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Extended Poster-Abstract

Nanoparticles on HD Diesel Engines – some new results of AFHB

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During the didactic projects of the Laboratories for IC-Engines and Exhaust Emission Control (AFHB), of the Berne University of Applied Sciences (BFH-TI) several interesting results were obtained, which confirm or enlarge the present state of knowledge.
Examples are presented about:

- NP with EGR and increased backpressure,
- Nanoparticles & DPF filtration efficiency during burner regeneration,
- NP nuclei mode with FBC, or with higher lube oil consumption.

On the Iveco engine Euro 4 with EGR it is possible to close the EGR by means of the ECU. This version of engine with closed EGR is called Euro (4). The objective was to investigate the influence of increased backpressure on emissions with and without EGR.
Without EGR there is lower NP emission level and the NP count concentrations increase with the increasing backpressure. With EGR the NP level is higher (roughly double) and there is no influence of backpressure.

An active burner regeneration of an uncoated DPF was investigated on Liebherr engine. The burner was switched on during a continuous increase of engine torque. The regulation of burner was set to keep the temperature after DPF (T_8) constant.
The particles emission after DPF shows that a strong regeneration takes place during the ramp time. The efficiency remains above 90% before the regeneration starts and falls between 70% and 90% during the regeneration.

The third represented working package concerned the research of NP size distributions on Liebherr engine with FBC, or with higher lube oil consumption.
Oil consumption was simulated by mixing 2% v/v oil to the fuel. Two types of lube oil were used: a standard oil with additive packages and additive-free oil DEA. As FBC satacen 3 was added at 40 ppm.
As a results the NP size distribution were clearly influenced:
standard lube oil with additive package increases much stronger the nanoparticle counts in nuclei mode, than the additive-free oil.
The increase of nuclei mode with FBC (double dosing rate) is similar range of magnitude, like with the standard lube oil.

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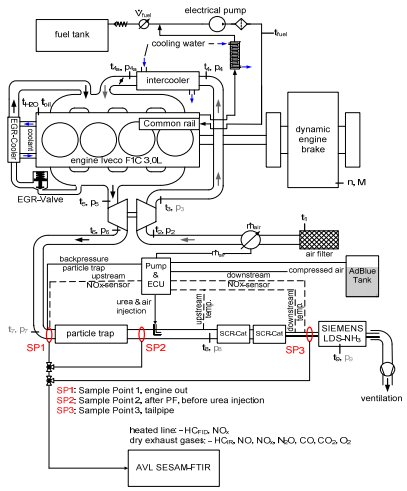
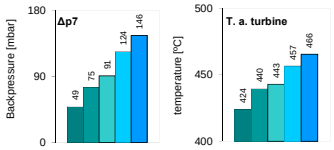
Nanoparticles with EGR and increased backpressure

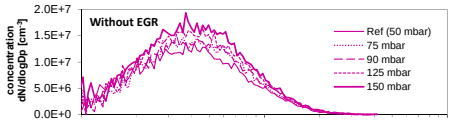
Engine: IVECO F1C E(4), with and without EGR
Fuel: ULSD, <10 ppm Sulphur
2200rpm / 245Nm

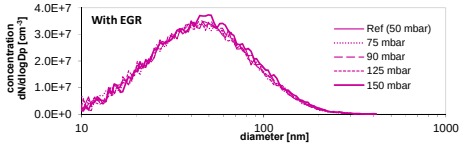


The objectives of these tests were to increase the backpressure of the engine at stationary and dynamic engine operation and to test the influences on emissions without exhaust gas after treatment.

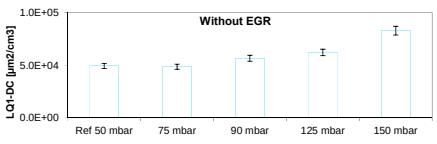


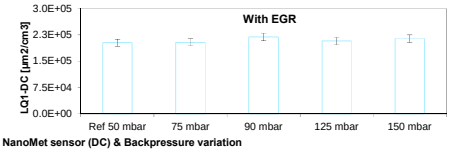
Backpressure variation before DPF and Temperature variation after turbine





SMPS - size spectra & Backpressure variation





NanoMet sensor (DC) & Backpressure variation

CONCLUSION:

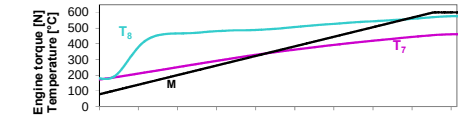
Without EGR there is lower NP emission level and the NP count concentrations increase with the increasing backpressure. With EGR the NP level is higher (roughly double) and there is no influence of backpressure.

Nanoparticles & DPF filtration efficiency during burner regeneration

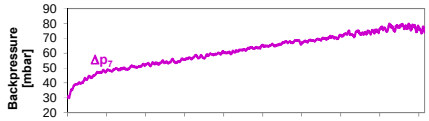
Engine: LIEBHERR D934S A6
Fuel: ULSD, <10 ppm Sulphur

Regeneration burner and DPF (right)

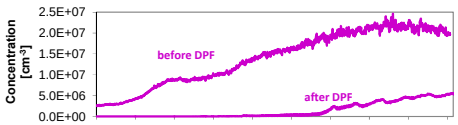
A prototype of a new burner has been tested. We operated the engine at 1400 rpm and ramped the torque from 50 to 600 Nm over 30 minutes. The burner was in function during the whole ramp and regenerated the previously soot loaded DPF.



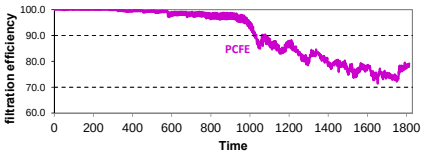
Torque ramp and temprature profile before (T7) and after (T8) the DPF



Backpressure before the DPF



Particles emission before and after the DPF



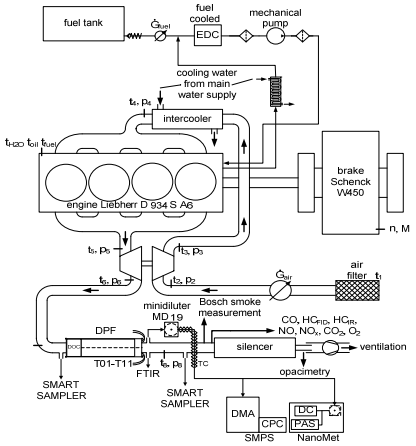
Filtration efficiency before and during the regeneration

CONCLUSION:

The particles emission after DPF shows us that a strong regeneration takes place during the ramp time. The efficiency remains above 90% before the regeneration starts and falls between 70% and 90% during.

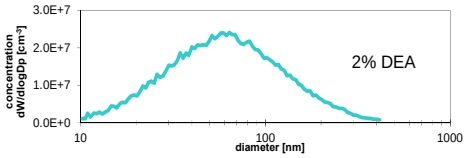
Nanoparticles nuclei mode with FBC, or with higher lube oil consumption

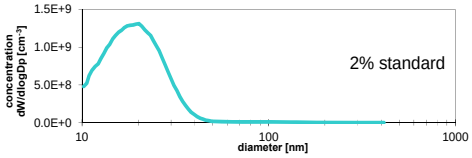
Engine: LIEBHERR D934S A6
Fuel: ULSD, <10 ppm Sulphur
1400rpm / 685Nm

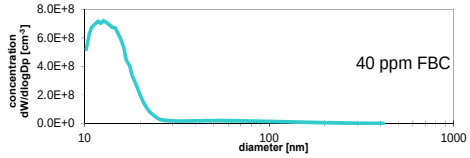


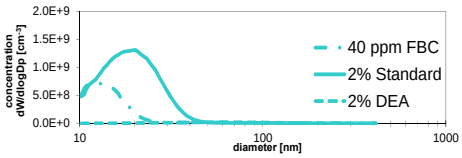
The main purpose of that study was to determine the impact of an oil consumption on the nanoparticle emissions. We simulated an oil consumption by adding oil in the fuel. To stick to the reality, we mixed up 2% of oil with 98% of ULSD. This is representative of the standard gasoline used by the two-stroke engines.

For the first measurment, we used an additive-free oil (DEA).
For the second one, we used a standard 5W30 engine oil, with traces of calcium, zinc, nitrogen, sulfur, phosphorous and chlorine.
For the last measurment, we added 40ppm of Satacen 3 (FBC) to the ULSD.









The particle size and counts distributions were analysed with following apparatus:
- SMPS – Scanning Mobility Particle Sizer, TSI (DMA TSI 3081, CPC TSI 3010 S)
- NanoMet – System consisting of:
- DC – Diffusion Charging Sensor (Matter Eng. LQ1-DC)
- MD19 tunable minidiluter (Matter Eng. MD19-2E).

Thermoconditioner (TC) (i.e. MD19 + postdilution sample heating until 300°C)

CONCLUSION:

Standard lube oil with additive package increases much stronger the nanoparticle counts in nuclei mode, than the additive-free oil.
The increase of nuclei mode with FBC (double dosing rate) is in similar range of magnitude, like with the standard lube oil.

Further information: herve.nauroy@bfh.ch; jan.czerwinski@bfh.ch