Investigations of Emissions with Different Filtration Materials on a 2-Stroke Scooter Peugeot TSDI

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Exhaust emissions measurements of a small 2-S Scooter Peugeot TSDI *), 50cc with different particle filters have been performed in the present work according to the measuring procedures, which were established in the previous research in the Swiss Scooter Network.
The investigated particle filtration materials were supplied from different manufacturers as samples without specifications and they were applied by the research laboratory in a special muffler able to be taken apart.
The investigated scooter represented a modern (2002) 2-stroke technology with direct injection, with oxidation catalyst and with injection of the lube oil to the intake air.
Since there is a special concern about the particle emissions of the small engines, the particle mass and nanoparticle measurements were systematically performed.
The nanoparticulate emissions were measured by means of SMPS (CPC) and NanoMet *).

The most important results are:

- for the 2-S aerosol, which consists mostly of lube oil droplets the oxidation in the trap is more important than the filtration quality,
- with catalytic coated filters the reduction efficiency of summary aerosol surface (DC) is higher than the reduction of particle counts (CPC, SMPS), with uncatalysed filter inversely,
- the highest reduction rates were found: for DC 94% and for CPC 81%
- there is a little influence of different PF's on the maximum speed (speed limitation 45km/h), but a remarkable influence on the full load power.

The present investigations did not concern the durability of the filtration materials, the continuous regeneration and the deposition of ashes during the real world operation.

PARTICLE FILTER

The filtration materials were supplied by the manufacturers (Alantum, HJS, Inteco and GEO_2) as new samples without specifications. They were canned either by the supplier or by AFHB and were installed in the special research muffler which can be dismantled to use different filtration or oxidation materials.

In this arrangement the geometry of exhaust system upstream of the muffler stays unchanged in order to influence the gas dynamic of the engine as little as possible.

Two oxidation catalysts were used:

- Original exhaust system with muffler and with catalyst – reference for all evaluations,
- Oxidation catalyst from Peugeot Carburettor (ox-cat.2) in the research muffler, only in ECE 47 warm.

PARTICLE SIZE ANALYSIS

In addition to the gravimetric measurement of particulate mass, the particle size and counts distributions were analyzed with following apparatus:

- SMPS – Scanning Mobility Particle Sizer, TSI (DMA TSI 3071, CPC TSI 3025 A)
- DC – Diffusion Charging Sensor (Matter Eng. LQ1-DC)
- MD19 tunable minidiluter (Matter Eng. MD19-2E, see Fig. 1).

MEASURING PROCEDURES

The sampling for nanoparticle analysis took place at tailpipe through MD19, like in previous works [5, 6, 7]. The gravimetric measurements of PM were performed at the CVS tunnel (with the same method as for diesel cars).

The investigations with each variant of exhaust system were performed according to the same procedure:

- Cold start and acceleration to v = 40 km/h
- constant speed 40 km/h during 20 min
  - first 4 min cold start & warm-up
  - second 5 min change CPC to SMPS
  - further 10 min measurements of PSD's with SMPS
  - last 3 min → last scan SMPS,
- engine stop: evaluation,
- 5 min conditioning at full load
- legal test cycle ECE 47,
- engine stop: evaluation,
- conditioning at FL and measurement of FL power,
- cool down and change of PF,

Each particle filter prototype in this program was used as new.

At the end of tests another oxidation catalyst was mounted in the research muffler and tested at ECE 47 warm only. These results can be compared with the original muffler with original catalyst.

The driving resistances of the test bench were set according to the Swiss exhaust gas legislation.

Short CV:

BIOGRAPHICAL SKETCH Dr. J. Czerwinski:

- Since 2009, SAE fellow
- Since 1989, professor for thermodynamics and IC-engines, head of the Laboratory for Exhaust Gas Control, University of Applied Sciences, Biel-Bienne, Switzerland
- R & D turbocharging systems, Asea Brown Boveri, Switzerland
- R & D diesel injection systems, diesel combustion, Voest Alpine Friedmann, Austria
- Assistant on the Technical University, Vienna Ph.D. about combustion in SI-engines
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IC-Engines and Exhaust Gas Control

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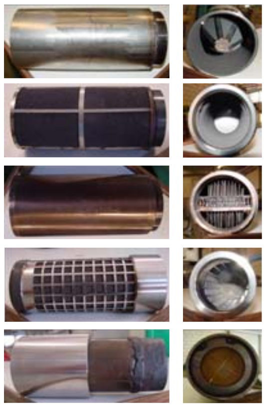
Investigated Scooter Peugeot TSDI 2-S

Technical data of the Scooter Peugeot TSDI 2-S 50ccm

vehicle identification	Peugeot Looxor TSDI
model year	2002
Transmission, no. of gears	variomat
km at beginning	1400
engine: type displacement cm³ number of cylinders	 2 stroke 49.1 1
cooling	air forced
rated power kW rated speed rpm idling speed rpm	3.6 7800 1700
max vehicle speed km/h	45
weight empty kg	94
mixture preparation	directed injection with automatic oil pump
catalyst	yes
catalyst data	Pt/Rh 5/1 50g/ft³ 200 CPSI metal support ∅ 60.5 / L 40

Used Particle Filters



Alantum 1

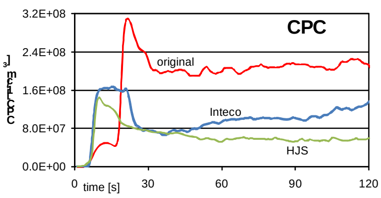
Alantum 2

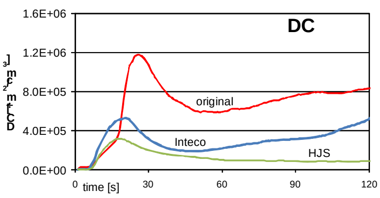
HJS

Inteco

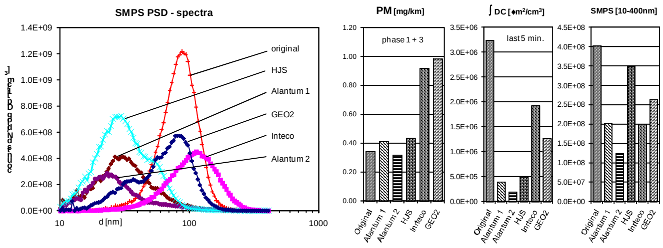
GEO2

Results of cold start and at vconst=40 km/h, warm.



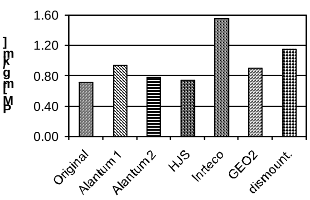


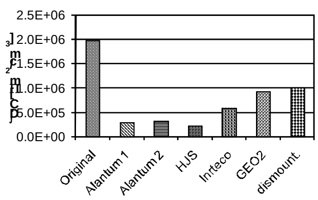
Nanoparticle emissions during cold start followed with a constant speed at v=40 km/h with different particle filters. Measured at tailpipe.

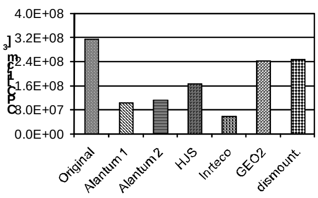


Nanoparticles at constant speed 40 km/h, warm, with different particle filters. Average of the last 3 samples.

Results by driving cycle ECE 47, warm







Comparison of nanoparticle emissions with different particle filters, warm.

Average of NP Filtration Efficiencies (FE) by:

- **cold start**
- **vconst=40 km/h, warm**
- **ECE 47 driving cycle, warm .**

Average

	DC FE	CPC FE
	[∪]	[∪]
Alantum 1	**84.4**	**67.5**
Alantum 2	**86.7**	**68.7**
HJS	**87.0**	**58.0**
Inteco	**45.0**	**56.5**
GEO2	**59.4**	**35.1**

Conclusions

- 2-S aerosol-mostly oil droplets
- oxidation more important than filtration
- catalytic PF: reduction DC stronger, than reduction CPC (SMPS)
- max, reduction rates DC 94%, CPC 81%
- impact of PF on gas dynamic of the engine reduction of max. power

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