16th ETH-Conference on Combustion Generated Nanoparticles
June 24th – 27th 2012

Paper/Poster-Abstract Form

Name of Author: Jan Czerwinski, AFHB
Co-Authors: Pierre Comte, AFHB
Affiliation: Abgasprüfstelle AFHB der BFH-TI, Biel
Mailing address: Gwerdtstrasse 5, CH-2560 Nidau
Phone / Fax: 032 321 66 80 E-mail:jan.czerwinski@bfh.ch

Title: NANOPARTICLES in the Exhaust Gas of a Chainsaw

Abstract: (min. 300 – max. 500 words)

The abstracts for papers and posters must contain unpublished information on your research subject: background, investigation methods, results and conclusions. Graphs and references are very welcome. Acronyms should be avoided. Abstracts with < 300 words can not be considered. General information on products which are already commercially available can not be accepted as presentations for the conference but are very welcome at the exhibition of particle filter systems and nanoparticle measurement instruments.

The research of nanoaerosols from small 2-Stroke engines started at AFHB 1999 with a project focusing on the exhaust emissions of chainsaws and mandated by the Swiss Federal Office of Environment (FOEN). For more than a decade this research concentrated on 2-S Scooters. In 2011, a Handheld Machines Network (HaMaNet) was initiated with the scope to continue the progress and the knowledge exchange concerning the non-legislated emissions of handheld equipment.
The present poster gives the technical information from that previous research, a message of still a high actuality.

The conclusions are:

higher lub-oil content
- increases strongly the PN emission
- increases the peak values of PN at idling and shifts the PSD to the bigger sizes at full load

mixture control screw
- richer mixture tuning increases very much CO- and PM
- moves the PSD at full load to the bigger sizes
- increases slightly the integrated PN (20-200 mm) at full load

special gasoline
- reduces PM
- reduces the integrated PN (20-200 mm)
- shifts the PSD to the smaller sizes

NanoMet / filter residue
- confirm that about the totality of the nanoparticulates and of the PM consists of the lube-oil residues (SOF)

Perspectives of the technical development to meet the future emission standards
- oxidation catalyst
- improvements of 2-stroke engines (scavenging, fuel injection, lubrication)
- application of small 4-stroke engines

Short CV:

- Study of Mechanical Engineering in Austria
- Assistant on the Technical University, Vienna, Ph.D. about combustion in SI-engines
- R & D diesel injection systems, diesel combustion, Voest Alpine Friedmann, Austria
- R & D turbocharging systems, Asea Brown Boveri, Switzerland
- Since 1989, professor for thermodynamics and IC-engines, head of the laboratory for emission gas control, University of Applied Sciences, Biel-Bienne, Switzerland
- Member of Societies of Automotive Engineering, SAE: USA, Switzerland, Austria, Poland
- Swiss Delegate to the IEA Implementing Agreement Advanced Motor Fuels.
- Nominated for SAE Fellow 2009
- Author & Coauthor of more than 170 technical publications: engine technology, emissions & environment.

Return by e-mail latest 14th of April 2012 to ttm.a.mayer@bluewin.ch

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

NANOPARTICLES in the Exhaust Gas of a Chainsaw

Czerwinski Jan, Comte Pierre, AFHB *)

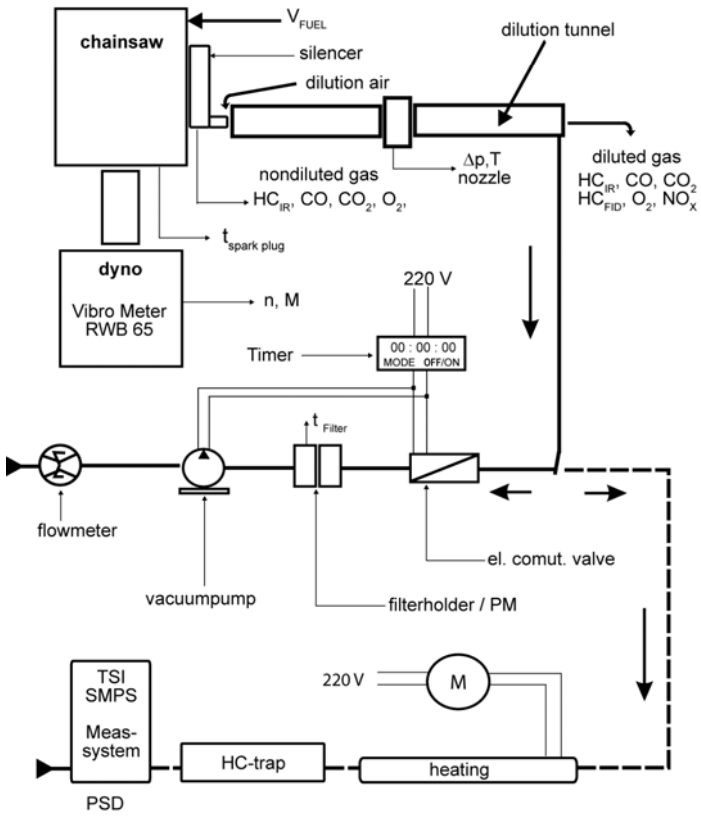
Further research of emissions is needed for the 2-stroke technology in the traditional 2-stroke sectors, like small two-wheelers, handheld equipment and small watercraft.

Most important handicaps of the SI-2-stroke engine concept form the point of view of emissions and of exhaust gas aftertreatment are:

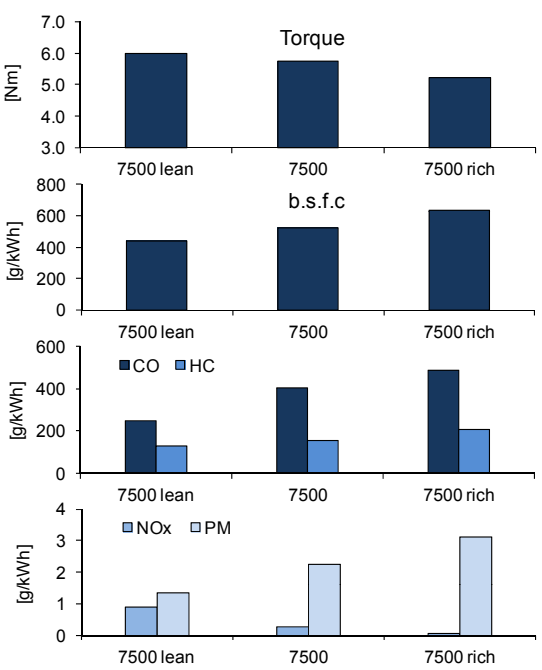
- impossibility of a proper gas exchange without short-circuiting of a part of air-fuel-mixture (no 3-way-catalyst),
- mixture lubrication for a simple engine concept (heavy HC in exhaust gas).

The actual state of knowledge can be summarized as follows:

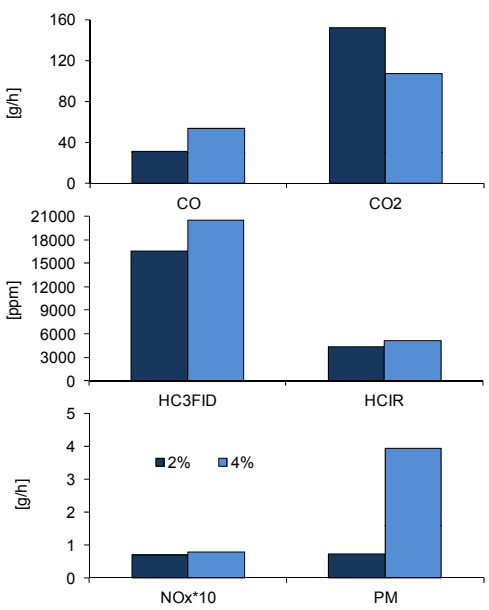
- about 98% of the particulate mass (PM) consists of the lube oil residues (SOF),
- the 2-stroke particulate matter (PM) has a mutagenous potential,
- PM can be reduced roughly proportional with the reduction of the lube oil ratio,
- PM depends on air-fuel-ratio, it is increased with the richer mixture,
- PM can be influenced to a limited extend by the fuel quality,
- oxidation catalyst can reduce PM of about 40 to 70% - this oxidation can be improved by the secondary air introduction in the exhaust pipe,
- oxidation of HC and SOF in the oxidation catalyst by the rich operation causes a supplementary production of CO due to the lack of oxygen. This effect can remarkably reduce, or even invert the CO-conversion efficiency,
- at cold start there is higher PM-emission and a higher part of solid PM,
- the deterioration factor of PM- and HC-emissions over the lifetime of the engine is very low. Those emissions depend mainly on the actual conditions of the machine: lube oil content, mixture tuning, scavenging losses (engine construction),
- for different engines there is a large PM-emission dispersion of about factor 5.



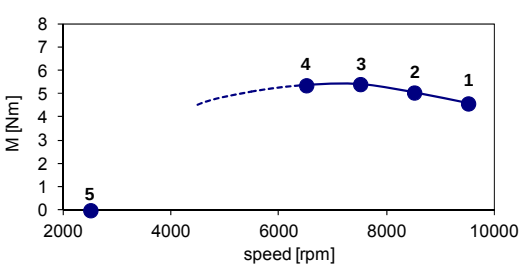
Experimental set-up and the measured parameters for chainsaws



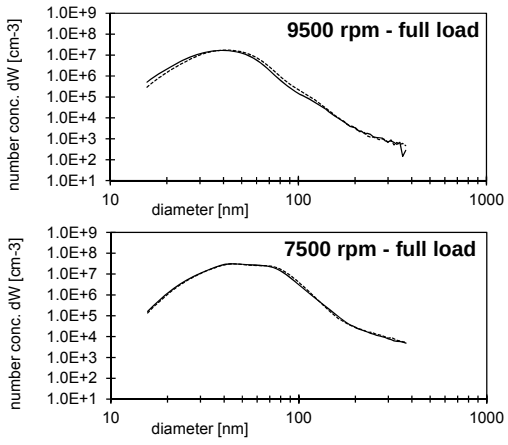
Results at full load 7500 rpm with different mixture tuning
λ_{lean}=0.72, λ=0.62, λ_{rich}=0.55



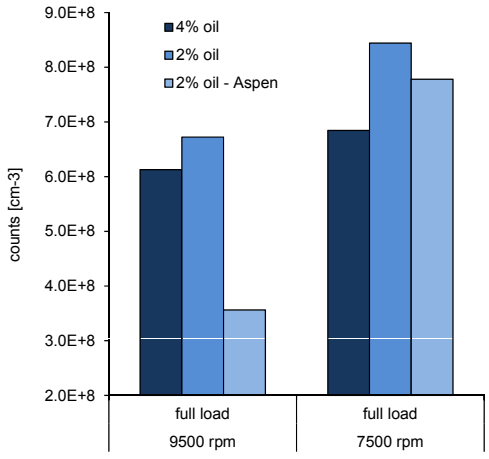
Exhaust emissions at idling with 2% and 4% oil in fuel



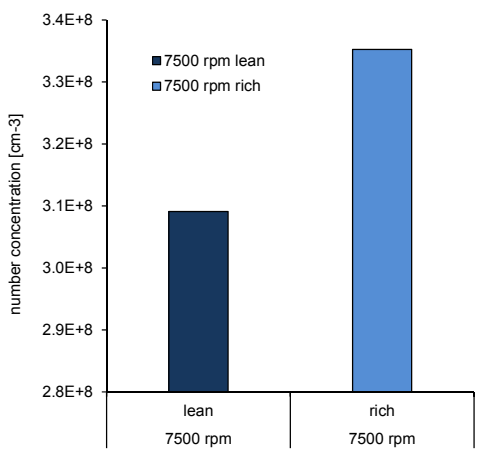
Full load characteristic of the chainsaw STIHL 066



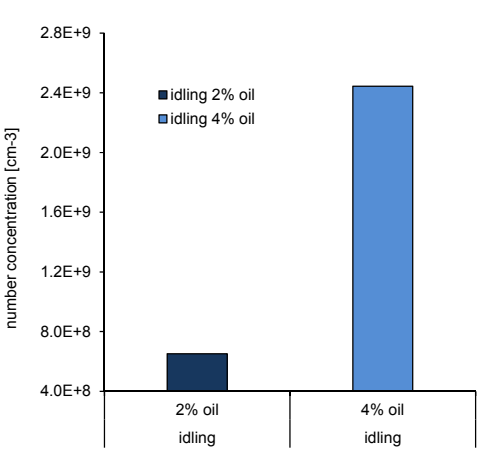
Particles size distribution (PSD) at 9500 rpm / 7500 rpm – full load
Chainsaw STIHL 066, HC-Trap, Aspen 2%



Integrated particles numbers
in the size spectrum 20 – 200 nm
Chainsaw STIHL 066, with HC-trap



Integrated particles numbers
in the size spectrum 20 – 200 nm
Full load lean / rich, Chainsaw STIHL 066, with HC-trap



Integrated particles numbers
in the size spectrum 20 – 200 nm
Idling 2% oil / 4% oil , Chainsaw STIHL 066, with HC-trap

Conclusions:

Mixture control screw
- richer mixture tuning increases very much CO- and PM
- moves the PSD at full load to the bigger sizes
- increases slightly the integrated PN (20-200 mm) at full load

NanoMet / filter residue
- confirm that about the totality of the nanoparticulates and of the PM consists of the lub-oil residues (SOF)

Special gasoline
- reduces PM
- reduces the integrated PN (20-200 mm)
- shifts the PSD to the smaller sizes

Perspectives of the technical development to meet the future emission standards
- oxidation catalyst
- improvements of 2-stroke engines (scavenging, fuel injection, lubrication)
- application of small 4-stroke engines

Higher lube-oil content
- increases strongly the PN emission
- increases the peak values of PN at idling and shifts the PSD to the bigger sizes at full load

*) according to: NPC ETHZ Aug. 2000 & SAE 2001-01-1830/4249

Further information: jan.czerwinski@bfh.ch, pierre.comte@bfh.ch