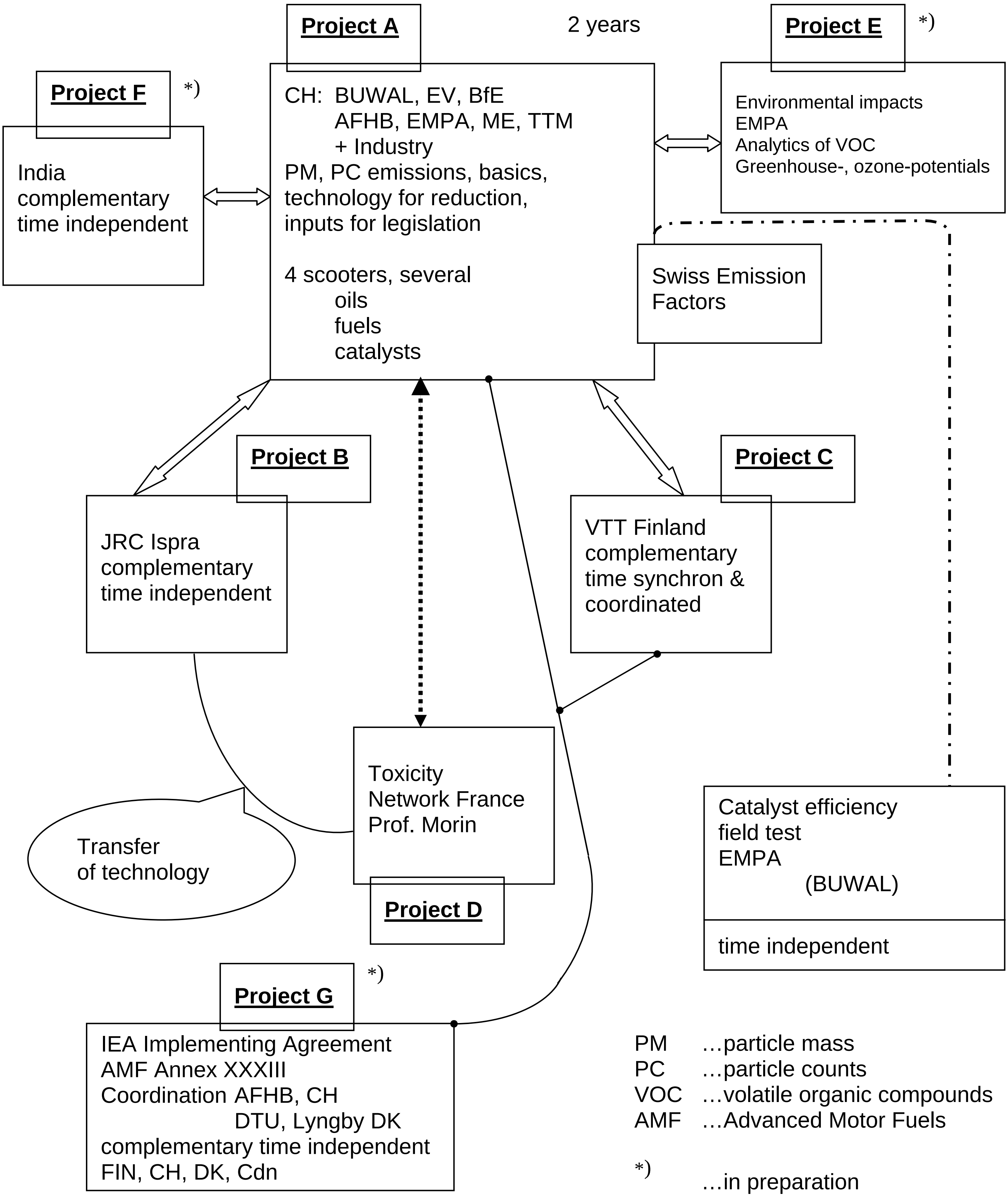
2-S Scooters International Projects Network: Particle emissions, toxicology & environmental impacts

November 2004



PM …particle mass
PC …particle counts
VOC …volatile organic compounds
AMF …Advanced Motor Fuels

*) …in preparation

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

TTM

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

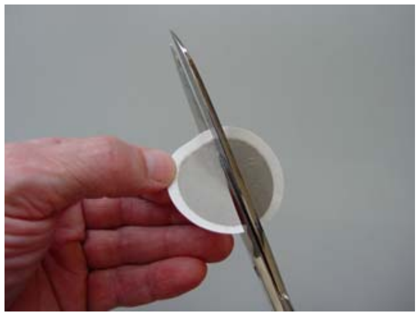
(Nano) Particles from 2-S Scooters: SOF/INSOF, Improvements of Aftertreatment, Toxicity

Jan Czerwinski, AFHB
M.C. Astroga, M. Rey, JRC

A. Mayer, TTM
F. Reutimann, BAFU

Peugeot scooters: left TSDI, right "carburetor"

SOF / INSOF



The preceeding

solvent extraction

Influences very much the

Coulometric results EC, OC, & TC

EC after ext. / TC before ext.

3 - 4,5% wt. for TSDI

10 - 17% wt. for Carb.

Charing

- Partial polymerisation of heavy HC's during the thermal extraction of SOF
- Increased supply of carbon for the final O_2- oxidation → increase of EC

Buck WFC

WFC… Wiremesh Filter-Catalyst

BUCK 1 = WFC + Ox.Cat.

BUCK 2 = WFC only

WFC ⟶ stainless steel, coated Pt/Rh 5:1

NP Conference ETHZ, Aug. 2006

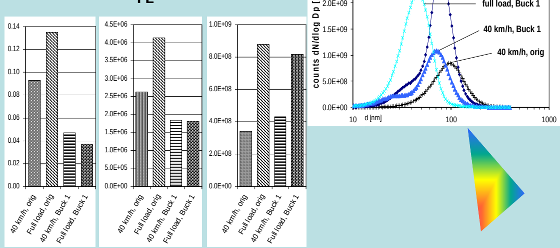
BUCK - WFC

Wiremesh Filter-Catalyst - For Scooter application

Particle mass and nanoparticles at 40 km/h and full load, warm, with original muffler and Buck 1
Peugeot Looxor TSDI; gasoline; lube oil Motorex N°2.

t_{40} ~ 250°C

t_{FL} ~ 330°C



EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

TTM

University of Applied Sciences
Biel-Bienne, Switzerland

IC-Engines and Exhaust Gas Control

(Nano) Particles from 2-S Scooters: SOF/INSOF, Improvements of Aftertreatment, Toxicity

Jan Czerwinski, AFHB
M.C. Astroga, M. Rey, JRC
A. Mayer, TTM
F. Reutimann, BAFU

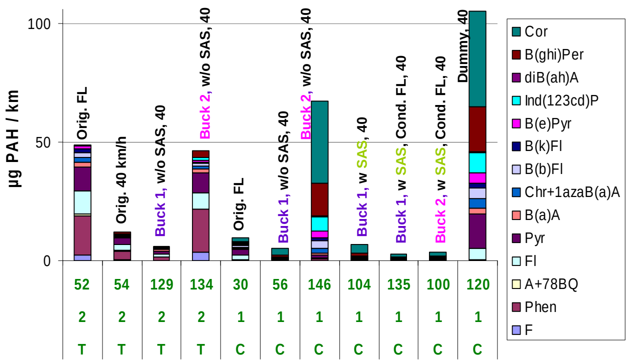
Toxicity

TEQ … Toxicity Equivalence

TEF … Toxicity Equivalence Factor

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

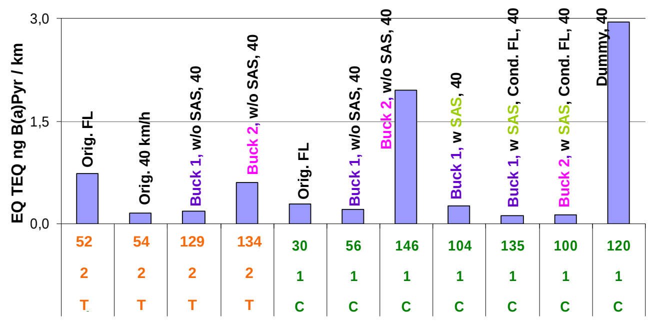
Comparison between PAH emissions from 2 different technologies (TSDI and Carburator) and different combinations of after-treatment, cycles and preconditioning of the motorbikes.



Joint Research Centre

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Variation of B(a)P toxicity equivalents from 2 different technologies (TSDI and Carburetor) and different combinations of after-treatment, cycles and preconditioning of the motorbikes.



Joint Research Centre

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

TEF for PAC

PAH	TEF	PAH-derivative	TEF
benzo[*a*]pyrene	=1		
dibenzo[*a,l*]pyrene	10	7,12-dimethylbenzanthracene	65
dibenzo[*a,h*]pyrene	10	1,6-dinitropyrene	10
dibenzo[*a,i*]pyrene	10	6-nitrochrysene	10
dibenz[*a*,h]anthracene	1.1	3-methylcholanthrene	5.7
7H-dibenzo[*c,g*]carbazole	1	5-methylchrysene	1
dibenzo[*a,e*]pyrene	1	1,8-dinitropyrene	1
indeno[1,2,3-*cd*]pyrene	0.1	4-nitropyrene	0.1
benzo[*a*]anthracene	0.1	1-nitropyrene	0.1
benzo[*b*]fluoranthene	0.1	5-nitroacenaphthene	0.034
benzo[*j*]fluoranthene	0.1	2-nitrofluorene	0.01
benzo[*k*]fluoranthene	0.1		
dibenz[*a,j*]acridine	0.1		
dibenz[*a,h*]acridine	0.1		

$$\text{Total TEQ} = \Sigma\, TEF_i \times CONC_i$$

EPA Revision, 1994; OEHHA,Children's Environmental Health Protection Act, California 2001

Joint Research Centre

Conclusions:

- PAH analysis confirmed that the WFC inline with oxidation catalyst traps and oxidizes the volatile and particulate compounds more efficiently than the WFC itself.
- Total PAH results and TEQ are very much influenced by oxidative capacity of the complete aftertreatment system – WFC lowers the emission level.
- WFC shows storage – release effects at different operating conditions dependent on the exhaust gas temperature.
- Conditioning at full load cleans the WFC, may improve the oxidation ability, but also may damage the catalytic coating.
- The investigated WFC lost its catalytic efficiency after some extreme thermal operating conditions (until 950°C).

Comparison of Real-World Emissions from Two-Wheelers and Passenger Cars

A N A - M A R I J A V A S I C * A N D M A R T I N W E I L E N M A N N
Swiss Federal Laboratories for Materials Testing and Research (EMPA), Ueberlandstrasse 129, 8600 Duebendorf, Switzerland

Passenger cars are the primary means of transportation in Europe. Over the past decade, a great deal of attention has therefore been paid to reducing their emissions.
This has resulted in notable technical progress, leading to unprecedentedly low exhaust emissions. In the meantime, emissions from motorcycles have been ignored due to their subordinate role in traffic. Even though the motorcycle fleet is small in comparison with the car fleet, and logs lower yearly mileage per vehicle, their contribution to traffic emissions has become disproportionately high. Exhaust emissions of CO, HC, NO_x, and CO2 from 8 powered two wheelers were measured and compared to previous measurements from 17 gasoline-powered passenger cars performed at EMPA with the aim of ascertaining their relevance. Using exhaust emission ratios from both vehicle types, comparisons based on mean unit, mean yearly, and fleet emissions are considered. Present-day aftertreatment technologies for motorcycles are not as efficient as those for cars. A comparison of mean unit emissions shows that motorcycles exceed cars in NO_x emissions. All comparisons reveal a significant HC ratio, to the detriment of two-wheelers. Overall, the relevance of emissions from powered two-wheelers is not negligible when compared with modern gasoline-powered passenger cars.

TABLE 4. Mean Values and Standard Deviations of 17 Euro-3 Cars' Emissions in Driving Cycle CADC Used for Comparison

	CO [g/km]		HC [g/km]		NO_x [g/km]		CO_2 [g/km]	
	avg.	SD	avg.	SD	avg.	SD	avg.	SD
urban	0.57	0.91	0.017	0.015	0.089	0.069	278.4	53.4
rural	0.85	0.97	0.018	0.016	0.052	0.030	160.4	24.5
highway	3.04	3.00	0.031	0.017	0.065	0.048	192.4	19.4

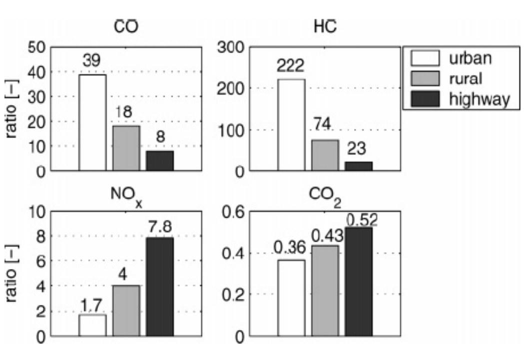


FIGURE 4. Ratios of mean unit emissions [g/km] of two-wheelers and passenger cars.

TABLE 5. Fleet and Vehicle Mileage[a]

	two-wheelers FAV3 and Euro-1			passenger cars Euro-3		
		yearly mileage			yearly mileage	
	sales	fleet [10^6 km]	vehicle [km]	sales	fleet [10^6 km]	vehicle [km]
urban	48,077	57	1194	151,867	821	5406
rural	27,001	44	1640	151,867	856	5635
highway	25,717	31	1200	151,867	839	5524

[a] Data from ref 6.

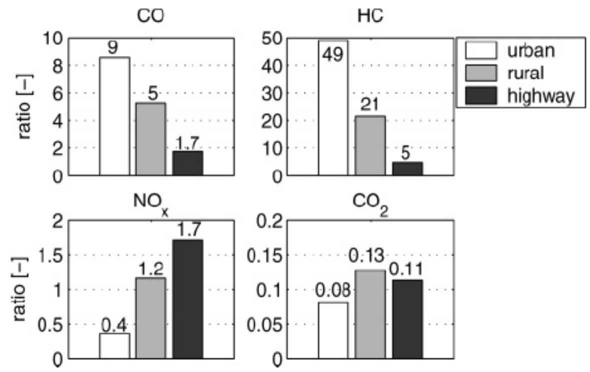


FIGURE 5. Ratios of mean *yearly* emissions [kg/vehicle/year] from two-wheelers and passenger cars.

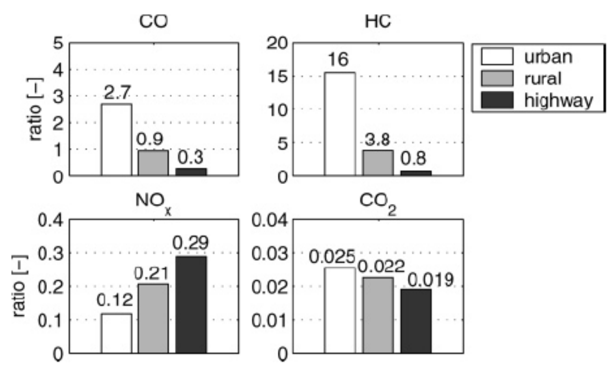


FIGURE 6. Ratios of *fleet* emissions [tons/year] from two-wheelers and passenger cars for the Swiss fleet.

Discussion

Several comparisons show that the powered two-wheelers on the market in 2001 produced significantly higher emissions of all pollutants exceptCO2 than gasoline-powered passenger cars from the same sales period. Whether in a direct comparison of mean unit emissions
(in g/km), mean yearly emissions (in kg/vehicle / year), or fleet emissions (in tons/year), the two-wheelers' HC and CO emissions were all, and often significantly, higher. In addition, the NO_x contribution of the motorcycle fleet is roughly one-fifth that of the car fleet and is thus not negligible.

CO emissions may cause local health problems and further oxidize to CO2, contributing to the greenhouse effect. However, limit values have not been exceeded in Switzerland for several years, with the result that this gas has become less significant.

The situation is different for HC. The HC values used here are the sum of unburned hydrocarbons. Some of them contribute to the greenhouse effect, while others have been proven to be carcinogenic or to contribute to ozone formation. It was shown that powered two-wheelers emit substantially more HC than passenger cars. The significant ratios in the urban pattern (222 for mean unit emissions [g/km], 49 for yearly vehicle emissions, and 1 6 for yearly fleet emissions) are mainly caused by two-cycle machines, which emit more HC than motorcycles with four-cycle engines (*1*, *2*, *13*). However, the use of technologies similar to those employed in cars – such as regulated three-way catalytic converters with fuel injection (vehicles 7 and 8) – does not yield similar results either. It must be assumed that work on implementing the lambda control loop has not been performed with the same care as for cars.

It has to be stressed again that all the comparisons discussed here are subject to the uncertainties mentioned above. From a purely statistical point of view these seem to be unacceptably large, but as the vehicles are intentionally chosen to represent the variety of the fleet with regard to engine size, manufacturer, technical solutions etc., the results appear to be fairly representative of the fleet.

Overall, emissions from motorcycles have become relevant compared to those from modern passenger cars. Even if they account for a comparatively small number of vehicles, motorcycles' impact on traffic emissions cannot be overlooked. Directive 2002/51/EC of the European Parliament and Council is a step in the right direction. With the introduction in 2006 of new emissions limits which are intended to correspond to Euro 3 gasoline cars, and with checking procedures for the correct operation of emission

Control systems, motorcycle emissions are expected to decrease. However, the fact that more than half of the two wheelers failed the statutory test is indicative of the need for periodical inspection and maintenance. With regard to this study, the introduction of similar regulations as for passenger cars such as checking the durability of the aftertreatment system and periodic testing of exhaust gases should be considered. It would therefore be expedient to repeat this study two to three years after introduction of the new rules.

Untersuchungsbericht **Nr. 20327e**

Katalysatoralterung an Rollern mit 50cm3 2-Takt-motor

Claudio Rüdy
Martin F. Weilenmann
Abteilung Verbrennungsmotoren

EMPA Dübendorf

3.1 Fahrzeugauswahl

Im Rahmen dieser Untersuchung wurden 6 Scooter so ausgewählt, dass sie bezüglich Verkaufszahlen in dieser Fahrzeugkategorie repräsentativ sind.

Alle Scooter haben eine ungeregelte Gemischaufbereitung und Abgasnachbehandlung. Die Eigenschaften der ausgewählten Scooter sind in Tabelle 1 aufgeführt. Die Bezeichnung (FZ-Nr.) der Fahrzeuge entspricht folgendem Muster:

- 1. Zeichen: S für Scooter
- 2. Zeichen: Z für Zweitakter
- 3. Zeichen: 1 für Euro-1, 2 für Euro-2
- 4. und 5. Zeichen: Fahrzeugnummer

Fahrzeug	Fz-Nr.	Hub-raum [ccm]	Leistung (OEM)	Gemisch-aufbereitung	Kaltstart-einrichtung	Abgas-nachbe-handlung	Leer-gewicht VTS	Emmis-sions-code	Typen-genehm igung
Aprilia SR 50 Ditech	SZ2-01	49	3.90 kW	Benzindirekt-einspritzung	automatisch	Oxi-Kat., ungeregelt	181 kg	C01 (EURO-2)	6AA155
Peugeot Jet Force	SZ2-02	49	4.80 kW	Benzindirekt-einspritzung	automatisch	Oxi-Kat., ungeregelt	190 kg	C01 (EURO-2)	6PA153
Kymco Super 9	SZ1-03	49	3.94 kW	Vergaser	automatisch	Oxi-Kat., ungeregelt	181 kg	C00 (EURO-1)	6KB615
Yamaha Aerox R	SZ2-04	49	2.75 kW	Vergaser	handbetätigt	Oxi-Kat., ungeregelt	172 kg	C01 (EURO-2)	6YA266
Honda SZX50S1	SZ1-05	49	3.95 kW	Vergaser	automatisch	Oxi-Kat., ungeregelt	173 kg	C00 (EURO-1)	6HA149
Piaggio Zip 50	SZ1-06	49	3.50 kW	Vergaser	automatisch	Oxi-Kat., ungeregelt	161 kg	C00 (EURO-1)	6PA461

Tabelle 1: Stichprobe Scooter

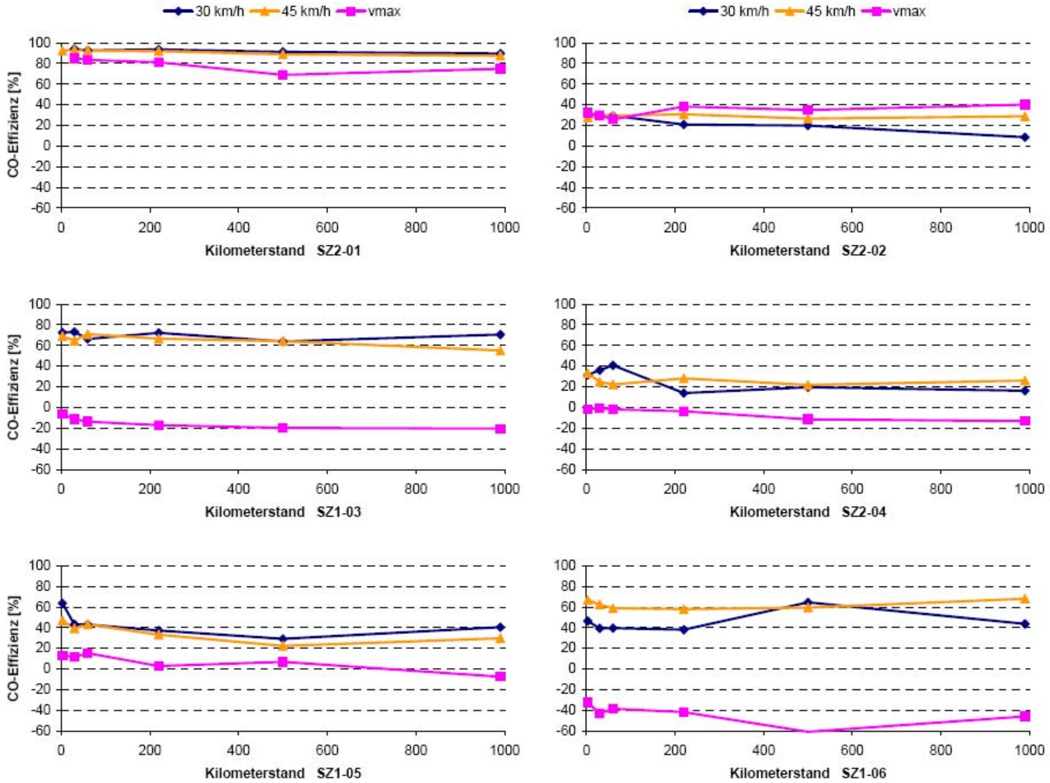


Abbildung 2: CO-Kat-Effizienz bei konstanten Geschwindigkeiten

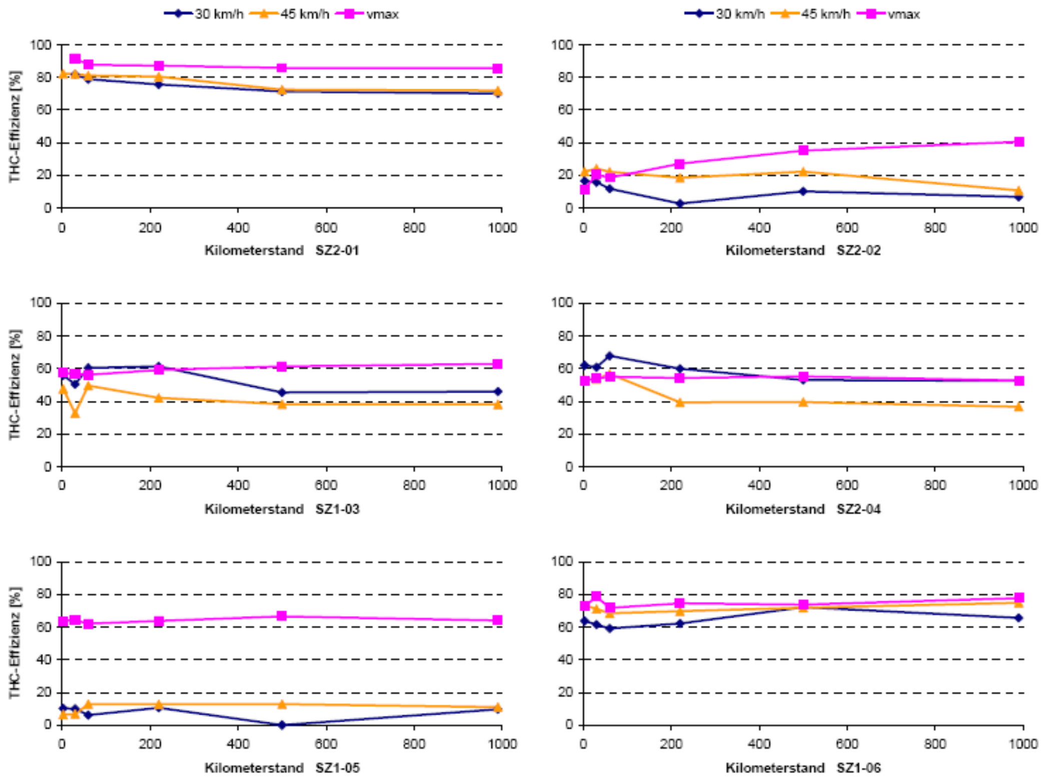
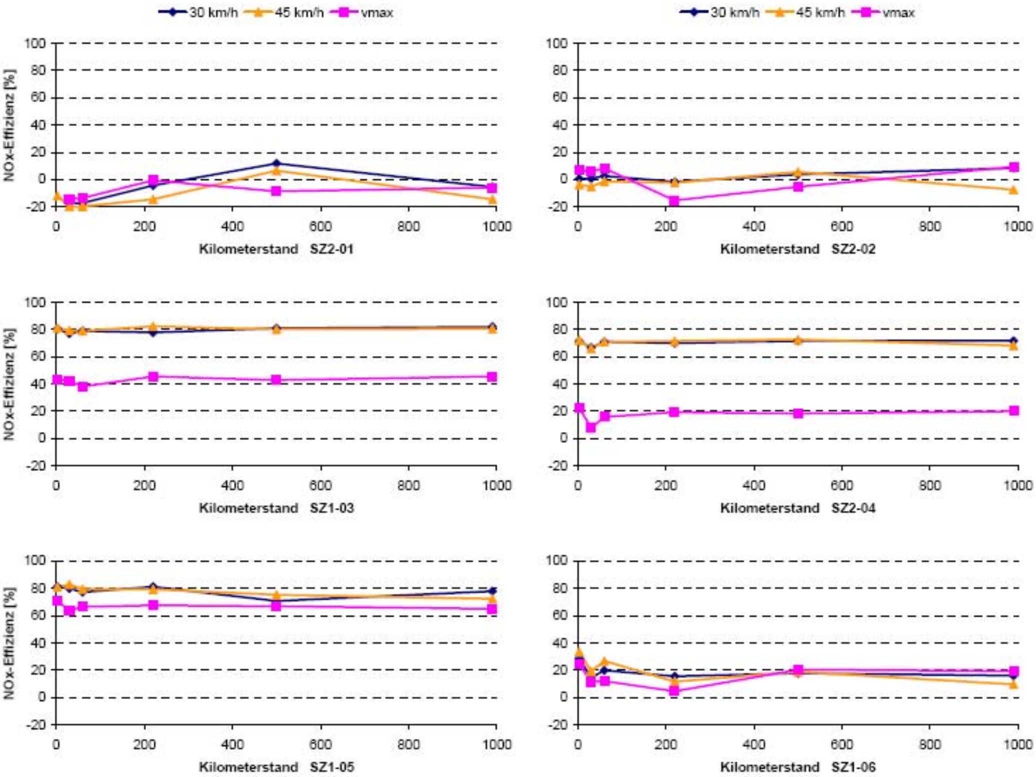


Abbildung 3: THC-Kat-Effizienz bei konstanten Geschwindigkeiten


30 km/h
45 km/h
vmax
NOx-Effizienz [%]
Kilometerstand SZ2-01
Kilometerstand SZ2-02
Kilometerstand SZ1-03
Kilometerstand SZ2-04
Kilometerstand SZ1-05
Kilometerstand SZ1-06

Particulate Polycyclic Aromatic Hydrocarbons and Particulate Matter Emissions from Two-Wheel Motor Vehicles

P. Picini, P. Spezzano, D. Cataldi, F. Messale, C. Manni, D. Santino
ENEA:
National Agency for New Technologies, Energy and Environment, Rome, Italy.

E. Donato
Municipality of Rome:
Department of Environmental Policies: Air Quality and Environmental Noise Management Unit

ABSTRACT

Two wheels powered motor vehicles are an important pollutant source especially in urban areas. ENEA, in cooperation with Municipality of Rome, carried out an experimental activity aimed at evaluate particulate matter (PM) and polycyclic aromatic hydrocarbons (PAHs) emissions from two-wheel motor vehicles.

In this paper, cold and hot PM and particulate PAHs emissions from eight 2-stroke 50 cc in-use mopeds, (3 pre-Euro I, 3 Euro I and 2 Euro II) and four 4-stroke 150 cc in-use scooters (2 pre-Euro I and 2 Euro I), are presented. Mopeds and scooters were tested according to ECE-47 and ECE-40 driving cycles, respectively.

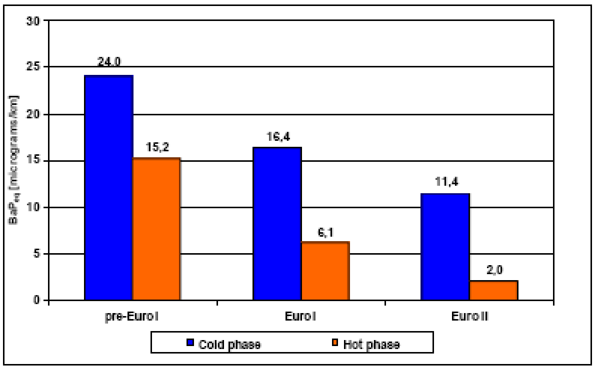


Figure 9 - Pre Euro I, Euro I, and Euro II mopeds: cold and hot phase BaP_{eq} emissions.

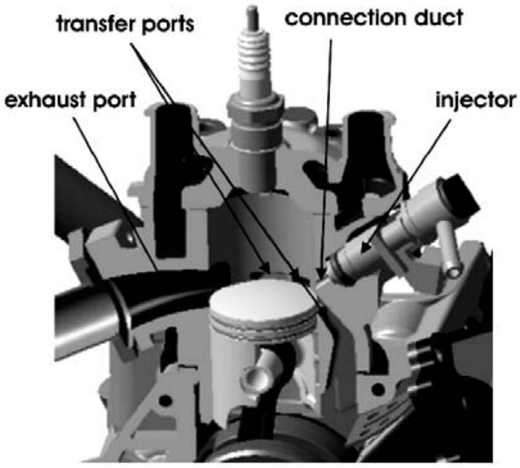
CONCLUSIONS

The tests performed indicate that particulate matter emission from non-catalyzed mopeds is related to lubricant consumption. In the case of Euro I mopeds, lubricant in the exhaust gases is oxidized by the catalyzer. In ECE-47 driving cycle oxy-cat reduced particulate emissions by about 80%.

The two tested models of Euro II mopeds showed very different hot emissions factors so, at the moment, we cannot attribute a unique figure to this moped category. Further investigation is necessary. In any case PM moped emissions cannot be neglected in urban emission inventories. For instance, in Italian urban areas moped PM emissions can be of the same magnitude of those from diesel passenger cars, according to the fleet composition. Scooter PM emissions are, as expected, quite low and their contribution to the PM emission inventory could be disregarded as a first approximation. Two-wheel motor vehicles seem to be an important source of atmospheric PAHs releases. Due to their prevailing use in an urban environment, especially mopeds, further investigation is necessary for estimating the contribution of this vehicle category to the amount of this group of unregulated pollutants in an urban atmosphere and for the development of strategies to mitigate their adverse health effects.

Visualization and simulation of a stratified scavenge process for a 50cc two-stroke engine

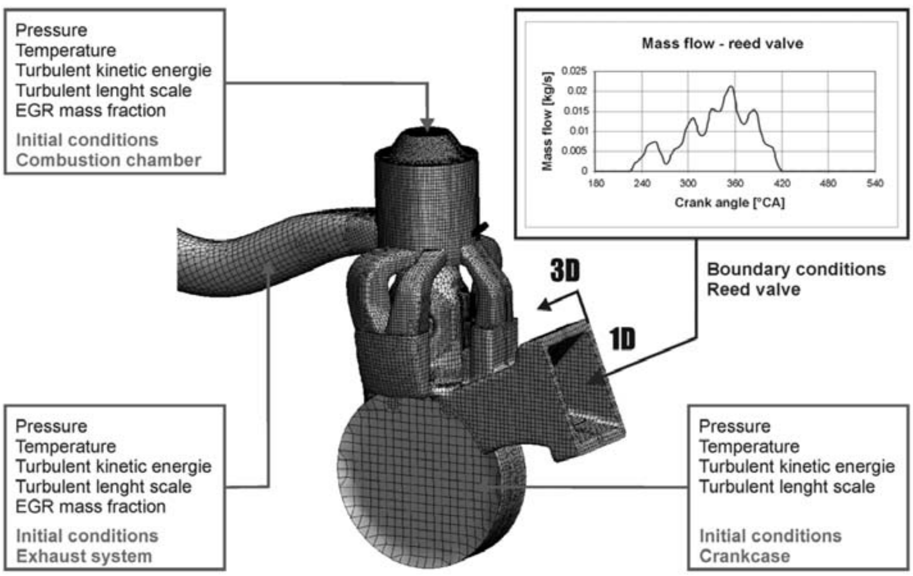
Dipl.-Ing. Franz Winkler, Oliver Schögl, Dipl.-Ing. Roland Oswald, Dipl.-Ing. Dr. Roland Kirchberger
Institut für Verbrennungskraftmaschinen und Thermodynamik, Technische Universität Graz



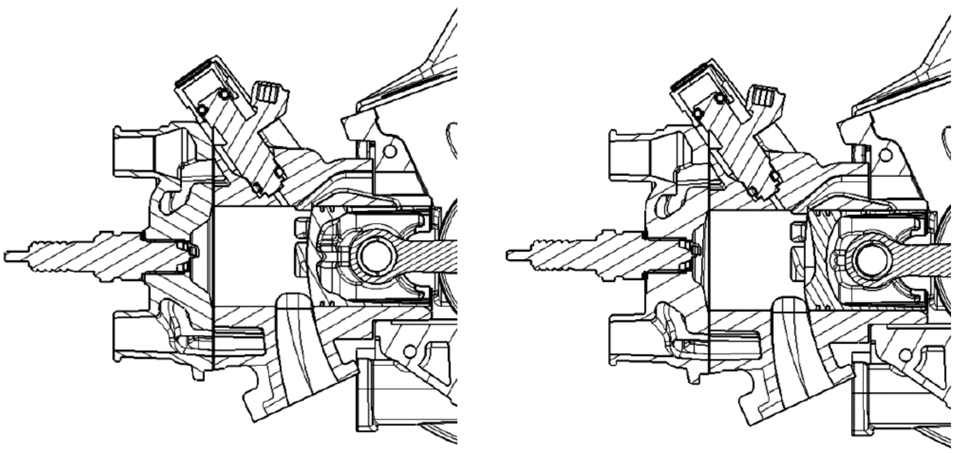
Tools for development of modern low emission concepts

Displacement	50 [cm³]
Bore	40 [mm]
Stroke	39.2 [mm]
Conrod lenght	80 [mm]
Compression Ratio	11.68 [-]
Rated Speed	6500 [1/min]
P_{max}	3.3 [kW]
T_{max}	4.9 [Nm]
EO	96.5 [°CA]
TO	124 [°CA]

System description



Initial and boundary conditions for 3D CFD-calculation



Standard combustion chamber (right), asymmetrical piston bowl (left)

VSAE 00096

Metallic Substrates for Catalytic Converters in 2 & 3 Wheelers

Turbulent Catalysts meet the Requirements of the Future

Alfred Reck, Friedrich-Wilhelm Kaiser, M.D. Nguyen
EMITEC GmbH, Germany
Matjaz Korman, Roland Kirchberger, Mario Hirz
Institute for Internal Combustion Engines and Thermodynamic
Graz University of Technology, Austria

ABSTRACT

The 2 & 3 wheeler industry is using world-wide metallic substrates for catalytic converters in their production. To achieve higher efficiencies of metallic catalytic converters, progressive developments in the area of turbulent foil structures have taken place. First results show, that 15 % smaller volume of the catalysts with turbulent structure offers higher conversion efficiencies applied to smaller size 2 & 3 wheeled vehicles.

The design details of so called TS and LS structures as well as catalytic converter performance behaviour will be reported in this paper. Especially the influence of these new structures and the new catalyst performance improvement applied to smaller size 2 & 3 wheeled vehicles are discussed.

TS – Structure

Transversal Foil Structure (TS) catalyst is the second generation of metallic substrates. The first generation had straight and unstructured channels.

In this type, the corrugated foils are embossed with secondary micro- corrugations (Figure 2), which are provided transverse to the direction of flow i.e. at 90 degree to the flow direction (see above described mass transfer to the wall).

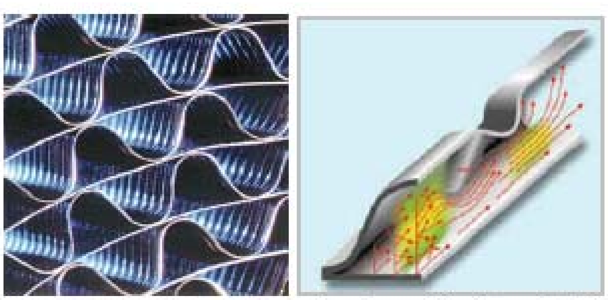


Figure 2: TS structure design with flow details

These micro-corrugations help intense ex-changes of unconverted gases in the core of channel with the converted gases close to the walls.

LS – Structure

Longitudinal Structure (LS) is the third generation of metallic substrate structure, which has been developed by EMITEC. In the LS design the corrugated foil is characterized by additional cuts and depressions to pro-vide shovel like shapes (Figure 3).

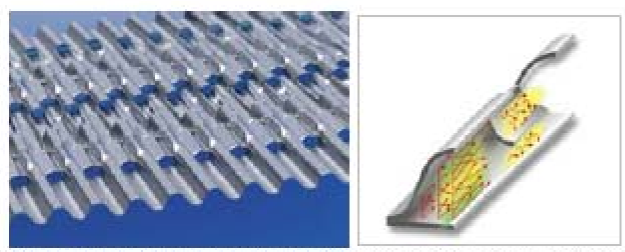


Figure 3: LS structure design with flow details

These counter corrugations projecting into the basic channels create the effect of additional channels within the same given volume, which results in turbulent mass transfer to the channel walls and an increased catalytic reaction.

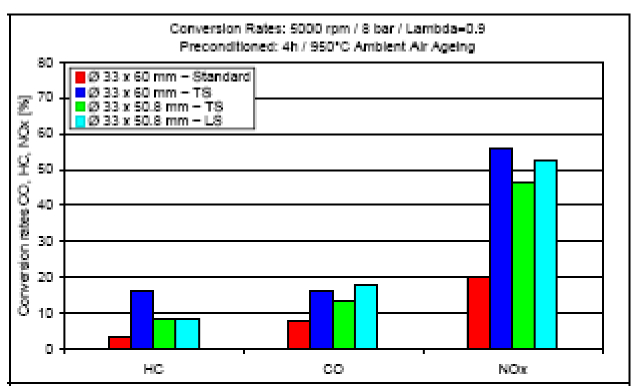


Figure 5: Conversion rates 5000 rpm / 8bar / Lambda 0.9

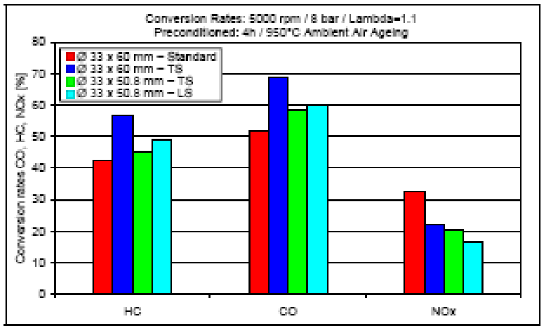


Figure 9: Conversion rates 5000 rpm / 8bar / Lambda 1.1

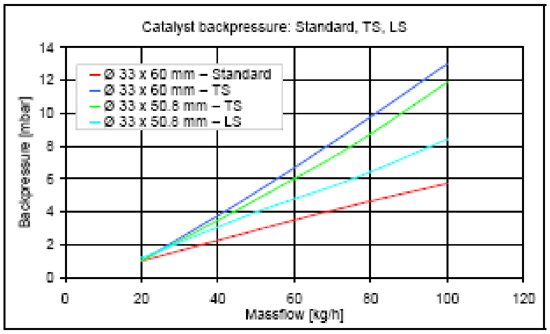


Figure 11: Catalyst backpressure as function of the mass flow

CONCLUSION

Experimental results show that the turbulent catalysts have a future perspective and will dominate the application in the future.

The results presented in this publication show that a 15 % smaller catalyst with turbulent structure offers the same or even better conversion efficiency than the reference catalyst with 100 % volume. Thereby gained volume reductions of up to 25 % offer significant lower consumption of precious metal (PGM); advantageous especially at times when it is expected that the PGM costs will further increase in the future.

The production technology of the second generation TS-structure is mature and ready to be launched.

Catalysts equipped with turbulent LS-structure substrates show an even higher potential than TS-structure and are ready to leave the R & D status with proven durability [7, 8].

The new turbulent substrate technology should be accompanied by a new coating technology being introduced as a worldwide standard.

AECC NEWSLETTER

September - October 2006

Motorcycle Directive with WMTC Limits published

The correlated European limit values for the World-harmonised Motorcycle Test Cycle have been published as Commission Directive 2006/72/EC.

The following table shows the existing Euro 3 limits on the ECE cycles (Row B) with the new limits for the WMTC (Row C).

g/km	Vehicle class	Test cycle	CO	HC	NOx
B	< 150 cc	Cold, 6*UDC	2,0	0,8	0,15
	≥ 150 cc	Cold, 6*UDC + EUDC	2,0	0,3	0,15
C	V_{max} <130km/h	WMTC	2,62	0,75	0,17
	V_{max} ≥130km/h	WMTC	2,62	0,33	0,22

The Commission is now expected to publish an Internet consultation on a draft co-decision Directive on the other motor cycle issues within the next few weeks. The main issues are durability, CO_2 requirements, Euro 3 for tricycles and quadricycles, Stage 3 for mopeds, and evaporative emissions.

Study on Regulatory Measures for Emissions Control of Two-Wheelers

A European Commission-sponsored study on possible regulatory measures for powered two-wheelers has now been published[1]. The study examines the contribution to emissions made by motorcycles and mopeds in Europe over the period 1999-2012 and assesses the environmental benefits and the costs associated with different emissions control measures. These include durability requirements for emissions control, in-use compliance and roadworthiness procedures, on-board diagnosis, control of evaporation emissions, specific measures regarding particulate matter and new steps for emissions standards.

The study finds that, if no additional regulatory measures are taken, motorcycles and mopeds in Europe will emit more than 7% and 20% of total road transport carbon monoxide and unburned hydrocarbons respectively by the year 2012. In order to control rising unburned hydrocarbon emissions, both evaporative emissions control and roadworthiness tests are cost-effective. A further tightening of the emissions standards for mopeds will be the most expensive but also the most effective measure.

[1] Ntziachristos et al (2006); Emission control options for power two wheelers in Europe, Atmospheric Environment 40(24):4547-61

Association for Emissions Control by Catalyst AISBL

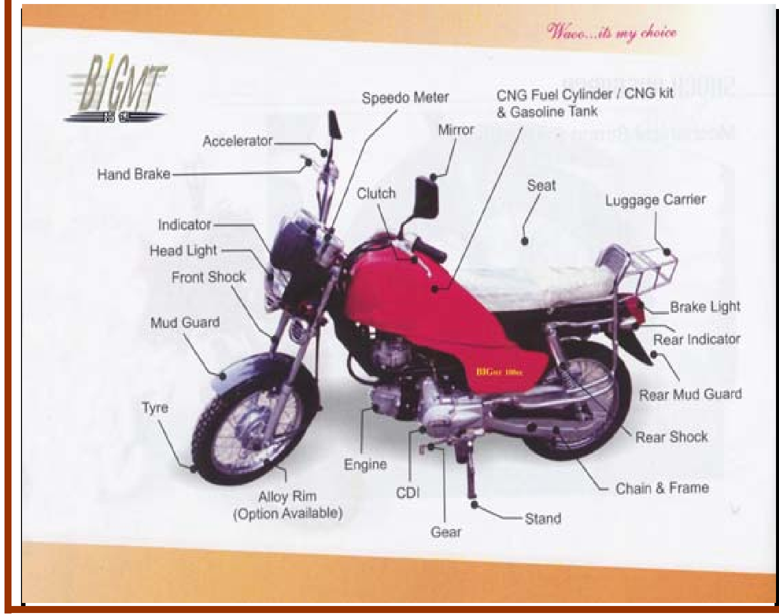
Diamont Building
Boulevard A. Reyers, 80
B-1030 Brussels
Belgium

Tel: +32 2 706 81 60
Fax: +32 2 706 81 69
info@aecc.be
www.aecc.be

Chongqing BIG Science & Technology Development Co., Ltd

CNG MOTORCYCLE SERIES

BGMT 100cc Motorcycle



SPECIFICATION

Maximum Power:	5.5/8000(kw/r/min)	Dimension:	((L×W×H)mm): 1830x775x1040
Maximum Torque:	6.5/5750(N.m./rpm)	Wheel base:	1200mm
Max. Voice:	80(dB(A)	Min.Ground clearance:	120mm
Ignition mode:	CDI Electronic ignition	Dry weight:	75kg
Engine technical data:		CNG consume:	1.9 M3/100 KM
Break Performance:	≤7m/30km/h	Max. Speed:	75KWkm/h
package way:	Iron and Seven-layer carton	Economical fuel consumption:	1.6(l/100km)
Starting mode:	Electric Start/Kick Start	Rim type:	spoke / alloy
Engine model:	1P47FMD	Min.Ground clearance:	120mm
	four-stroke	Fr. Tyre size and air pressure:	2.25-17/175KPa
package size:		Fr. Brake: drum	Rr. brake: drum
Displacement:	110ml	Max.loading capacity:	75kg
Compression ratio:	7.0:1	Fuel tank capacity:	3L
Bore X Stroke:	47x41.4(mm)	Cylinder water capacity:	7L
Engine type:	single-cylinder, air-cooled,	Gag capacity:	2 M3
Package information:		Rr. tyre size and air pressure:	2.50-17/200KPa
		Fr. Tyre size and air pressure:	2.25-17/175KPa

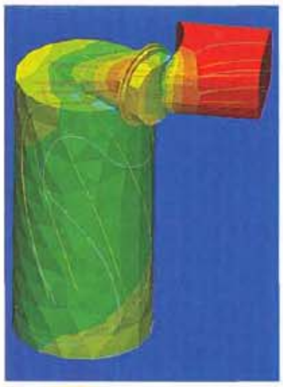
Price: FOB USD 420 FOR 100cc

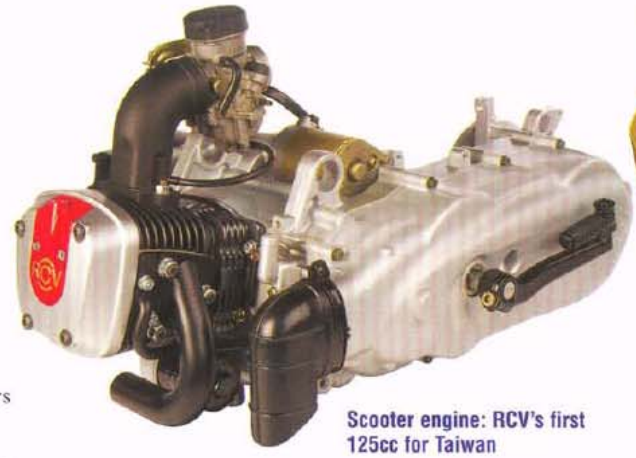
FOB USD 440 FOR 110cc

TECHNOLOGY

Taiwanese scooter set to pioneer new engine

UK company RCV Engines sees markets for its rotating cylinder valve technology in motorbike engines and small gardening and forestry products





Scooter engine: RCV's first 125cc for Taiwan

Small UK company RCV Engines has unveiled a prototype 125cc motor scooter engine it has built with a Taiwan company using its patented Rotating Cylinder Valve technology.

RCV announced two years ago that it was working with Motive Power Industry (MPI) of Taiwan to develop its engine for use in small scooters. Other uses are foreseen in garden equipment such as trimmers and saws, and in small unmanned aircraft.

RCV says the 125cc engine developed at its research base at Wimborne in Dorset for the Taiwanese company, which makes scooters under the PGO brand, has exceeded performance expectations.

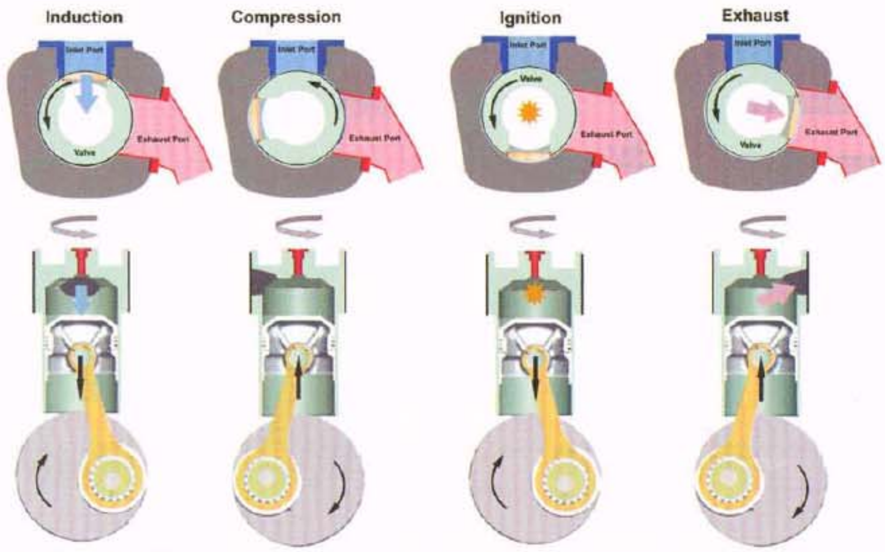
RCV managing director Eric Hill said: "The impressive performance and potentially low manufacturing cost of the 125cc RCV engine developed for MPI demonstrates the potential of RCV technology as an enabler for products with premium performance coupled with high standards of fuel efficiency and low exhaust emissions."

MPI chief executive Michael Hwang said: "MPI has invested in the research and development of 2-stroke and 4-stroke scooter engines for several decades and has built up a great deal of experience in this field. To achieve enhanced engine properties and reduced costs MPI is making a significant investment to co-operate with RCV Engines and to apply RCV technology to the PGO 4-stroke scooter engine. We believe the competitive ability of our products will be strengthened outstandingly by the new 4-stroke Rotating Cylinder Valve Engine."

RCV engines share the same induction, compression, power and exhaust strokes found in a conventional 4-stroke engine, but differs in the manner the intake air and exhaust gases are induced into and expelled from the cylinder.

The cylinder is mounted on bearings and rotates at exactly half of the crankshaft rotational speed, driven from the crankshaft either through a gear train or a toothed belt system. A single large cross-sectioned area port and combustion chamber is combined within the cylinder, the entrance to which forms the rotating cylindrical valve together with the openings of the external intake and exhaust ports.

RCV Engines says that the large valve area of this configuration is like that of high-performance sleeve valve aircraft engines, but has none



Cycle time: The RCV engine gains efficient combustion through increased intake turbulence