Characterization of particles in the gas exchange system of DI/SI engines

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Particles Emissions and Health

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Numbers indicate Euro levels

PM – Particle Mass
PN – Particle Number

PM (VI) WHSC
8 \times 10^{11} \text{#/kWh}

PN (5b) \geq 6 \times 10^{11} \text{#/km}
(all DI vehicles)
Agglomeration Pipe (AP)

**Agglomeration**: Process of combining particles to form larger particles
Schematic of The Setup

Adjustable Measuring Probe (AMP)

Position controlled by a Computer Program

Sample to Particle Measurement System

Exhaust Out

DOC

DPF

SCR

Exhaust Out

HPR

Particle Measurement System

Adjustable Measuring Probe (AMP) locations

Agglomeration Pipe

Thermal Insulation

Stationary Measuring Probe (SMP) locations

Sample for Measurement

Primary Diluter

Evaporation Tube 300°C - 400°C

Secondary Diluter

CPC

EEPS

Engine

Inlet Manifold

Exhaust Manifold

Turbine

Compressor

Charge Air Cooler

Air In
Setup with Stationary Measuring Probe

Stationary Measuring Probe

Switching Valves
# Engine Operating Points

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Engine Speed [rpm]</th>
<th>$T_{\text{exh}}$ [°C]</th>
<th>$\dot{m}_{\text{exh}}$ [g/s]</th>
<th>Remarks</th>
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<td>300</td>
<td>154</td>
<td>Constant $T_{\text{exh}}$</td>
</tr>
<tr>
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<td>241</td>
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<td>1600</td>
<td>201</td>
<td>250</td>
<td>Constant $\dot{m}_{\text{exh}}$</td>
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</tbody>
</table>

![Engine Torque vs Engine Speed Graph](image)

- $\dot{m}_{\text{exh}}=250$ g/s
- $T_{\text{exh}}=300$°C
Setup with Adjustable Measuring Probe

Adjustable Measuring Probe

Positioning System
Conclusion

- The SP case in comparison with the AP case shows that the AP behaves like the SP with regards to non-volatile PN reduction.

- The grouping phenomenon observed in previous literatures with the AP might be due to three possibilities:
  - The size range of most particles emitted are larger than 50nm. As grouping is noticed only after those sizes.
  - The grouping particles in previous studies might have been mostly volatile particles. This study used particle measurement systems with evaporation tube as a volatile particle remover.
  - The grouping might have been favoured by the increase in colder surface area of the AP. This was avoided in this study by using a double walled and insulated AP.
Competence Center for Gas Exchange

"Charging for the future"