University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

Cold Start and Particle Emissions of Scooters

Dr. Jan Czerwinski
Professor IC-Engines
Lab. For Exhaust Emission Control (AFHB)
University of Applied Sciences,
Biel-Bienne, Switzerland

BUWAL Bundesamt für Umwelt, Wald und Landschaft
OFEFP Office fédéral de l'environnement, des forêts et du paysage
UFAFP Ufficio federale dell'ambiente, delle foreste e del paesaggio
UFAGC Uffizi federal d'ambient, guaud e cuntrada

Swiss EPA

- SAEFL - Swiss Agency for Environment, Forests and Landscape
- BUWAL- Bundesamt für Umwelt, Wald and Landschaft

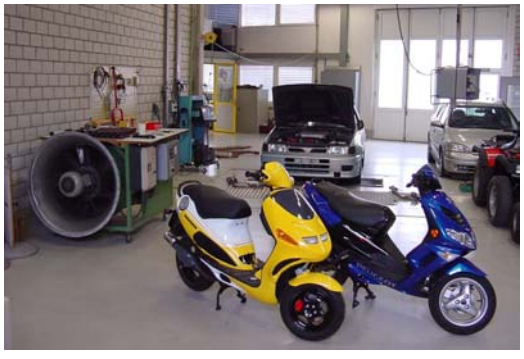
University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

- BUWAL
  Dipl. Ing. F. Reutimann
  Dr. M. Delisle
- Matter Engineering, ETHZ
  Dr. M. Kasper
  Dipl. Ing. Th. Mosimann
- TNO ARTEMIS WP 500
  Dipl. Ing. R. Gense
- WMTC
  Dr. A. Paul
- EMPA
  Dipl. Ing. Ch. Bach
  Dr. M. Weilenmann

University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

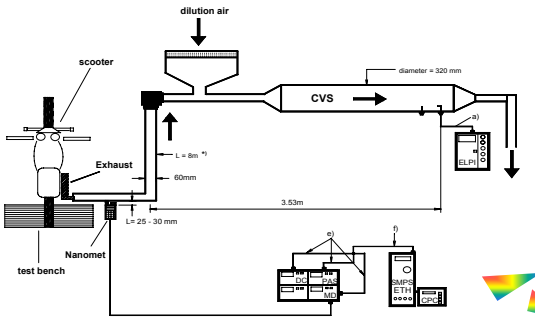


Investigated scooters

Aprilia Leonardo 125	Yamaha EW50 Slider
4-stroke, 125 cc	2-stroke, 50 cc
water cooling	air cooling
Variomat, v_{max} = 95 km/h	variomat, v_{max} = 60 km/h
8,5 kW at 9000 rpm	2,5 kW at 6800 rpm
weight empty: 136 kg	weight empty: 81 kg
constr. year: 1999 (33 km)	constr. year: 2000 (22 km)
original: without catalyst	original: with ox. cat.

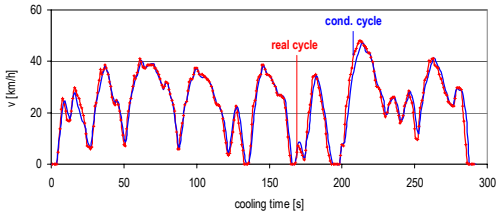
University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

Sampling and measuring set-up for nanoparticulates analysis of the scooters



University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

Driving cycle for warm-up after the cold start and for nanoparticulates analysis



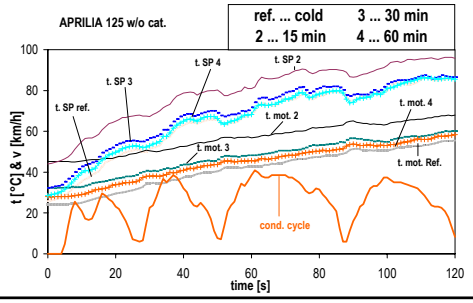
Characteristic parameters of the driving cycle (ZUS 98)

cycle	t	s	v=0		v=const		stab v	stab a	v mean	a+	a-
[-]	[s]	[m]	[s]	[%]	[s]	[%]	[m/s]	[m/s^2]	[m/s]	[m/s^2]	[m/s^2]
cond.	291	1888.2	24	8.2	65	22.3	12.592	0.872	23.36	1.062	-0.777
real	291	1895.4	21	7.2	59	20.3	11.956	0.768	23.29	0.909	-0.722

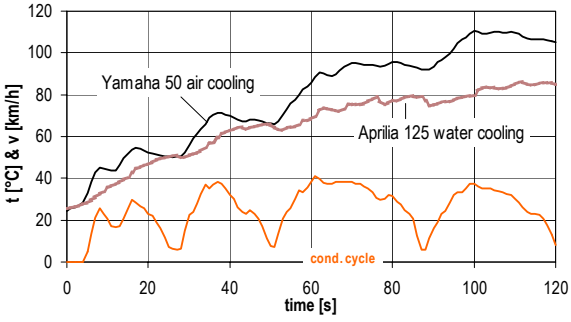
University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

Cold Starts

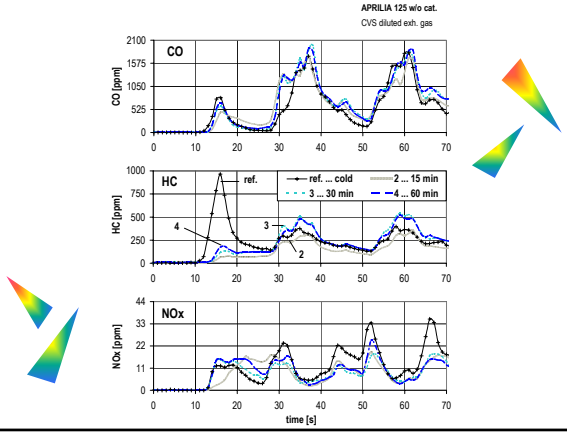
Temperatures: spark plug (SP) & cooling water (mot.) after the start with different cooling time



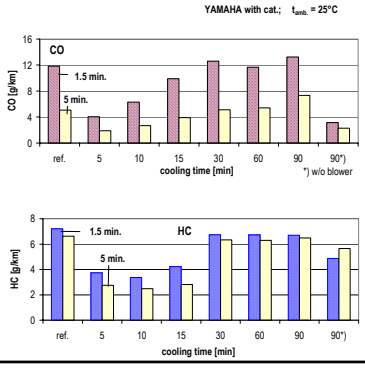
Temperatures of the spark plug (SP) after the cold start with different cooling systems



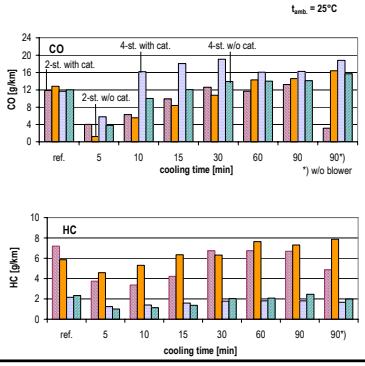
Emissions after cold start with different cooling time



Comparison of the emissions CO & HC accumulated during 1.5 min & 5 min after the cold start dependent on cooling time



Comparison of emissions CO & HC during 1.5 min after the cold start – 2-stroke / 4-stroke; with / without catalyst



Particle Analysis

University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

Particulate emissions analysis

- PM gravimetric measurement
- SMPS – Scanning Mobility Particle Sizer, TSI
- ELPI – Electrical Low Pressure Impactor, DEKATI
- NanoMet – System consisting of:
  PAS – Photoelectric Aerosol Sensor (Eco Chem PAS 2000)
  DC – Diffusion Charging Sensor (Matter Eng. LQ1-DC)
  MD19 tunable minidiluter (Matter Eng. MD19-2E).

University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

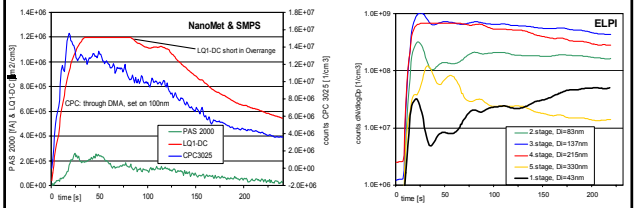
Measuring procedure

- cold start - acceleration to 30 km/h
  - constant speed
- warm cycle - bag sampling, PM
- cooling down during 30 min
- cold cycle - bag sampling, PM

University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

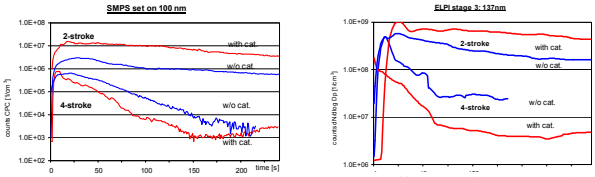
Nanoparticulates at v = 30km/h, with cold start Yamaha EW 50, with catalyst



University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

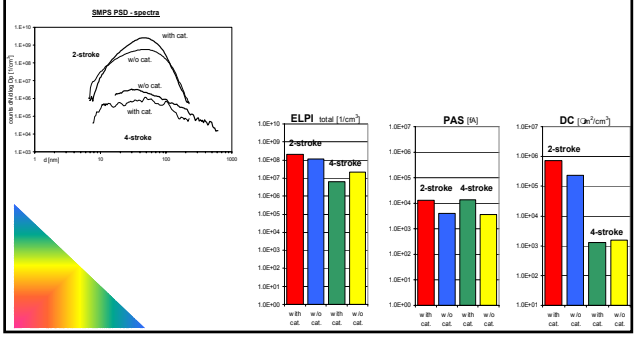
Nanoparticulates at v=30 km/h, with cold start & warm up for 2-stroke / 4-stroke; with/without catalyst



University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

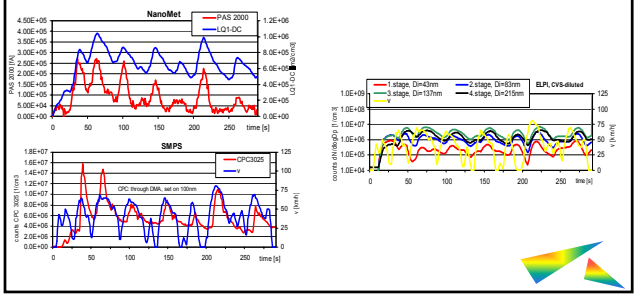
Nanoparticulates at v=30 km/h, with warm engine for 2-stroke / 4-stroke; with/without catalyst



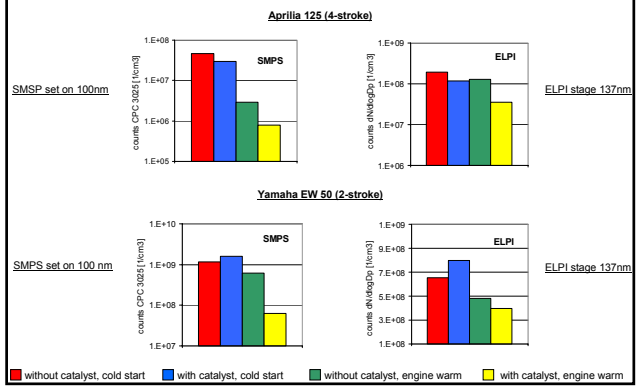
University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

Nanoparticulates at transient cycle, with cold start Yamaha EW 50, with catalyst



Integrated nanoparticulates of selected size at transient cycle time 250 sec.



Summary (1)

cold start

- after a cooling period of 30 min the emission level is similar to that of a long-cooling cold start
- the catalyst has no positive influence on the emissions (CO and HC) in the short period (1,5 min) after a cold start, it becomes efficient in a longer term operation

Summary (2)

- the cold start causes also higher particle mass- and nanoparticulates emissions
- 2-stroke engine has higher particulate emissions than the 4-stroke engine, this emission riches the level of a diesel engine, but consists mostly of the condensates of unburned lube-oil
- 4-stroke engine has a very low particulate emission, which consists mostly of insoluble fraction

Summary (3)

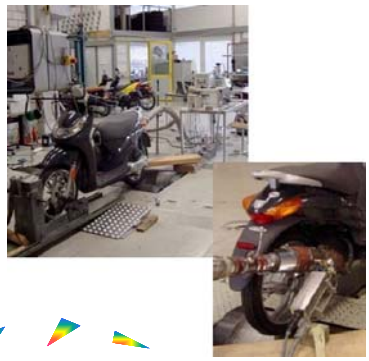
- the catalyst has different, sometimes controversial influences on the particulate number concentrations, it can:
  - change the basis engine emissions by influencing the air-fuel ratio and the gas exchange (here: richer operation of the 2-stroke engine)
  - change the number of solid particulates through the deposition and removal effects (here: general reduction of particle counts for the 4-stroke engine)
  - change the number of soluble particulates (condensates) through the oxidation of hydrocarbons (diminishing of part. number) or oxidation of sulphur (increasing of part. number)

Those two later effects depend on the gas flow and temperature of gas and catalyst.

Further Research

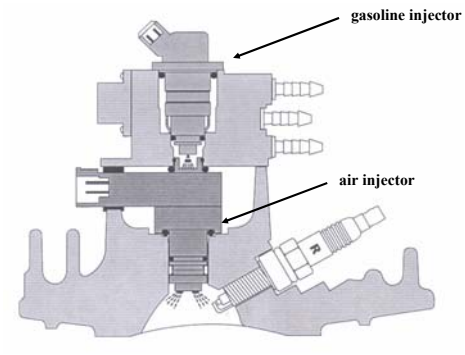
University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

Peugeot scooter Looxor TSDI 2-stroke on the chassis dynamometer



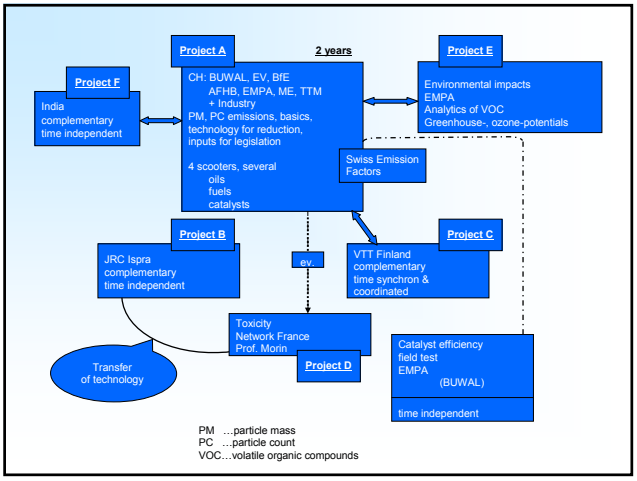
University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

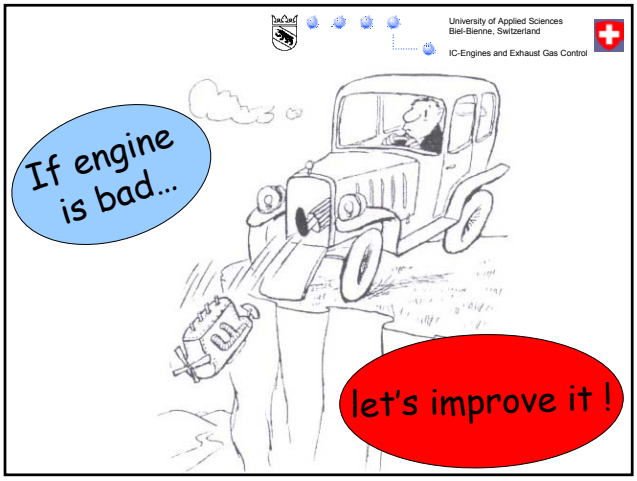
Peugeot 2-stroke Direct Injection System (TSDI)

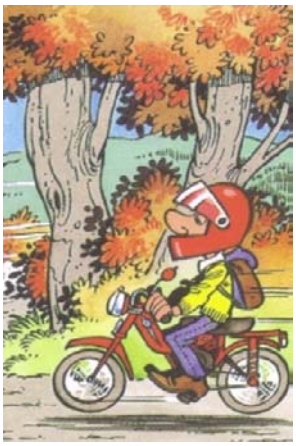


University of Applied Sciences
Biel-Bienne, Switzerland
IC-Engines and Exhaust Gas Control

- **Sampling and measuring methods of oil aerosols**
- **Influences of oils and fuels**
- **Catalyst light off and ageing**







Thanks for
attention!