Characterization of Particulate Matter and the Capture Efficiency in Open Metal Substrates

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Introduction

- Particulate Matter (PM) emission causes problem for human health as well as for the environment
- PN (Particle Number) legislation requires wall-flow filters (DPF) and increases fuel consumption
- To reduce fuel penalty a detailed understanding of capture related phenomena is needed
- What is the potential to use open metal substrates with protrusions for PM removal?

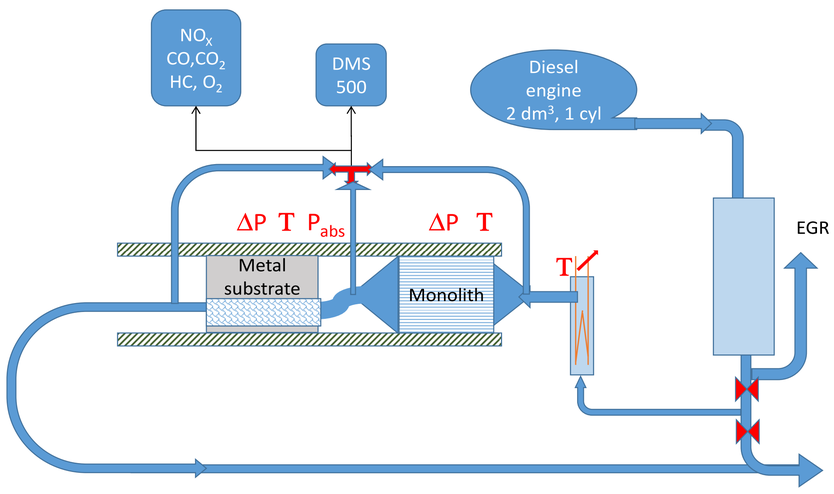

Figure 1. Schematic picture of the experimental setup.

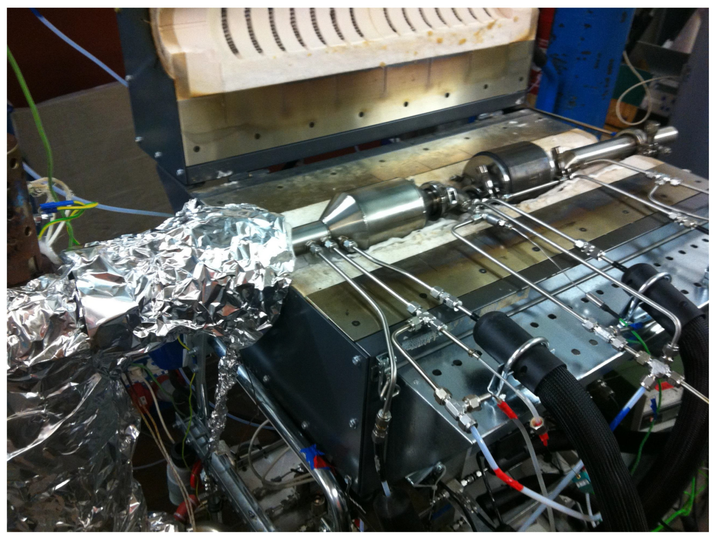

Figure 2. Photo of the different substrates placed in the oven.

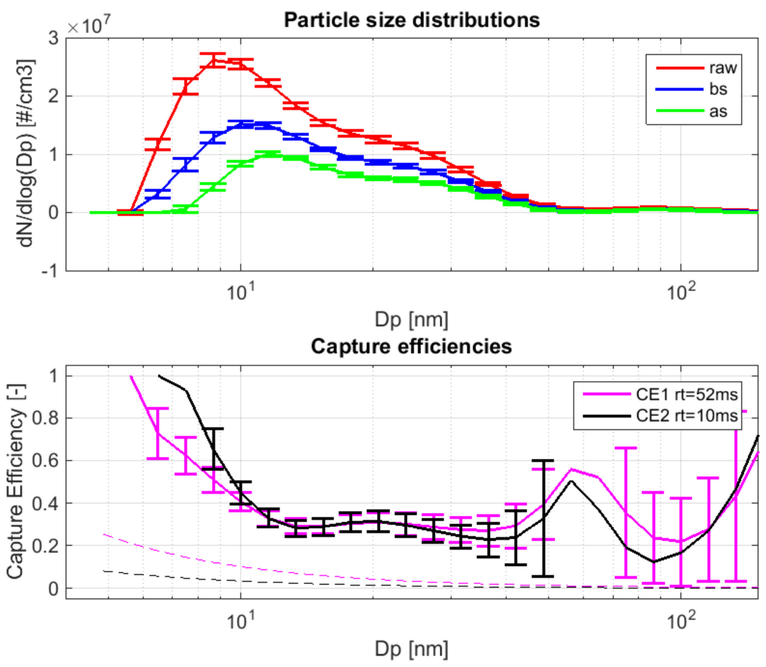

Figure 3. Example of the PM particle size distribution (PSD) for 250 °C, 5 sm/s and L=152mm. upstream the inert monolith (raw), between the cordierite and the metal substrate (bs) and after the metal substrate (as). Lower panel: CE over the inert monolith (CE1) and over the metal substrate (CE2). The dashed lines are the theoretical CE, assuming laminar flow.

Engine: 1 cyl (2 dm^3), Low sulfur diesel fuel (MK1), 1000 rpm, 120 Nm, EGR = 15%
Substrates:
1: Inert, uncoated cordierite monolith from Corning (400cpsi, L = 100 mm, D = 98 mm)
2: Metal substrate from Nilcon AB with protrutions D=34 mm by using flanges, OFA=83%,
Coating Pt/Al2O3 (Pt: 40 g/ft3, washcoat thickness: 40 µm)
PM instrument: DMS 500, 1st dilution=2, 2nd dilution=50

$$CE_{\exp} = \frac{PSD_{before} - PSD_{after}}{PSD_{before}}$$

$$CE_{theory} = (1 - PE_{theory}) = 1 - \exp\left(\frac{-h_m A_s}{Q}\right)$$

$$h_m = \frac{D_p Sh}{d_{ch}}$$

Objective

To evaluate the PM capture in an open metal substrate

- For different conditions
- Compared to straight channel geometries

Experimental

PM emissions from HD diesel engine. EATS rig [1] enabling variation in conditions (factorial design) by:

- Temperature
- Velocity
- Substrate length

Removal of volatiles in inert monolith [2]

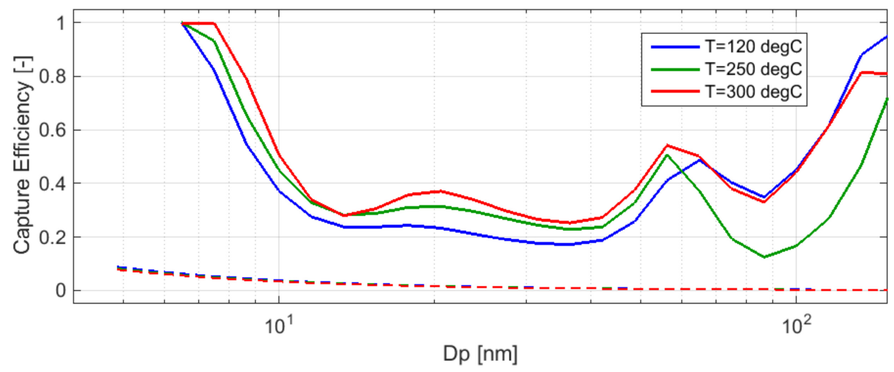

Figure 4. Capture efficiencies for the metal substrate at different temperatures. The substrate was 152 mm and the standard velocity was 5m/s (corresponding to 9, 15 & 19 m/s). The dashed lines are the theoretical CE, assuming laminar flow.

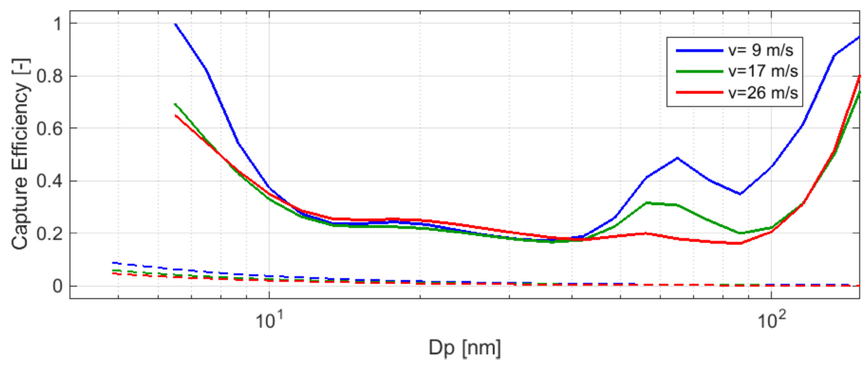

Figure 5. Capture efficiencies for the metal substrate at different velocities. The substrate was 152 mm and the mean temperature was 120 °C. The dashed lines are the theoretical CE, assuming laminar flow.

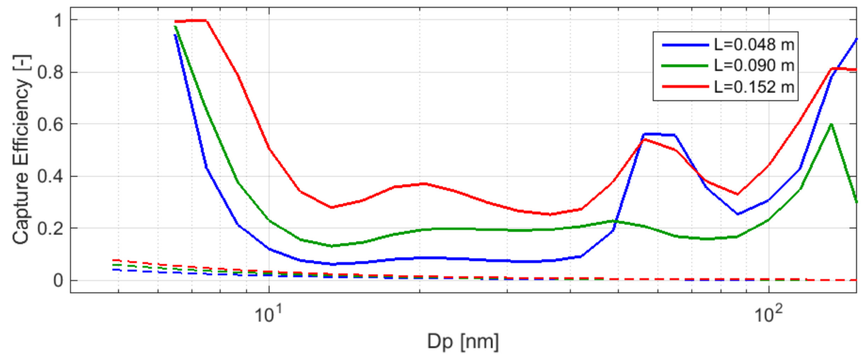

Figure 6. Capture efficiencies for the metal substrate of different lengths. The mean velocity was approx. 18 m/s and the mean temperature was 300 °C.The dashed lines are the theoretical CE, assuming laminar flow

References

[1] Sjöblom, J., *Bridging the gap between lab scale and full scale catalysis experimentation*. Topics in Catalysis, 56 (2013) p. 287-292.

[2] Sjöblom, J. and Ström, H., *Capture of automotive particulate matter in open substrates.* Industrial & Engineering Chemical Research 52 (2013) p. 8373–8385.

Conclusions

- Observed trends:
  - CE increase with temperature
  - CE increase with velocity
  - CE increase with channel length
- However, unexpected high CE compared to diffusion-only

Future work

- Investigate effects of sampling pressure
- Further characterization of PM (change in reactivity upon/after capture)