

Standardisation of 1st generation biofuels – investigating the effect of ash-forming fuel elements of rape seed oil in combustion chamber and exhaust aftertreatment system

Initial situation

„Manufacturers' wishes vs. oil millers' possibilities“

	Unit	Limit values	
		min	max
Density at 15 °C	kg/m ³	800	900
Flashpoint (Pensky-Martens)	°C	200	250
Kinematic viscosity at 40 °C	mm ² /s		36
Calorific value	kJ/kg	36 000	
Carbon number		39	
Carbon residue (CR)	% (m/m)		0.40
Iodine number	g/100 g	95	125
Sulfur content	mg/kg		10
Total contamination	mg/kg		24
Acid number	mg KOH/kg		2.0
Oxidation stability	h	6.0	
Phosphorus content	mg/kg		12
Earth-alkali content (Ca + Mg)	mg/kg		20
Ash content	% (m/m)		0.01
Water content	% (m/m)		0.075

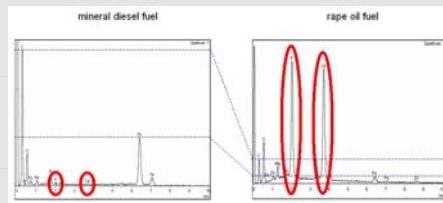
Not all the specifications and limit values of the draft norm for rape seed oil as fuel (DIN V 51605) are agreed by fuel suppliers and engine manufacturers.

→ Critical fuel parameters and limit values have to be identified

Method

Determination of relevant fuel parameters

A comparative analysis (EDX-screening) of the injection nozzle shows the main difference in nozzle deposits between mineral diesel fuel and rape oil fuel:



→ Variations of ash-forming fuel elements Phosphorus, Calcium and Magnesium chosen for further investigations:

Test fuel	Phosphorus mg/kg	Calcium + Magnesium mg/kg
1	< 0,5	< 0,5
2	9,5	12,1
3	23,0	20,4
4	91,9	78,0

Combination of lab and field tests with the same engine

	Lab tests	Field tests
Number of engines used	2	35
Total operating hours	8 913	143 580
Fuel quality	Specially defined test fuels	random
Operating profile	Specially defined test cycles	random
Observation period	short	long
Data acquisition	advanced	basic
Observation method	Permanent on-site	Automatic online-reporting system; frequent on-site visits



Engines used

„SenerTec Dachs RS“, small CHP for the use of rape seed oil other versions for heating oil, natural gas and liquefied petroleum gas

Results

The lab tests showed different areas of deposit formation. The magnitude and relevance of **fuel-based** effects differs for each area, being strongest for the diesel particulate filter.

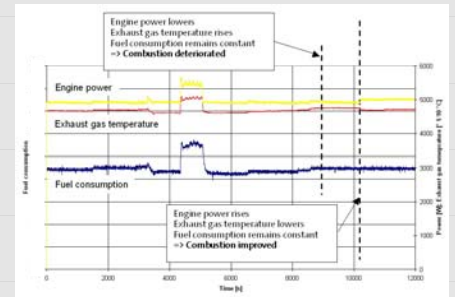
At the injection nozzle, the fuel-based effect is also dominant, followed by effects based on design and operating profile.

Primary Effect (deposit formation on...)		Sensitivity (Σ of each primary effect = 1)			Relevance (Σ = 1)
		Fuel	Design Variations	Operating Profile	
		Injection Nozzle	0.5	0.2	
Valves	0.6	0.3	0.2	0.05	
Piston Bowl	0.7	0.3	0.2	0.05	
Particulate Filter	0.8	0.2	0.0	0.40	

Besides the general deterioration of the combustion caused by insufficient fuel quality, frequent improvements of the combustion could also be seen. This is considered to be caused by injection nozzle deposits, which break off from time to time, if their mechanical stability is too low.

This causes a positive effect on the hydraulic performance and/or the atomisation performance of the nozzle.

The break-off-tendency seems to be influenceable by variations in nozzle design and operating profile.



Summary

The investigations showed a general influence of certain fuel properties on the deposit formation in combustion chamber and exhaust aftertreatment system (especially closed diesel particulate filter (DPF) systems). The long-term formation of ashes in the DPF system is a non-reversible process, whereas deposit formation in the combustion chamber is at least partly reversible during operation.

The maximum limit value for ash-forming elements in the fuel is therefore determined by the ash-storing capacity of the DPF system. For the investigated typical application in a combined heating plant, limit values of 7 mg/kg Phosphorus and 12 mg/kg Calcium and Magnesium are suggested for economical operation of these units. These limit values can still be achieved by oil mills which operate on cold pressing principle, without a refining process.

For further improvement of the engine operation, the operating profile showed an effect on the mechanical stability on combustion chamber deposits and can therefore enhance the frequent reduction of these deposits, especially at the injection nozzle tip. In general, frequent load-changes or engine-stops can cause this beneficial effect. The detailed “regenerating cycle” has to be investigated for each type of engine and operating condition separately.

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