terms of emission standards as well as differences between rapeseed oil fuel and diesel fuel operation.

Table I: Technical Data of the Tested Tractors

Tractor Manufacturer	Deutz-Fahr	Fendt
Tractor Model	Agrotron TTV 1160	Farmer Vario 412
Number of Cylinders	6	4
Engine Power in kW	119	94
Engine Type	Deutz BF6M1013EC	Deutz BF4M2013C
Year of Manufacture	2005	2003
Default Exhaust Gas Stage	II	I
Adaptation Company	Hausmann	VWP
Operating Hours at Time of Adaptation	250	0
Operating Hours at Time of Measurement	245-1525	1940-3230

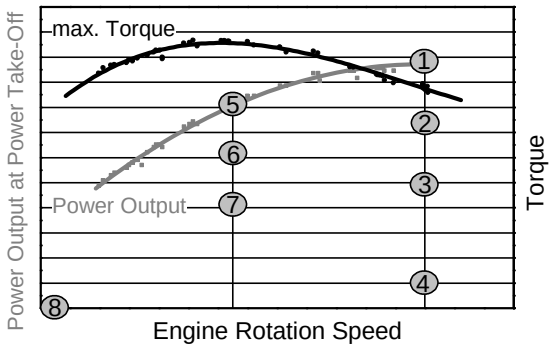

Figure 1: Eight Test Stages within the Engine Operating Map according to 2000/25/EG for Emission Tests

3 RESULTS

3.1 Deutz-Fahr Agrotron TTV 1160

The emission tests of the tractor took place immediately before adaptation (245 operating hours) and after adaptation (263 operating hours). After 870 operating hours the injectors were changed, in order to check possible effects on emissions. During the emission tests at 1064 and 1525 operating hours with diesel fuel, the injector pre-heating (adaptation measure for rapeseed oil fuel operation) was turned off.

Prior to engine adaptation the limiting values of exhaust gas stage II are proven to be fulfilled with diesel fuel (Figure 2 to 5). The demands on NO_X-emissions are hit accurately. By adaptation (among others: pre-heated injectors, increase of injection pressure) emission behaviour is changed significantly: With diesel fuel approximately 50 % higher particle mass and 4 % higher nitrogen oxides are determined. Running on rapeseed oil, NO_X-emissions show a further increase, exceeding the limiting value at 14 %. However, for particle mass emissions a reduction could be observed with rapeseed oil fuel. HC-emissions are more than 60 % less with rapeseed oil fuel, compared to diesel fuel for both, prior and after adaptation meeting even exhaust gas stage IV. The change of the injector at 870 operating hours resulted in a reduction of CO, HC and particle mass during rapeseed oil fuel operation, but only of HC during diesel operation.

After 1525 operating hours no significant affecting of the limited exhaust gas emissions is recognized.

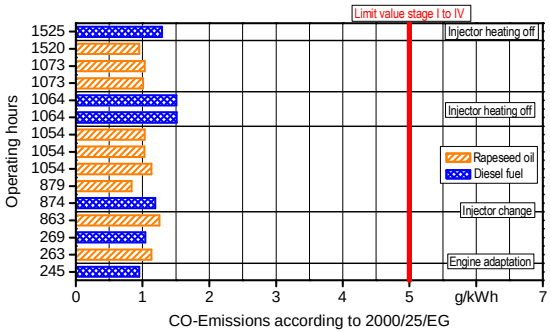

Figure 2: CO-Emissions of a Deutz-Fahr Agrotron TTV 1160 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

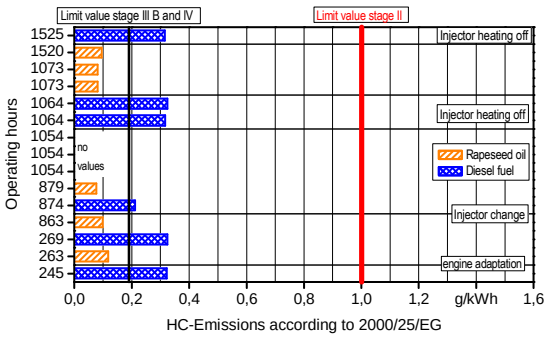

Figure 3: HC-Emissions of a Deutz-Fahr Agrotron TTV 1160 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

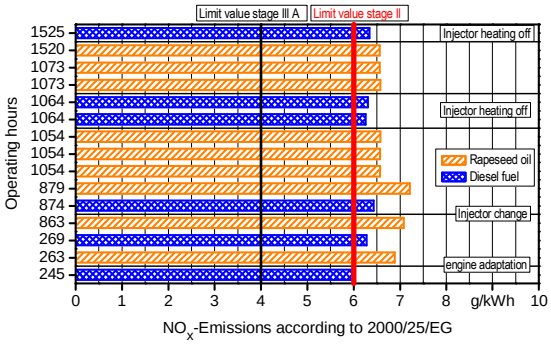

Figure 4: NO_X-Emissions of a Deutz-Fahr Agrotron TTV 1160 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

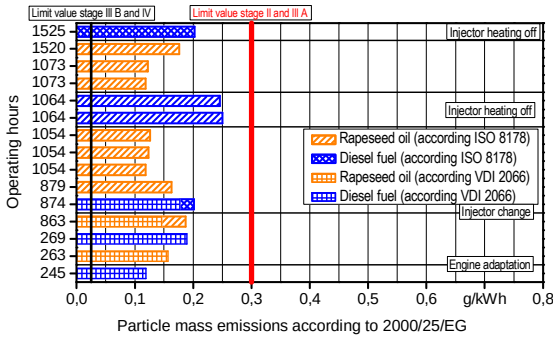

Figure 5: PM-Emissions of a Deutz-Fahr Agrotron TTV 1160 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

3.2 Fendt Farmer Vario 412

The tractor (exhaust gas stage I) was converted to rapeseed oil fuel operation in new condition in 2003 and achieved a total of 1940 operating hours (exclusively with rapeseed oil), when being measured first. At about 2500 operating hours the injected fuel rate has been increased. Injectors were changed after a total of 2650 operating hours.

The fulfilment of exhaust gas stage I with rapeseed oil fuel could be verified (Figure 6 to 9). Though with diesel fuel, the limiting value of CO was exceeded at 13 %. After increasing the injected fuel rate and additionally after the change of the injectors, an enormous decrease of CO and particle mass was observed. In average NO_X-emissions were 13 % higher with rapeseed oil fuel, compared to diesel fuel. All other limited emission compounds showed major advantages with rapeseed oil fuel. For particle mass even the exhaust gas stage III A and for CO and HC the final exhaust gas stage IV was fulfilled with the exhaust gas stage I tractor operated with rapeseed oil.

Since the injector servicing after 2650 operating hours another 580 operating hours without significant change of emission characteristics were recognized.

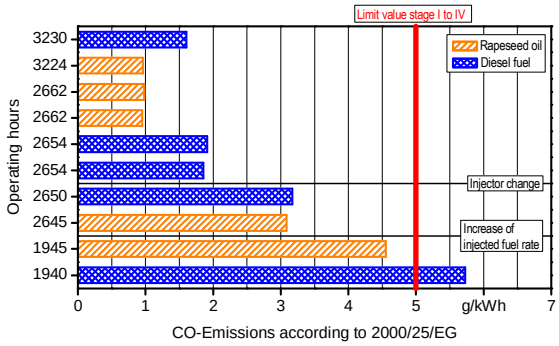

Figure 6: CO-Emissions of a Fendt Farmer Vario 412 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

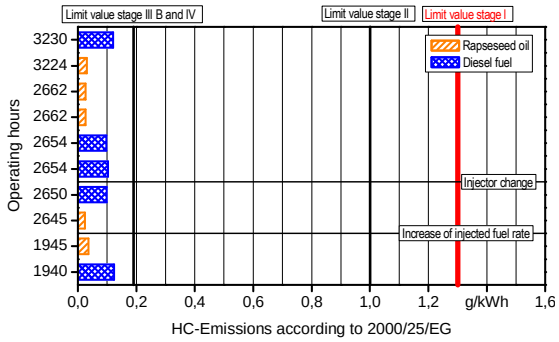

Figure 7: HC-Emissions of a Fendt Farmer Vario 412 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

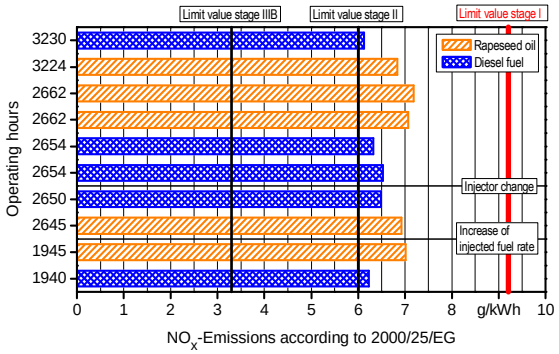

Figure 8: NO_X-Emissions of a Fendt Farmer Vario 412 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

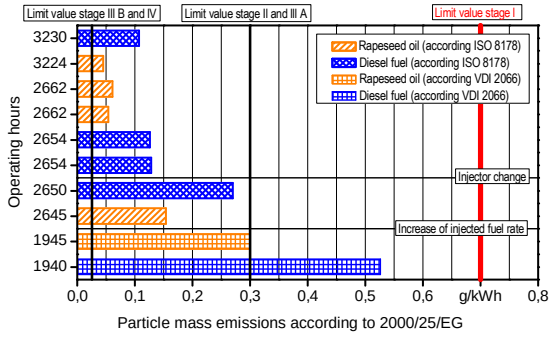

Figure 9: PM-Emissions of a Fendt Farmer Vario 412 tractor with a stationary 8-Mode test according to 2000/25/EG at recurrent measurements

4 CONCLUSIONS AND OUTLOOK

With the tested Deutz-Fahr Agrotron TTV 1160 tractor the relevant exhaust gas stage II is proven to be fulfilled with rapeseed oil fuel for CO, HC and particle mass, but not for NO_X. For the Fendt tractor the fulfilment of relevant exhaust gas stage I with rapeseed oil fuel could be verified. Apart from NO_X, rapeseed oil fuel operation has significant advantages for limited emission compounds over diesel fuel, in particular for HC. The emission characteristics of both tractors hold stable over a long operation time.

However, by comparing emissions between rapeseed oil and diesel fuel operation, it has to be considered, that engines can only be optimised for either, rapeseed oil or diesel fuel. Because of the fact that there is no sophisticated optimisation, regarding emission behaviour, of the presently available adapted conventional diesel engines, a high potential of emission reduction can be deduced. With fuel specific optimisation of the engine and the engine operating map, the fulfilment of upcoming emission demands appears to be also feasible with rapeseed oil fuel, when strategies for NO_X-Emission reduction aim at an actual NO_X-concentration, which is at least 15 % below the requested limiting value.

Further tests will be conducted, focussing also on “stage III tractors” and other emission compounds. With knowledge of the actual exhaust gas emissions from rapeseed oil fuelled tractors, the compliance with present and future emission standards can be reviewed. If necessary, measures for exhaust gas reduction can be deduced and tested to allow environmental low impact operation of rapeseed oil fuelled tractors.

5 ACKNOWLEDGEMENT

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6 REFERENCES

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