


Success through Fuel Borne Catalysts in the Mining Market

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Success through Fuel Borne Catalysts in the Mining Market

Outline

- Introduction
- Functionality of FBC supported DPF-Systems
- Fuel-Borne-Catalyst – Cost Driver versus Performance Booster
- Effects on Engine Performance
- Smart Regeneration Technology
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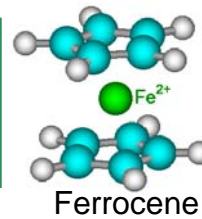
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Introduction

- PM – Risk for miners of serious health hazards (MSHA)
- NO₂ - Risk for miners of serious health hazards (MSHA)

- DPF-Systems reduces PM exposures up to 99 % (see MSHA Filter List)
- DPF-Systems + FBC reduces **PM** and **NO₂** exposures (SwRI)
- FBC-Additive is fuel-soluble metal based product (e. g. Ferrocene)



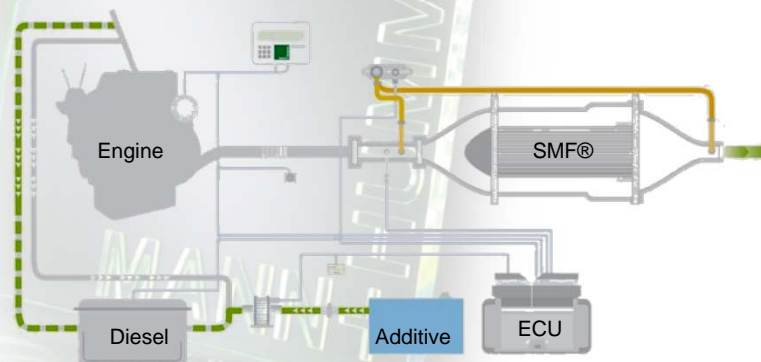
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Functionality of FBC based DPF-Systems

- FBC-Additive automatically dosed in diesel fuel (22–28 ppm; 1/2300 – 1/1800)



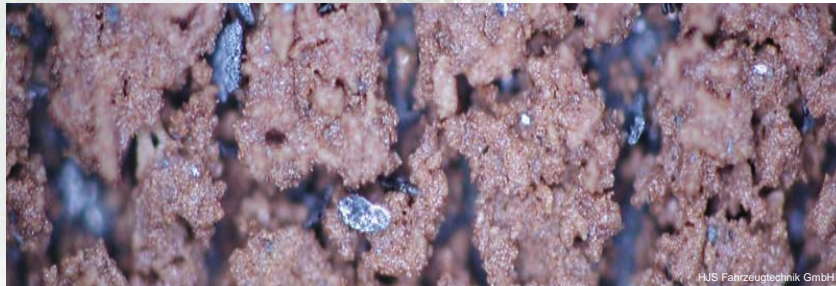
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Functionality of FBC based DPF-Systems

- FBC-Additive is burned in combustion chamber into Fe_2O_3 (rust)
- Fe_2O_3 is a catalyst - soot particles linked with Fe_2O_3 in combustion chamber
- Soot particles together with Fe_2O_3 are captured in DPF downstream



Ash with Fe_2O_3 (red) on SMF[®] (metal grey) after regeneration

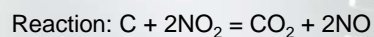
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Functionality of FBC based DPF-Systems

- Fe_2O_3 reduces the ignition temperature for soot and supports the oxidization of C (soot) into CO_2 (gas)
- Fe_2O_3 remains in the DPF and is removed with every filter service
- Fe_2O_3 also supports the conversion of NO_2 into $\text{NO} + \text{O}_2$



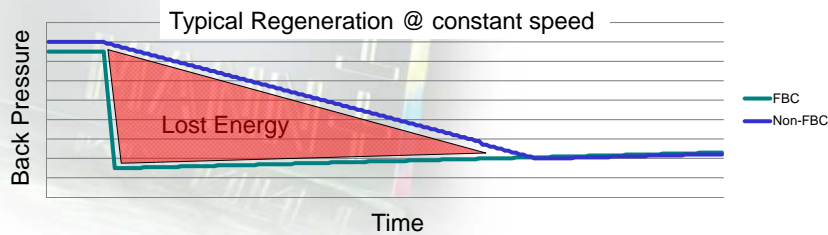
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Cost driver versus performance booster

- Cost for additive typically 2 – 4 % of the fuel cost in Canada
- No cost for cleaning device (power wash)
- No cost for additional service – service life matches with service interval of the engine
- Cost reduction 1 – 2 % of fuel cost due to reduced backpressure versus Non-FBC-Systems – faster regeneration 2 - 3 minutes versus 1 - 2 hours



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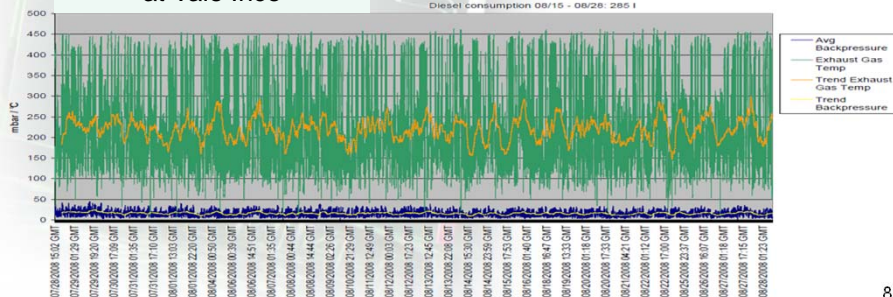
Cost driver versus performance booster

- Self ignition effect with exhaust gas temperatures higher than 380 °C
Reduction ignition temperature for soot from 600°C down to 380°C
Regeneration starts automatically and reduces average back pressure

Analysis - Equipment at Vale Inco

operating hours	132	since installation on 09/21/07
Additive consumption [l]	0.487	1502
Diesel consumption [l] (calculated on 28ppm)	756	5.569
Backpressure [mbar] min/max/avg	2 / 45 / 16	8550
Exhaust Gas Temp [°C] min/max/avg	36 / 464 / 220	2 / 87 / 26
		36 / 464 / 206

Diesel consumption 08/15 - 08/28: 285 l



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Cost driver versus performance booster

- No restrictions due to sulfur content in diesel fuel
- No secondary emissions due to FBC technology (see VERT test data; PAH, Nitro-PAH, HC, CO, CO₂, NO_x, PCDD, PCDF)

Empirische Messverfahren und Prüfverfahren
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Laboratori federal de ensaïes de materials i de recerca
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Test Report
Nr. 433'858

Client: TTM Technik Thermische Maschinen
Andreas Mayer
Führhildstr. 14b
CH-5443 Niederrhoden

Test Assignment: Influence of iron-based regenerative particulate trap
on the chemical composition of diesel exhaust gas
Test Objects: 5 exhaust gas samples

Client Ref. Nr.:
Client: March 12th, 2004
Test Object received: March 23rd - March 25th, 2004
Test performed: March 2004 - July 2004
Number of Pages: 37 (including front page)
Attachments: none

Dübendorf, 2004, July 14th
Project Leader: *N. Heeb*
Dr. N. Heeb

Laboratory of Organic Chemistry
Head of Laboratory: *Dr. M. Wolfensberger*
Dr. M. Wolfensberger

The test results are valid only for the object tested. The use of the test reports for the purpose of publicity, the news reference to them or publication of excerpts requires the approval of the EMPA (see emblem). Test reports and supporting documents are retained for 10 years. Unless otherwise stated in writing, test samples will be disposed of 2 months after testing.

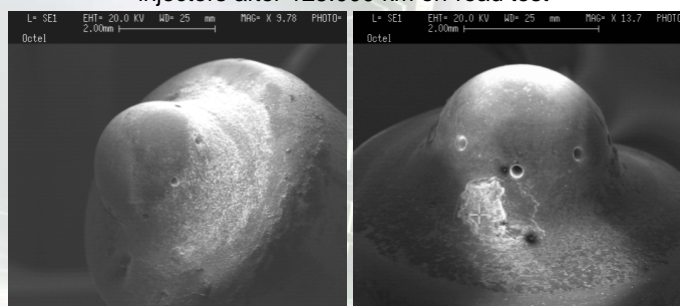
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Effect on engine performance

- Cleaning effect for combustion chamber and injection system
On-road test with identical trucks / 125.000 km (SAE paper 2004-01-0078)

injectors after 125.000 km on-road test



without FBC

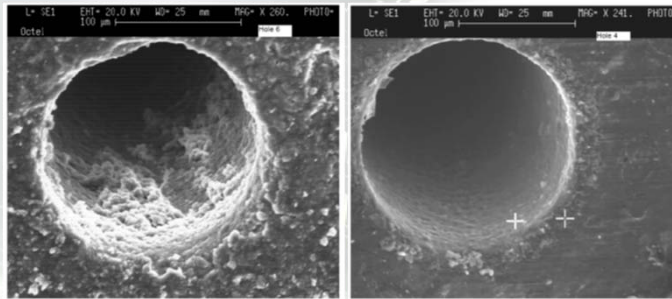
with FBC

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Effect on engine performance

injectors after 125.000 km on-road test



without FBC

with FBC

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Effect on engine performance

- Fuel economy will be improved by 1 – 2 % of total fuel cost (SAE paper 2004-01-0078)
- 4 trucks (Actros 1835 LS / engine Mercedes-Benz OM501LA)
- 1 truck without FBC / 3 with iron based FBC (Ferrocene)
- 8 Dynamometer test cycles with in total 114 km
- 4 tests under cold start conditions
- 4 tests under hot start conditions

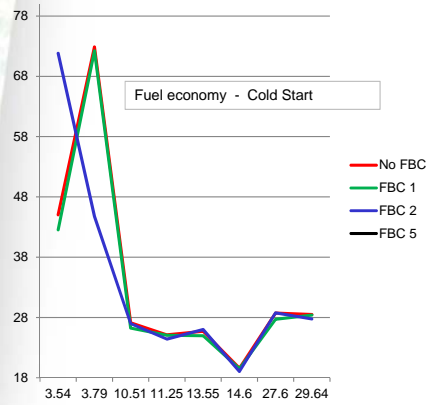
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Effect on engine performance

	Distance	No FBC	FBC 1	FBC 2	FBC 5
	/ 100 km	/ 100 km	/ 100 km	/ 100 km	/ 100 km
Cold Start	3,54	45,03	42,54	71,83	
Cold Start	3,79	72,89	72,24	44,76	72,2
Cold Start	10,51	27,14	26,25	26,98	
Cold Start	11,25	25,12	25,04	24,4	24,82
Cold Start	13,55	25,72	24,96	26,01	
Cold Start	14,6	19,59	19,5	19,03	19,37
Cold Start	27,6	28,74	27,69	28,77	
Cold Start	29,64	28,5	28,39	27,75	28,18
Average normalized		28,62	28,04	28,2	28,17
Advantage versus No FBC			2,00%	1,44%	1,50%



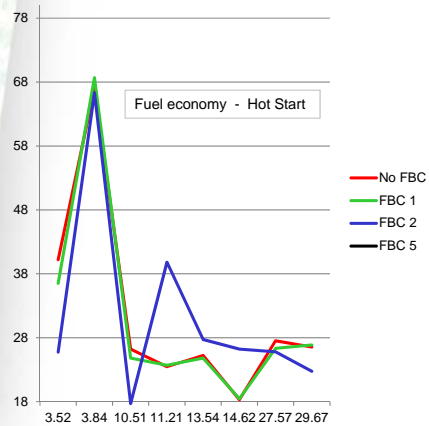
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Effect on engine performance

	Distance	No FBC	FBC 1	FBC 2	FBC 5
	/ 100 km	/ 100 km	/ 100 km	/ 100 km	/ 100 km
Hot Start	3,52	40,21	36,5	25,75	
Hot Start	3,84	66,99	68,69	66,33	67,92
Hot Start	10,51	26,22	24,82	17,69	
Hot Start	11,21	23,46	23,7	39,82	23,56
Hot Start	13,54	25,23	24,81	27,73	
Hot Start	14,62	18,29	18,46	26,22	18,35
Hot Start	27,57	27,52	26,35	25,78	
Hot Start	29,67	26,55	26,86	22,73	26,67
Average normalized		27,02	26,62	27,27	26,72
Advantage versus No FBC			1,45%	-0,93%	1,16%



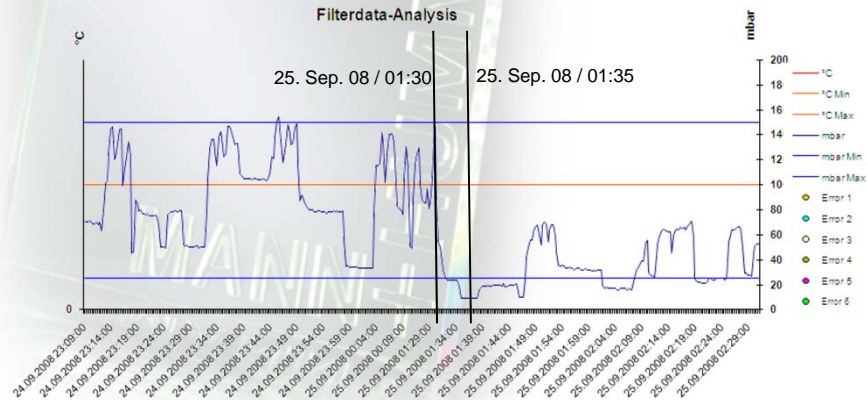
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Effect on engine performance

- Fast regeneration in less than 5 minutes



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Smart Regeneration Technology – SMF®-AR

- Monitoring: air flow signal, exhaust gas temperature, RPM signal, differential pressure (filter), additive tank level, fuel sender, additive dosing pump, heating coils, display, power supply
- ECU monitors all system components – data stored for 30 days
- Self learning strategy with three safety levels
 - 1. Standard: Soot load < 22 g /m²
 - 2. Advanced: Soot load < 35 g /m²
 - 3. Emergency: Soot load > 35 g /m²

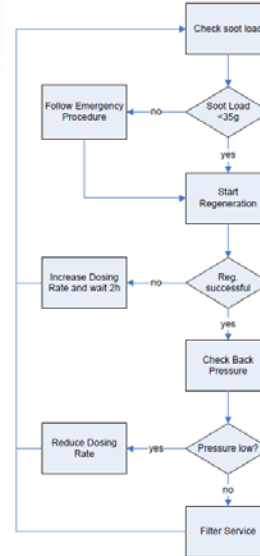
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Smart Regeneration Technology

- Increase and decrease of dosing rate based on regeneration success
- Self learning software with statistical tools to detect best available regeneration timing (level 2: advanced)
- Automatic optimization for dosing rate in a defined window



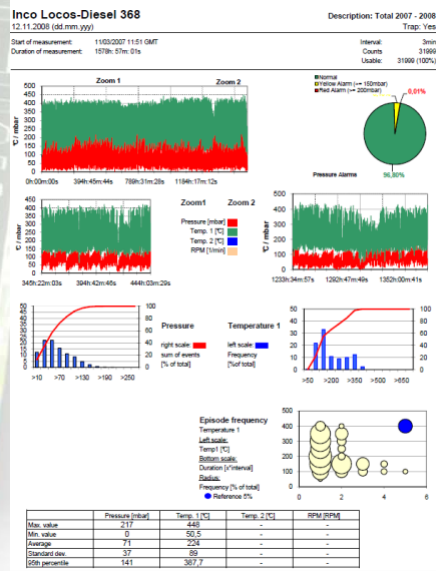
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Test Results

- Locomotive (INCO, Creighton Mine)
- Deutz Engine F6L912W; 80 hp / 60 kW @ 2300 rpm
- 1578h test – 0.01 % failure rate

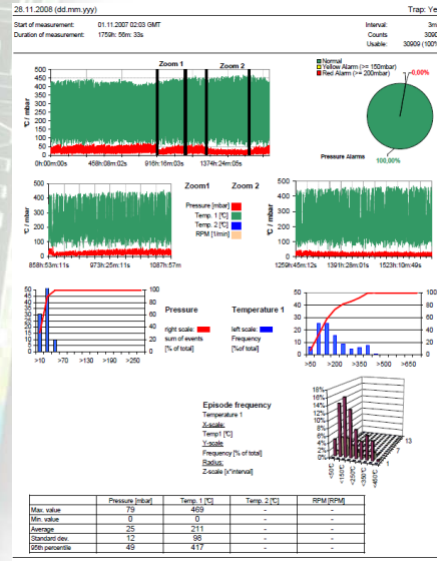


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Test Results

- Truck (Vale Inco, Creighton Mine)
- Engine V2203RP; 49 hp/36 kW @ 2600 rpm
- 1759h test; - 0.00 % failure rate

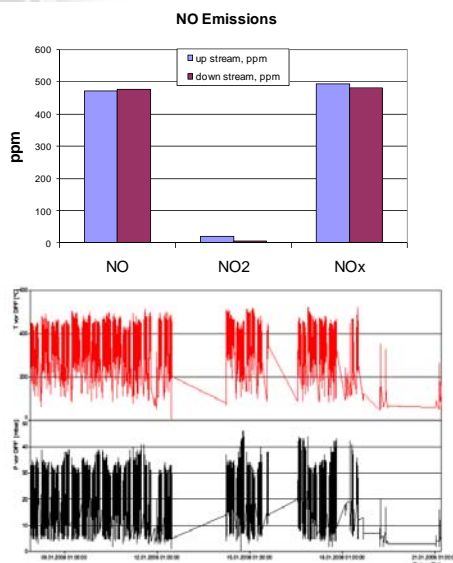


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Test Results

- Mining Loader (Kali+Salz, Germany)
- Deutz F 12 L 413 FW / 273 HP @ 2.300
- >2500 test; no failure



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Conclusion

- FBC Technology is used in non-road applications and it had been extensively tested for mining application
- FBC Technology reduces PM and NO₂ emissions for no extra operation cost (Cost for additives is compensated by better fuel economy)
- FBC Technology improves engine performance (cleaning effect)
- Smart regeneration technology in combination with FBC technology had been shown as a reliable solution for exhaust after treatment device in mining applications.

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Thank you for your time and attention!

