Comparison of loading and regeneration behavior of uncoated, coated and aged diesel particulate filters

Christian Zöllner and Dieter Brüggemann

Bayreuth Engine Research Center (BERC), Department of Engineering Thermodynamics and Transport Processes (LTTT), University of Bayreuth, 95447 Bayreuth, Germany, LTTT@uni-bayreuth.de

BAYREUTH ENGINE RESEARCH CENTER

LEHRSTUHL FÜR TECHNISCHE THERMODYNAMIK UND TRANSPORTPROZESSE
PROF. DR.-ING. D. BRÜGGEMANN

BACKGROUND

- Regeneration of diesel particulate filters (DPF) is necessary to avoid engine damages
- PM oxidation should lead to a regeneration process that minimizes fuel penalty, avoid high temperature peaks and gradients inside DPF by maintaining a high regeneration efficiency
- Lack of knowledge about thermal control of DPF regenerations and the variety of influencing factors

How do different engine operating conditions and different filter types influence DPF loading and regeneration behavior?

EXPERIMENTAL APPROACH

setup
- Selection of filter type
- Integration into exhaust line of diesel engine
- (DPF aging)

pre-tretment
- Degreening in exhaust of diesel engine
- Regeneration to clean the DPF

loading
- Loading in steady state engine mode 1 or 2 until target pressure drop

regeneration
- DPF regeneration in independent engine mode via post-injection

EXPERIMENTAL SETUP

engine characteristics

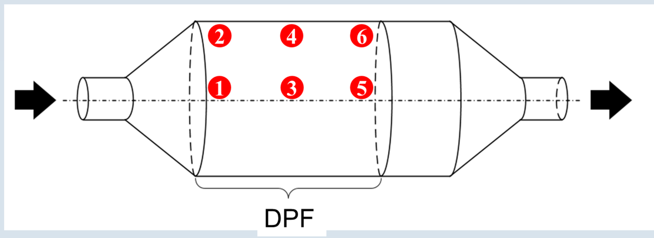
Manufacturer, Type	Daimler, OM 651
Capacity	2143 cm³, 4 cyl.
Rated RPM	4200 min^{-1}
Rated power	150 kW
Injection pump	Delphi Piezo
Emission standard	Euro 5

DPF characteristics

Material	Silicon carbide
Dimension	5,66'' x 6''
Cell density	200 cpsi
Porosity	58 %
Pore size	16 µm
Coating	20 g/cft platinum

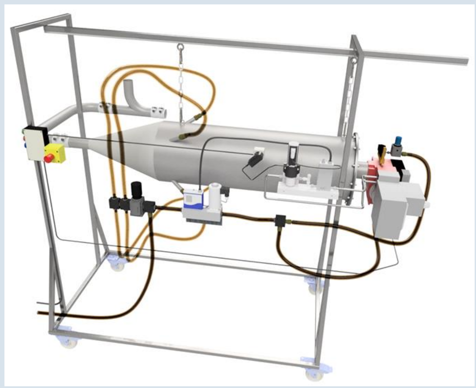
4 types of particulate filters:
- Coated filter without ash
- Uncoated filter without ash
- Uncoated filter with 5 g/l ash
- Uncoated filter with 17 g/l ash

Arrangement of thermocouples inside the diesel particulate filter:



DPF aging system

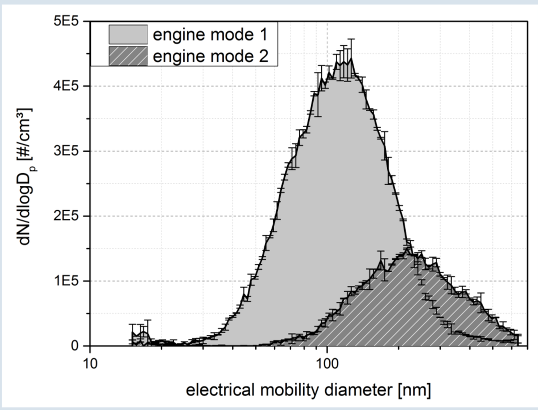
- Oil burner system
- Mass flow controller for air and fuel
- Loading of DPF with unburnt inorganic components of SAE 5W-30



RESULTS

Particle size distribution

Steady state engine mode conditions:

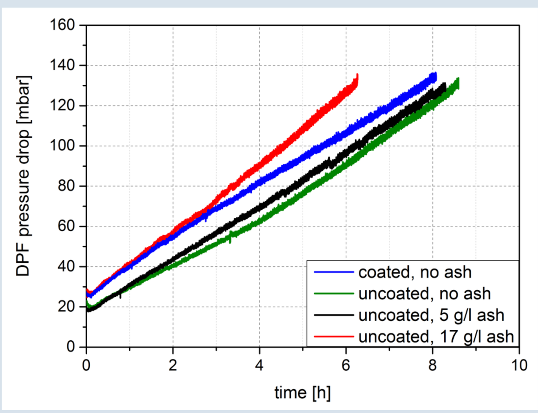


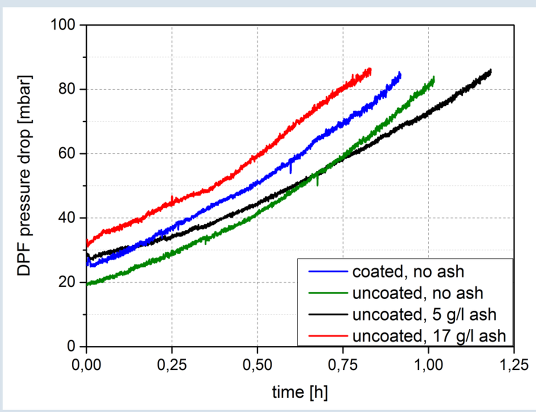
	engine mode 1	engine mode 2
Median particle diameter [nm]	112	218
Exhaust mass flow [kg/h]	115	61
Exhaust temperature [°C]	203	245

DPF loading behavior

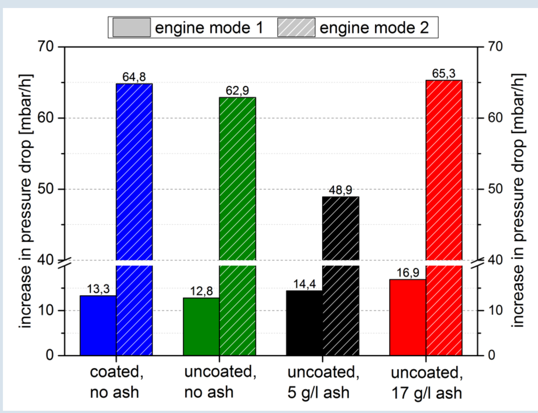
engine mode 1 | **engine mode 2**

Pressure drop behavior:





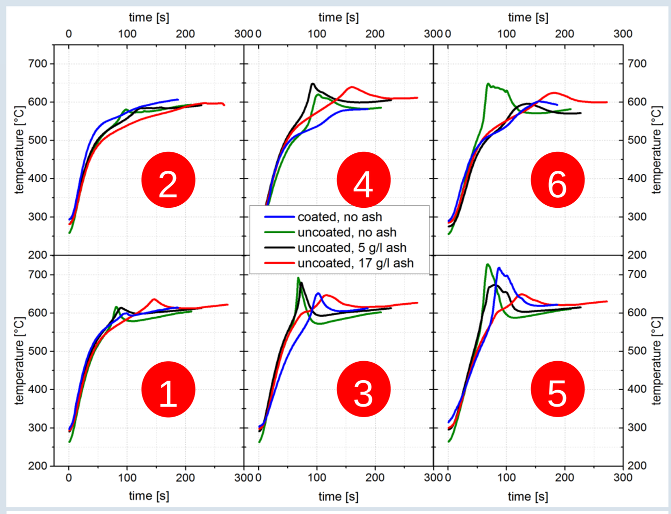
Hourly pressure drop increase:

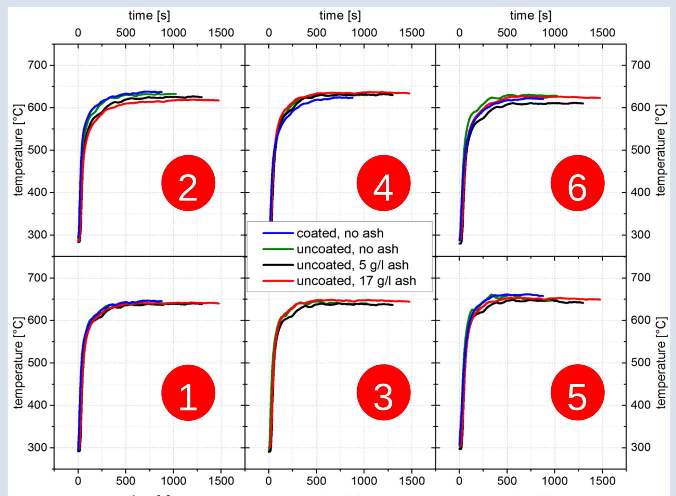


DPF regeneration behavior

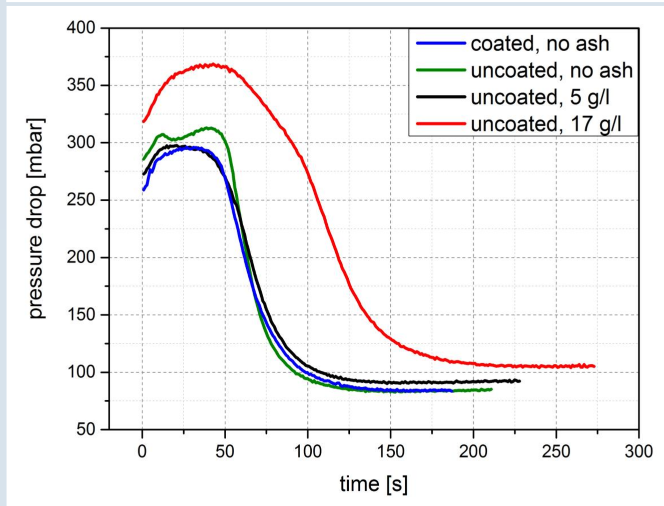
Regeneration after loading with: **engine mode 1** | **engine mode 2**

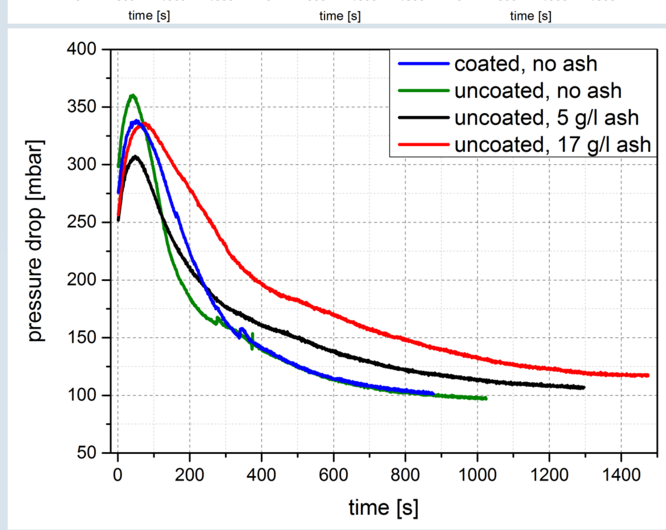
Temperature profile inside the DPF:
(position of thermocouples 1-6 in „Experimental Setup")



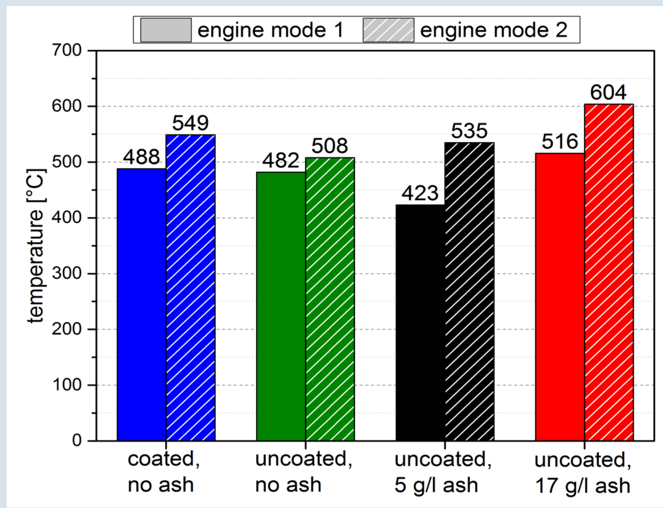


Pressure drop behavior:





Temperature at maximum pressure drop for quantification of the start of regeneration:



DISCUSSION

DPF loading behavior

- Huge differences in loading duration for comparison of smaller and larger particles
- Loading with smaller particles shows a linear rise of pressure drop whereas loading with larger particles has a rise in pressure drop gradient as a consequence
- Reduced durations of loading process are only visible at higher ash loads

DPF regeneration behavior

- DPF loading with smaller particles (engine mode 1) has a faster regeneration process and higher temperature gradients inside the DPF as a consequence than loading with larger particles (engine mode 2) → effect of specific surface area
- Oxidation of smaller particles starts at lower temperatures → less energy input is necessary
- Regeneration process of filters with certain ash loads takes longer → impact of inorganic components and/or changed local soot concentrations
- Increasing ash load leads to a start of the regeneration process at higher temperatures but also to smaller temperature gradients in case of loading with smaller particles

Acknowledgements
The research project is funded by the German Research Foundation (DFG): BR 1713/17-1.

DFG Deutsche Forschungsgemeinschaft

www.berc.uni-bayreuth.de

AUTOMOTIVE COMPONENTS ENGINEERING