Bio Liquids – CHP, Powergeneration from Biomass

Presentation: Dr. Georg Gruber
Vereinigte Werkstätten für Pflanzenöltechnologie, Dr. Gruber/Gruber GbR

Title: Conversion of engines to enable operation on vegetable oils

Location: Tuscany Regional Office, Brussels
Time: 08 Nov. 2011

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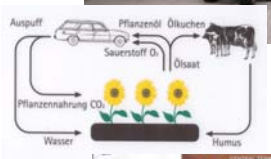

- The “Vereinigte Werkstätten für Pflanzenöltechnologie Dr. Gruber/Gruber GbR” are a company working on research and development of using vegetable oil for agriculture and cars, tractors, trucks and generators.
- VWP Gruber does research and development in plant oil engine technology, fuel development and sustainable fuel production (jatropha, camelina, etc.).
- VWP Gruber applied for and claims 20 patents for engine technology, fuel development, grant licenses and sells know-how.

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Prolog: Basic Rules For Engine Adaptation

- Pure Plant Oil (PPO) out of physical / chemical reasons is a perfect fuel concerning, environment and economics but is a challenge to burn in combustion engines

- Every engine family needs intensice R&D
Pre chamber engines tolerant, DI and CR engines sensitive, medium speed engines tolerant for ppo

- Every new plant oil needs intensive R&D
Combustion quality increases with saturation percentage of ppo

- Fuel quality is about 50% responsible for engine stops
DIN V 51605, DIN 51605, DIN Spec 51623, CEN WS 56

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Development Matrix For PPO Engines

	Großvolumig	Mittelgroß	Kleinvolumig	
Langsam-läufer				Mobile Anwendung
Mittelschnell-läufer				Stationäre Anwendung Generator
Schnell-läufer				Stationäre Anwendung BHKW
	Motortechnologie	Kraftstoffversorgung	Kraftstoffqualität/ Entwicklung	

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Single Tank IDI Diesel Engines (TIER 1)

IDI VWP Test engine at Test bench
Technical University Munich (TUM)

Technical Adaptations (Patented)

- fuel cycle adapted for PPO
- FDS: Fuel detection system for PPO and/or diesel
- PPO Injection needles for better fuel mixture and to avoid coke residues
- Improved glow plug
- PPO pre chamber positioning to centralize fuel/oxygen mixture to main combustion centre

Minor adaptation and fuel quality causes higher emissions and higher fuel consumptions

Risk for engine damage lower than for DI or CR engines

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Single Tank DI Diesel Engines (TIER 1+2)

VWP Deutz DI engine for Jatropha oil

Technical Adaptations (Patented)

- Fuel cycle adapted for PPO
- FDS: Fuel detection system for PPO and/or diesel
- Adapted injection nozzles for better fuel vaporization
- Different beam positioning
- New combustion process
- Valves adjustment

DI engines sensitive for minor adaptation quality: Engine damages power loss, high emission and consumption

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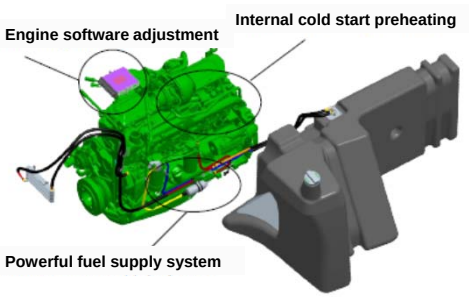
German DIN V 51605 and DIN 51605 as PPO Fuel Quality Standard For Canola Oil

Property	Unit	Limit value DIN V51605		Limit value DIN 51605		Test method
		min.	max.	min.	max.	
Visual examination	-	Free of visible contamination, sediments and free water		Free of visible contamination, sediments and free water		-
Density at 15°C	kg/m³	900,0	930,0	910,0	925,0	DIN EN ISO 3675 or DIN EN ISO 12185 inkl. ISO 12185 Technical Corrigendum 1
Flash point according to Pensky-Martens	°C	220	-	101	-	DIN EN ISO 2719
Kinematic viscosity at 40°C	mm²/s	-	36,0	-	36,0	DIN EN ISO 3104
Net calorific value	MJ/kg	36,0	-	36,0	-	DIN 51900-1, -2, -3
Ignition performance	-	39	-	40	-	See 5.5
Coke residue	% *(m/m)*	-	0,40	-	-	DIN EN ISO 10370
Iodine value	g iodine/100g	95	125	-	125	DIN EN 14111
Sulphur content	mg/kg	-	10	-	10	DIN EN ISO 20884 or DIN EN ISO 20846
Total contamination	mg/kg	-	24	-	24	DIN EN 12662:1998-10
Acid value	mg KOH/g	-	2,0	-	2,0	DIN EN 14104
Oxidation stability at 110°C	h	6,0	-	6,0	-	DIN EN 14112
Phosphorous content	mg/kg	-	12	-	12 (until 31.12.2011) 3,0 (ab 1.1.2012)	DIN EN 14107 or DIN 51627-6
Sum of contents of magnesium and calcium	mg/kg	-	20	-	1,0 each (ab 1.1.2012)	E DIN EN 14538 or DIN 51627-6
Ash content (oxide ash)	% *(m/m)*	-	0,01	-	-	DIN EN ISO 6245
Water content	% (m/m)	-	0,075	-	750 mg/kg	DIN EN ISO 12937

The 2nd VegOil Project - John Deere Common Rail Diesel Engines for PPO/Biodiesel/Diesel (TIER 3a/3b/4)



VWP single tank solution for John Deere PPO/Biodiesel/Diesel Flex Fuel Engine

- Development and testing of off road engines and exhaust gas after treatment systems for TIER 3a, 3b and 4 with rapeseed-, camelina sativa-, sunflower-, corn- and jatropha oil
- Demonstration fleet of 16 tractors in 4 countries with rapeseed-, camelina sativa-, sunflower and jatropha oil
- Proposal of an European fuel quality standard for Jatropha and other PPOs in CEN WS56 workshop

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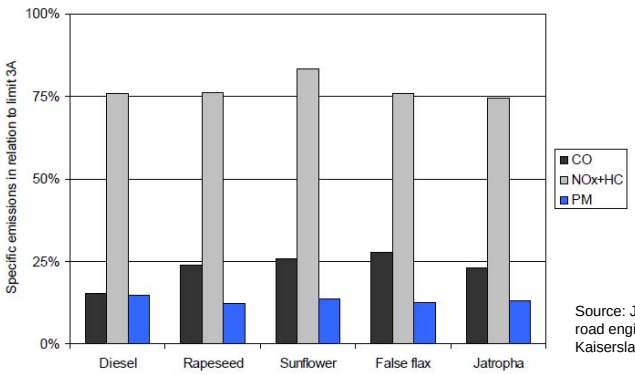
Emission Results TIER 3a for Diesel and Other Plant Oils



Source: John Deere CR off road engine at test stand TU Kaiserslautern

Figure 19 Limited engine out emissions of stage 3A engine (ante DPF/DOC) with different fuels

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Average Torque of Diesel and other Plant Oils (Off Road, TIER 3a)

	Average engine torque (Nm)				
Mode	Diesel	Rapeseed (RÖL)	Sunflower (SÖL)	False flax (LÖL)	Jatropha (JÖL)
A100	628	617	629	630	629
A75	472	472	478	478	478
A50	314	314	319	319	319
A10	61.7	61.6	62.9	62.9	63.0
B100	715	724	720	726	727
B75	542	542	553	553	553
B50	361	361	368	368	369
Idle	18.7	12.0	23.0	23.6	23.3

Source: John Deere CR engine at test stand TU Kaiserslautern

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CEN WS 56 Specification

Table 1 — Generally applicable requirements and test methods

Property	Unit	Limits				Test method [a]
		Direct processed		Improved quality		
		PPO1 minimum	PPO1 maximum	PPO2 minimum	PPO2 maximum	(See Clause 2)
Visual aspect	--	Free from visible contamination, sediment and free water				
Density at 15 °C	kg/m [3]	910,0	940,0	910,0	940,0	EN ISO 3675 EN ISO 12185
Flash point	°C	101	–	101	–	EN ISO 2719 [c] EN ISO 3679 [d]
Lower heating value	kJ/kg	36 000		36 000		DIN 51900-1 and -2, or DIN 51900-1 and -3
Sulfur content	mg/kg	–	10,0	–	10,0	EN ISO 20846 EN ISO 20884 prEN ISO/DIS 13032
Ignition quality [e]						
Water content	mg/kg	–	750	–	750	EN ISO 12937
Total contamination	mg/kg	–	24	–	24	EN 12662 [f]
Oxidation stability	h. at, 110 °C	6,0	–	6,0	–	EN 14112 EN 15751
Acid value	mg KOH/g	–	2,0 [g]	–	2,0 [g]	EN 14104
Phosphorus content [h]	mg/kg	–	12,0 [i]	–	1,0	DIN 51627-6
Ca + Mg [h]	mg/kg	–	20,0 [i]	–	1,0	DIN 51627-6

[a] See 7
[b] See 6.5.
[c] Procedure A to be applied. Only a flash point test apparatus equipped with a suitable detection device (thermal or ionization detection) shall be used.
[d] A 2 ml sample and apparatus equipped with a thermal detection device shall be used.
[e] See 6.6
[f] The test method developed for diesel may show analytical problems when applied to PPO. Lower levels are advisable for long term correct functioning of the engine.
[g] This limit may increase if future engine tests present positive results
[h] See 6.7.1.
[i] Lower limits may apply for specific countries or regions

Analysis of a Bad Jatropha Oil Quality

Vereinigte Werkstätten für Pflanzenöltechnologie
Am Steigbühl 2
D-90584 Allersberg

Ihr Auftrag : -
Ihr Auftrag vom : 22.09.2009
Eingegangen am : 24.09.2009
Probenahme : Auftraggeber
Prüfbericht vom : 30.09.2009
Seite : 3 von 4

Prüfbericht : 175618

Prüfmuster : Jatrophaöl PÖL 2009-294
Aussehen : Farbe gelblich, klar, frei von sichtbaren Verunreinigungen und Wasser, Geruch typisch
Gebinde : PE-Flasche 1000 ml
ASG-ID : 155355 Verplombung : -

Prüfparameter	Methode	Prüfergebnis	Grenzwert DIN V 51 605	Einheit
Dichte (15 °C)	DIN EN ISO 12185	918,4	900 - 930	kg/m3
Flammpunkt P.-M.	DIN EN ISO 2719	256,0	min. 220	°C
Kin. Viskosität (40 °C)	DIN EN ISO 3104	34,54	max. 36,0	mm2/s
Heizwert, unterer	DIN 51 900-2	37058	min. 36000	kJ/kg
Cetanzahl	IP 498	54,9	min. 39	-
Koksrückstand n. C.	DIN EN ISO 10370	0,23	max. 0,40	% (m/m)
Iodzahl	DIN EN 14111	98	95 - 125	g Jod/100g
Schwefelgehalt	DIN EN ISO 20884	1,6	max. 10	mg/kg
Gesamtverschmutzung	DIN EN 12662	34	max. 24	mg/kg
Säurezahl	DIN EN 14104	9,23	max. 2,0	mg KOH/g
Oxidationsstabilität 110 °C	DIN EN 14112	15,8	min. 6,0	h
Phosphorgehalt	DIN EN 14107	46,6	max. 12	mg/kg
Erdalkaligehalt (Ca + Mg)	DIN EN 14538	33,1	max. 20	mg/kg
Oxidasche	DIN EN ISO 6245	0,021	max. 0,01	% (m/m)
Wassergehalt K.-F.	DIN EN ISO 12937	653	max. 750	mg/kg

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Analysis of a Good Jatropha Oil Quality

Prüfmuster : Jatrophaöl QK2009-327
Aussehen : Farbe gelblich, klar, frei von sichtbaren Verunreinigungen und Wasser, Geruch typisch
Gebinde : PE-Flasche 500 ml
ASG-ID : 156932 Verplombung : -

Prüfparameter	Methode	Prüfergebnis	Grenzwert DIN V 51 605	Einheit
Dichte (15 °C)	DIN EN ISO 12185	918,2	900 - 930	kg/m3
Flammpunkt P.-M.	DIN EN ISO 2719	229,5	min. 220	°C
Kin. Viskosität (40 °C)	DIN EN ISO 3104	34,24	max. 36,0	mm2/s
Heizwert, unterer	DIN 51 900-2	37193	min. 36000	kJ/kg
Cetanzahl	IP 498	55,9	min. 39	-
Koksrückstand n. C.	DIN EN ISO 10370	0,24	max. 0,40	% (m/m)
Iodzahl	DIN EN 14111	99	95 - 125	g Jod/100g
Schwefelgehalt	DIN EN ISO 20884	<1	max. 10	mg/kg
Gesamtverschmutzung	DIN EN 12662	15	max. 24	mg/kg
Säurezahl	DIN EN 14104	11,2	max. 2,0	mg KOH/g
Oxidationsstabilität 110 °C	DIN EN 14112	37,6	min. 6,0	h
Phosphorgehalt	DIN EN 14107	<0,5	max. 12	mg/kg
Erdalkaligehalt (Ca + Mg)	DIN EN 14538	<0,5	max. 20	mg/kg
Oxidasche	DIN EN ISO 6245	<0,001	max. 0,01	% (m/m)
Wassergehalt K.-F.	DIN EN ISO 12937	668	max. 750	mg/kg
C12:0 / Laurinsäure	DIN EN 14103	<0,1	-	% (m/m)
C14:0 / Myristinsäure		<0,1	-	% (m/m)
C16:0 / Palmitinsäure		14,7	-	% (m/m)
C16:1 / Palmitoleinsäure		0,9	-	% (m/m)
C18:0 / Stearinsäure		6,6	-	% (m/m)
C18:1 / Ölsäure		40,6	-	% (m/m)
C18:2 / Linolsäure		36,3	-	% (m/m)
C18:3 / Linolensäure		0,3	-	% (m/m)
C20:0 / Arachinsäure		0,2	-	% (m/m)
C20:1 / Gadoleinsäure		<0,1	-	% (m/m)
C22:0 / Behensäure		<0,1	-	% (m/m)
C22:1 / Erucasäure		<0,1	-	% (m/m)
C24:0 / Lignocerinsäure		<0,1	-	% (m/m)
C24:1 / Nervonsäure		<0,1	-	% (m/m)
Elementscreening	ICP-OES	*	-	mg/kg

* Ag ,Al ,Ba, Cu, Fe, K, Cd, Cr, Mn, Mo, Na, Ni, Pb, Si, Sn, Ti, V, Zn : <0,5 mg/kg

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Biofuel Medium Speed Engines Technical Adaptations

Source: MAN Diesel & Turbo

-Quality adaptation reduces operational costs, fuel consumption and engine risks

-Selection of suitable engine type (large bore)

-Fuel cycle incl. storage system (heating, separating)

-Adapted Fuel injection systems (coating)

-Adapted maintening cycle (accumulation of lub. oil)

-Fuel quality control (degumming, deacidification, Seperation)

-Different Fuel Specifications of different engine producers

-Different emission standards and emissions after treatment systems (TA-Luft, World Bank etc.)

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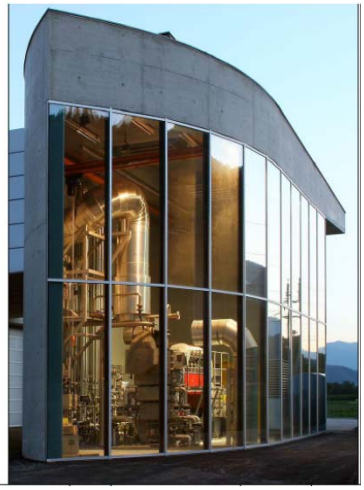
CHP For Used Cooking Oil/Fat (Fritzens/Austria/MAN)

- Engine type 6L21/31
- Power output: 1,160 kW
- Fuel: recycled frying fat
- Commissioning date: May 2004
- about 54,000 h
- Availability: > 90 % (8,000 h/a)

Source: MAN Diesel & Turbo



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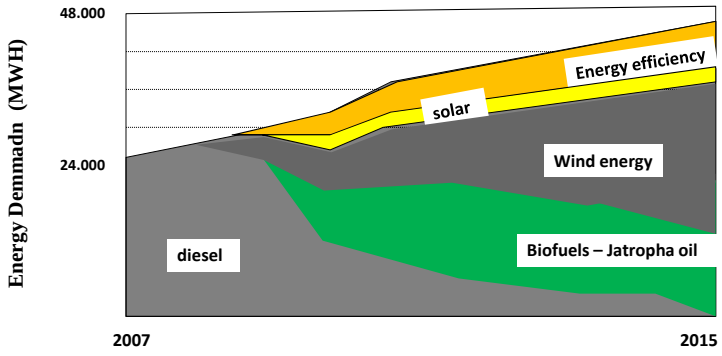
MAN Diesel Biofuel Specification

Density/15 °C	900 – 930 kg/m³	DIN EN ISO 3675, EN ISO 12185
Flash point	> 60 °C	DIN EN 22719
Lower Calorific Value	> 35 MJ/kg (typical: 37 MJ/kg*)	DIN 51900-3
Viscosity/50 °C	< 40 cSt (corresponds to viscosity/40 °C < 60 cSt)	DIN EN ISO 3104
Cetane number	> 40	FIA
Coke residue	< 0,4 %	DIN EN ISO 10370
Sediment content	< 200 ppm	DIN EN 12662
Oxidation stability (110 °C)	> 5 h	ISO 6886
Phosphorus content	< 15 ppm	ASTM D3231
Na + K content	< 15 ppm	DIN 51797-3
Ash content	< 0,01 %	DIN EN ISO 6245
Iodine Number	< 125g/100g	DIN EN 14111
Water content	< 0,5 %	EN ISO 12537
TAN (total acid number)	< 5 mgKOH/g (TAN 5 mgKOH/g ≙ ~2,5 % FFA)	DIN EN ISO 660
Cold Filter Plugging Point	< 10 °C below lowest temperature in fuel system	EN 116

Zero Fossil Fuel Strategy for the Galapagos Islands



Source: ERGAL Project

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Thank You Very Much For Your Attention!

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