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Practice Operation of Serial Rape Seed Oil Suitable Engines

Results of the demonstration project

In order to pave the way for the introduction of rape seed oil as a fuel for agricultural and forestry vehicles, the demonstration project "Practical operation of new serial rape seed oil suitable engines" was carried out. The purpose of this project was to determine the long-term year-round practice suitability, environmental impact and fatigue strength of serial diesel engines, which were modified for rape seed oil operation. The results appear in the following.

The demonstration project "Practical operation of new serial rape seed oil suitable engines", also well-known as "100-tractors-demonstration project", was initiated by the BMVEL (Federal Ministry of Consumer Protection, Nutrition and Agriculture) and supported by FNR e.V. The project was scientifically supervised by the University of Rostock, Chair of Piston and Internal Combustion Engines.

In annual 800 operation hours the 100 tractors should show whether pure rape seed oil can substitute for traditional diesel fuel, considering technical, economical as well as ecological aspects. Since for the application of rape seed oil not all technical problems seemed to be solved and no approval existed by the manufacturer of the tractors, there was a considerable technical and financial risk by using this fuel.

Project Procedure

From April 2001 till October 2002 111 tractors were converted to rape seed oil operation in this context. Seven companies converting engines for vegetable oil operation participated in the program, three of them act nation-wide and with 82% the main share of the conversions.

The conversion company "TC Bastorf" left the project because of technical problems, therefore all scientific supervisions are based on a total number of 107 tractors.

The tractors after conversion had in total 241.000 operating hours with pure rape seed oil, which should meet the requirements of "RK-Qualitätsstandard 05/2000" (rape oil fuel quality standard). The average per tractor was 2.257 operating hours.

Concepts of Conversion

The conversion of tractor engines to rape oil operation comprises several measures, e.g.

- pre-heating of the engine housing
- enlargement of the pipe diameters in the low-pressure fuel oil system

- upgraded low-pressure fuel oil pumps
- upgraded fuel oil filters
- pre-heating of the rape seed oil
- temperature control of rape seed oil before the high-pressure pump
- rape seed suitable injection pumps
- injection nozzles with a higher number of injection holes (>5),
- adjusted injection geometry
- optimisation of combustion via the engine control unit,

whereas the applied measures of adjustment differ between the type of engines. Most of the 107 tractors were converted to the so called "one-tank-concept" (one-fuel system). Only 11 CASE-tractors were equipped with "two-tank-concept" (two-fuel system).

The necessary conversion extent had to be determined specifically for every engine product line on the base of the valid exhaust gas standard. Common to all converting concepts is the pre-heating of the rape seed oil, the enlargement of the pipe cross sections and the preheating of the engine housing. Each converting concept as a part of the demonstration project is represented since August 2001 at least in one tractor .

Power Output

After the conversion measures the tractors achieved 90% to 106% of the rated engine power, measured at the PTO compared to the diesel fuel operation. Power output problems occurred with defects (e.g. at injection pumps).

Exhaust Emission

The emission level in the rape seed oil operation is determined by the emission classification of the tractor before conversion (Euro I or Euro II). The emissions in the rape seed oil mode showed during the first service hours after the conversion a slight increase of the NOx emission, slightly worse than in the Diesel mode prior to conversion. Through further modifications of the con-

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Keywords

Rape seed oil for fuel, conversion concept, tractor, exhaust gas emission

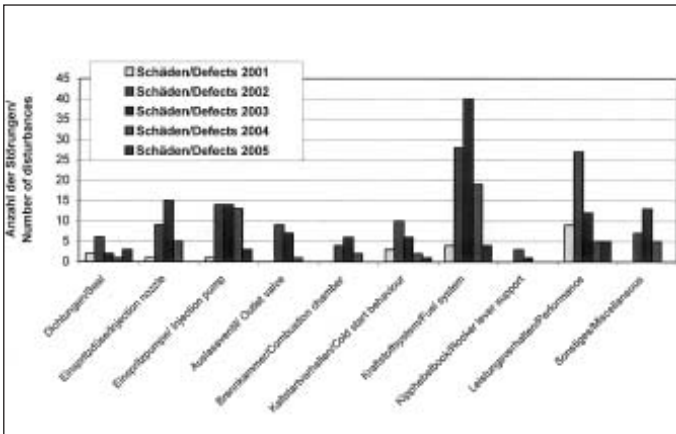


Fig. 1: Defects of the individual functional groups from 2001 till 2005

version concepts the emission level could be improved in general. The CO emissions of the tractors are in the same range as in the diesel fuel mode.

Operation Reliability

63 of 107 tractors completed the project time without or only with small defects (repair costs below 1 000 €) and they are still operated in rape seed oil mode. Serious and cost intensive defects occurred on 44 tractors. From this group 29 tractors are still operated in the rape seed oil mode after project end. 15 tractors were re-converted to the diesel fuel mode.

With none of the seven used conversion concepts there was a trouble-free engine operation over several hundreds service hours for all tractor types and production lines. The most frequent causes of defects were a loss of power, stuck outlet valves, injection pump damage and serious cold start problems. The susceptibility to trouble and the severity of the failures decreased during the project time from 2001 till 2004, the defects of the individual functional groups are described in *Figure 1*.

It has to be concluded that the susceptibility to trouble of a tractor in the rape mode depends essentially on the type of the tractor and only secondary on the conversion concept.

The Fendt-tractors of the types 4XX and 7XX turned out to be comparatively trouble-free with the conversion concepts of the company VWP as well as of the Hausmann company. Also there were only few incidents with the tractors of the company Deutz Fahr equipped with the engine Deutz 1013 in the second half of the program after the power loss problems had been solved in 2002.

Lubrication Oil Quality

The parameters viscosity, contamination, total basic number and rape seed oil content were used to evaluate the lubrication oil quality.

On the basis of trend analyses in periods of 50 to 80 operation hours the oil change intervals of the tractors were determined. A high content of rape seed oil in the lubrication oil at all converting concepts showed the necessity to shorten the oil change intervals (one half to one third of the original period).

About 75 % of the tractors could run with oil change intervals of more than 200 operation hours at the end of the program.

Rape Seed Oil Quality

An essential requirement for the trouble free engine operation is the use of a well defined fuel oil quality. In this regard the quality standard "RK-Qualitätsstandard 05/2000" was the basis to assess the rape seed oil during the demonstration project. However, more than 50% of the investigated samples did not meet the required limits of the "RK-Qualitätsstandard 05/2000".

Reasons were mainly unsuitable pressing conditions, missing purification steps, missing or in appropriately handled safety filters, contaminated storage tanks as well as both poor rape seed quality and storage.

Conclusion

Over a period of 3 years 107 converted tractors were monitored in a large-scale field test concerning environmental impact, fatigue resistance and operational reliability in rape seed oil operation. Regarding the type of the tractor and the design of the engine, different conversion measures at the low pressure injection system, the high pressure system and the combustion control system had to be applied. The costs of conversion depended essentially on the engine design. Engines with PLD injection systems could usually be converted successfully and operated sufficiently. The extent of necessary conversion measures was much higher at engines with distribution injection pumps and a longer trouble free operation with rape oil was not feasible.

63 of 107 tractors completed the project time without or only with small defects.

Serious and cost intensive failures occurred on 44 tractors these are more than 40 % of the participating tractors.

The most frequent causes of failures were a loss of power, cold start problems, stuck outlet valves, injection pump defects and combustion chamber damages.

15 tractors were re-converted to the diesel fuel mode because of massive technical problems.

The majority of the tractors achieved more than 90% of the nominal output in the rape oil mode. The emissions of NOx and CO at idle load and full load were almost the same as in the diesel fuel mode before conversion (at least for tractors of exhaust emission classification 1). High rape seed oil contents in the lubrication oil occurred with all conversion concepts and required the oil change intervals to be reduced to one-third to one-half.

Altogether it has to be concluded, that two of seven conversion companies succeeded in converting certain tractors for a long term rape seed oil operation. But none of seven companies were able to adapt all types of tractors for a long term rape seed oil use, like they agreed at the beginning of the project.

Besides, the demonstration project revealed large deficits concerning the rape seed oil quality and showed the necessity of introduction of extensive quality and safety verification for rape oil manufactured at decentralised sites.

A trouble free engine operation will be possible only on a basis of a standardised and safe fuel quality, the enforcement of warranty claims and the further improvement of rape seed oil fuel technology.

An important milestone in this regard was the release of the Draft of the preliminary standard for rape seed oil as fuel E DIN V 51506 in June 2005.

The experiences of this project can be directly adapted only to tractors corresponding to the technological level of the Emission standards EURO I and EURO II.

A broad marketing of rapeseed oil fuel makes substantial development investments necessary, in order to eliminate existing deficits of some tractor types and to reconcile the rape oil technology with applied emission regulations.

The project has proven that the use of rape seed fuel oil in the agriculture is possible observing certain conditions however at this time it can not be recommended without some restrictions.