EC-JRC/BAFU/Pirelli Ambience
Joint International Conference
June 11-12, 2009, Milano, Italy

Effects of Ethanol-Gasoline Blends on Exhaust Emissions from a Two-stroke Motorcycle

Jiun-Horng Tsai, Y.C. Yao,

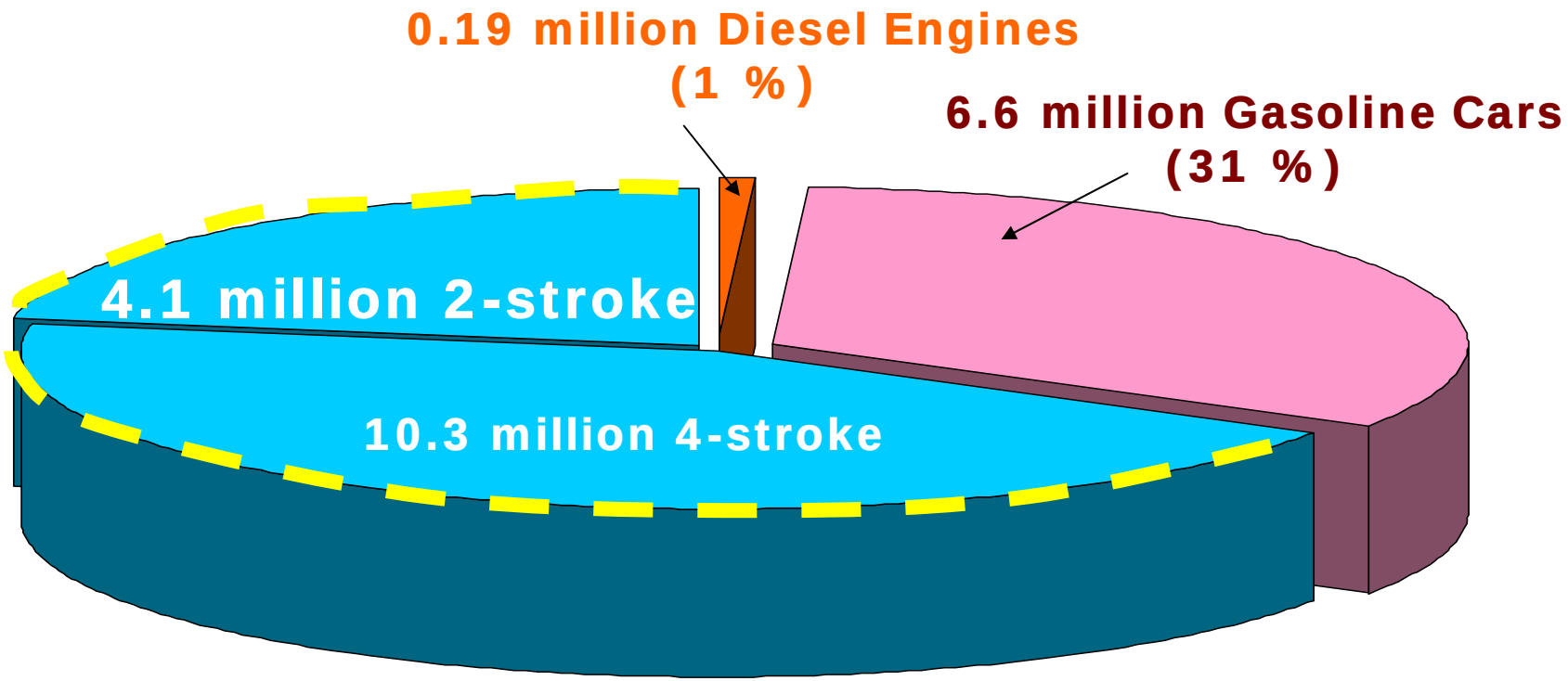
W.T. Chang, T.H. Yan

The Department of Environmental Engineering
National Cheng Kung University
Tainan, Taiwan, R.O.C

Motorcycles in Urban Area in Taiwan

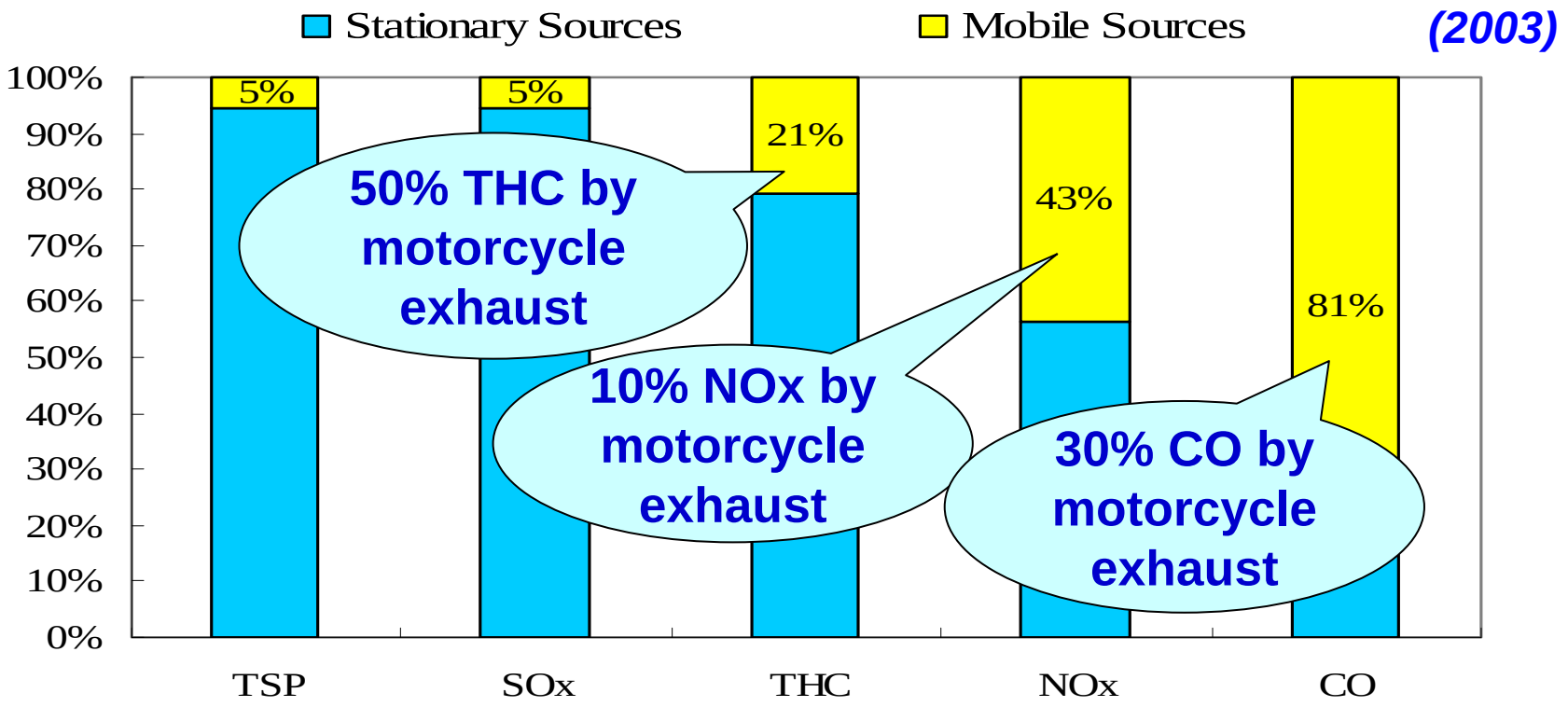
Motor Vehicle Populations in Taiwan

21.1 million Motor Vehicles in 2008



14.4 million Motorcycles
(68 %)

Air Pollutant Emission Inventory in Taiwan



Thousand ton/yr	TSP	SOx	THC	NOx	CO
Mobile Sources	44	12	211	217	674

Alternative Fuels

- The application of alternative fuels has received considerable attention
- Alternative fuels: ethanol, methanol, natural gas, hydrogen, bio-diesel, and electricity
- Ethanol is employed most widely
  - Many studies have focused on the effects of ethanol-blended gasoline (3-30 vol%) and pollutant emissions

Effects of Ethanol-blended Gasoline on Exhaust Emissions

- The quantification of pollutant emissions has mostly been done with passenger cars (Furey and King, 1980; Hsieh et al., 2002; Zervas et al., 2002; Al-Hasan, 2003; He et al., 2003).
- In general, exhaust CO and HC emissions are lower with oxygenated fuels, but comparable or higher NOx emissions are found in these studies

Rare study on motorcycle engine exhaust

Research Objective

- Investigated the effects of ethanol-gasoline blends on criteria air pollutant emissions of two-stroke motorcycle.

Experimental

Test Fuels (1/3)

- Three ethanol-gasoline blends
  - E10, E15, and E20
  - prepared by the largest petroleum refinery (China Petroleum Corporation) in Taiwan
  - controlled at a constant RON (ca. 95)
  - w/o MTBE
- Reference fuel (RF)
  - commercial unleaded gasoline with a RON 95
  - with MTBE as the oxygenated additive

Experimental

Test Fuels (2/3)

- Fuel properties

Fuel property	Test fuels			
	RF	E10	E15	E20
Research Octane Number (RON)	95.0	95.1	95.2	95.1
Ethanol (vol%)	0	9.8	14.7	17.9
MTBE (vol%)	10.3	0	0	0
Oxygen content (wt%)	1.8	3.4	5.2	6.1
Heating value (J/g)	2580	2520	2500	2450

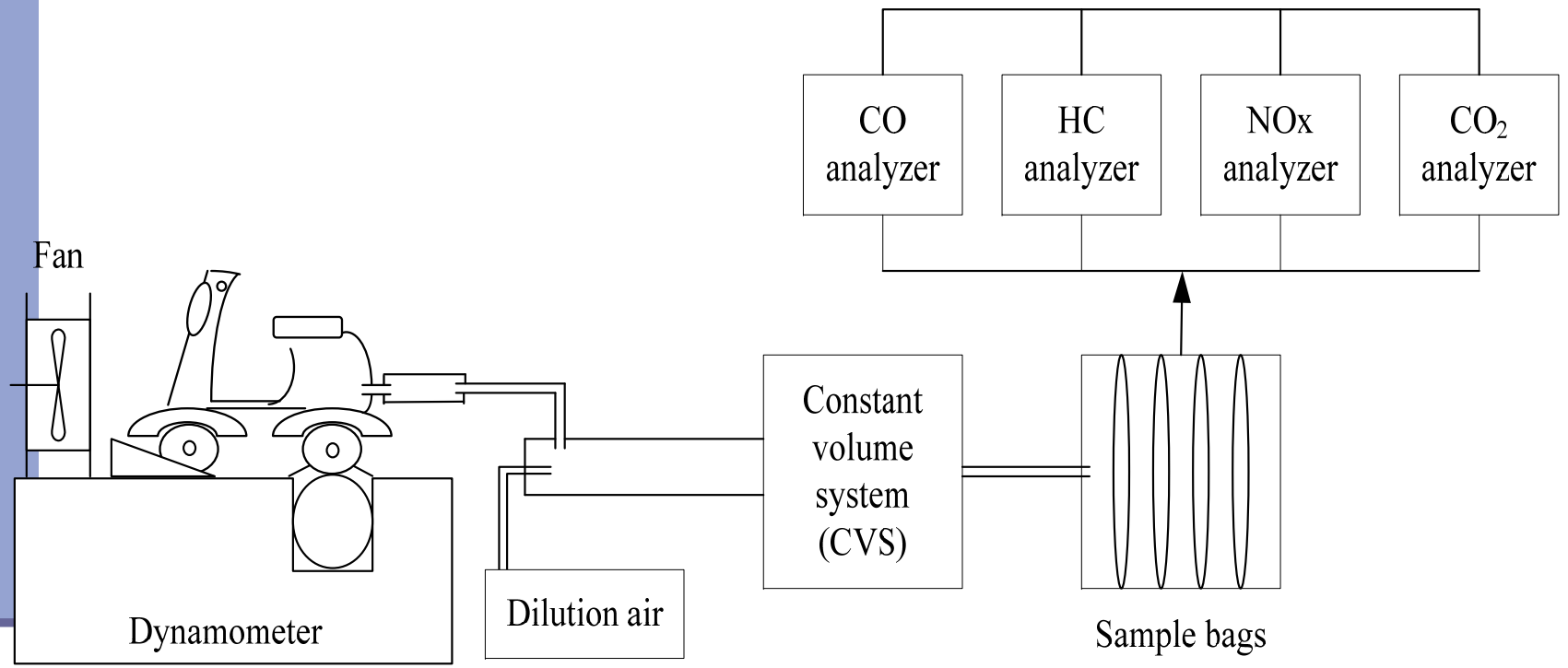
The RON of the ethanol-blended fuel was controlled at 95 by adjustment of the aromatic content.

Experimental

Test Motorcycle

- A new 2 stroke engine motorcycle
- Without catalytic converter
- Displacement : 49 cm^3
- Compression ratio : 7:1
- Fuel supply system: carburetor
- Maximum power : 4.7 KW/6500 RPM
- Idle RPM: 1800±100 RPM

Experimental Scheme

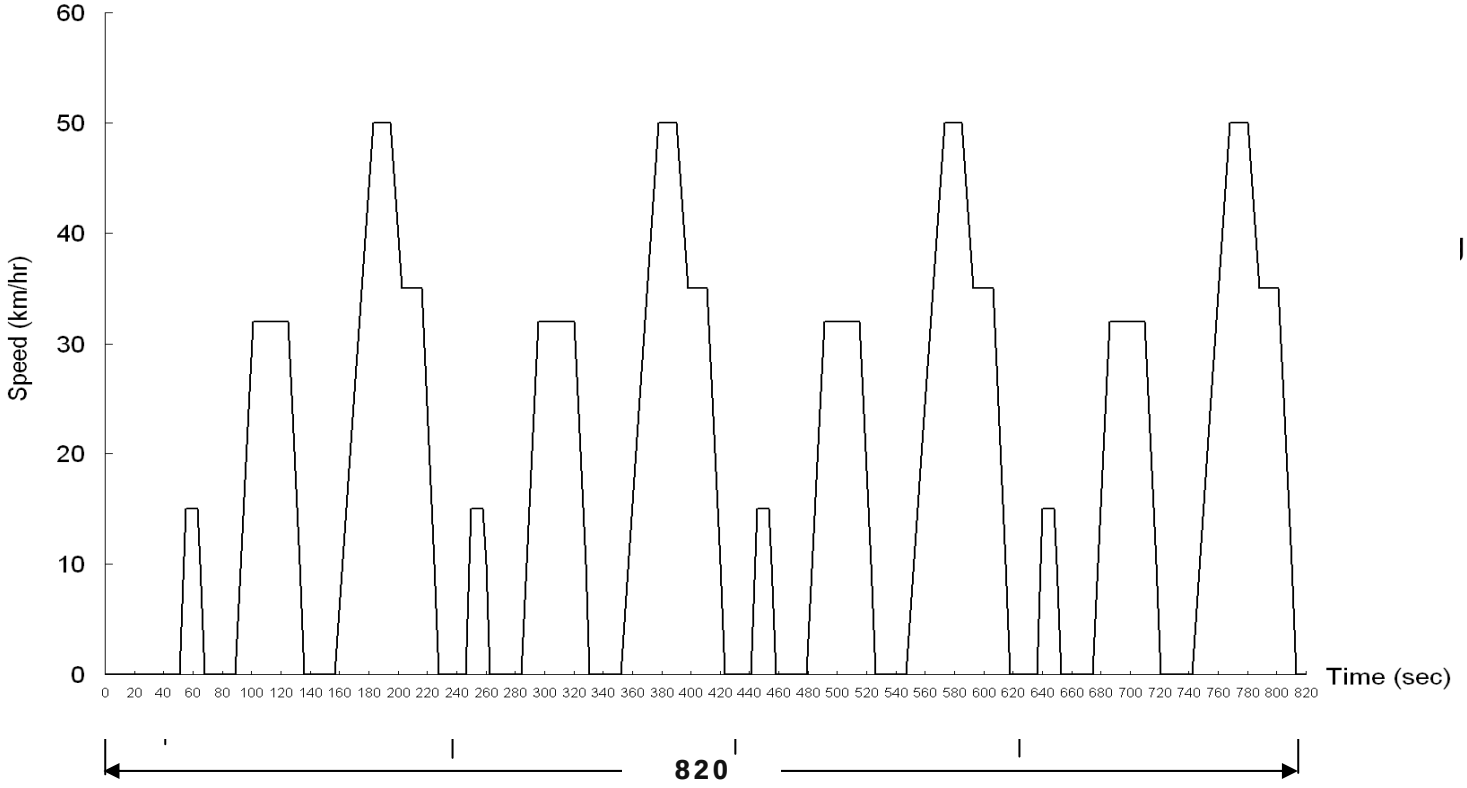


- Chassis dynamometer (MEIDEN, 20KW)
- Constant volume system unit (HORIBA, CVS-51S)
- Exhaust gas analyzer (HORIBA MEXA-7200)

Experimental

Test Procedures

- A legislative test procedure, CNS 11386, was used for the motorcycle emission test. It is the same as that of the Economic Commission for Europe cycle.



Experimental

Test Reproducibility

- Five tests of various test fuels were conducted in this study, including two tests each for the commercial gasoline, and one test each of the E10, E15 and E20.
- The values of reproducibility for CO, THC, and NOx were 90, 96, and 90%, respectively.

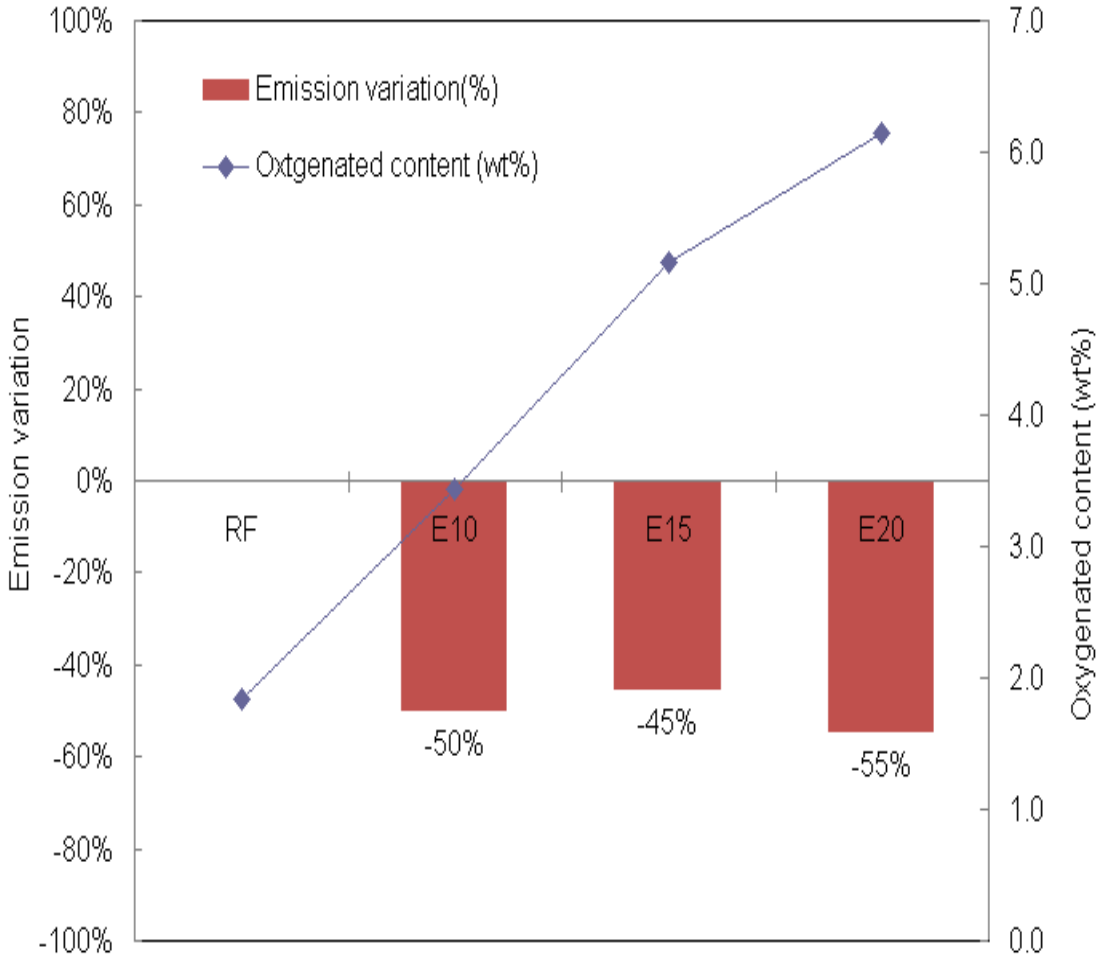
Emission Factors of Various Test Fuels

Fuel	Emission Factor (g/km)		
	CO	THC	NO
RF	6.91	6.38	0.071
E10	3.46	4.44	0.031
E15	3.78	4.27	0.029
E20	3.14	3.97	0.028

Results

Emissions of Criteria Air Pollutants

-- CO

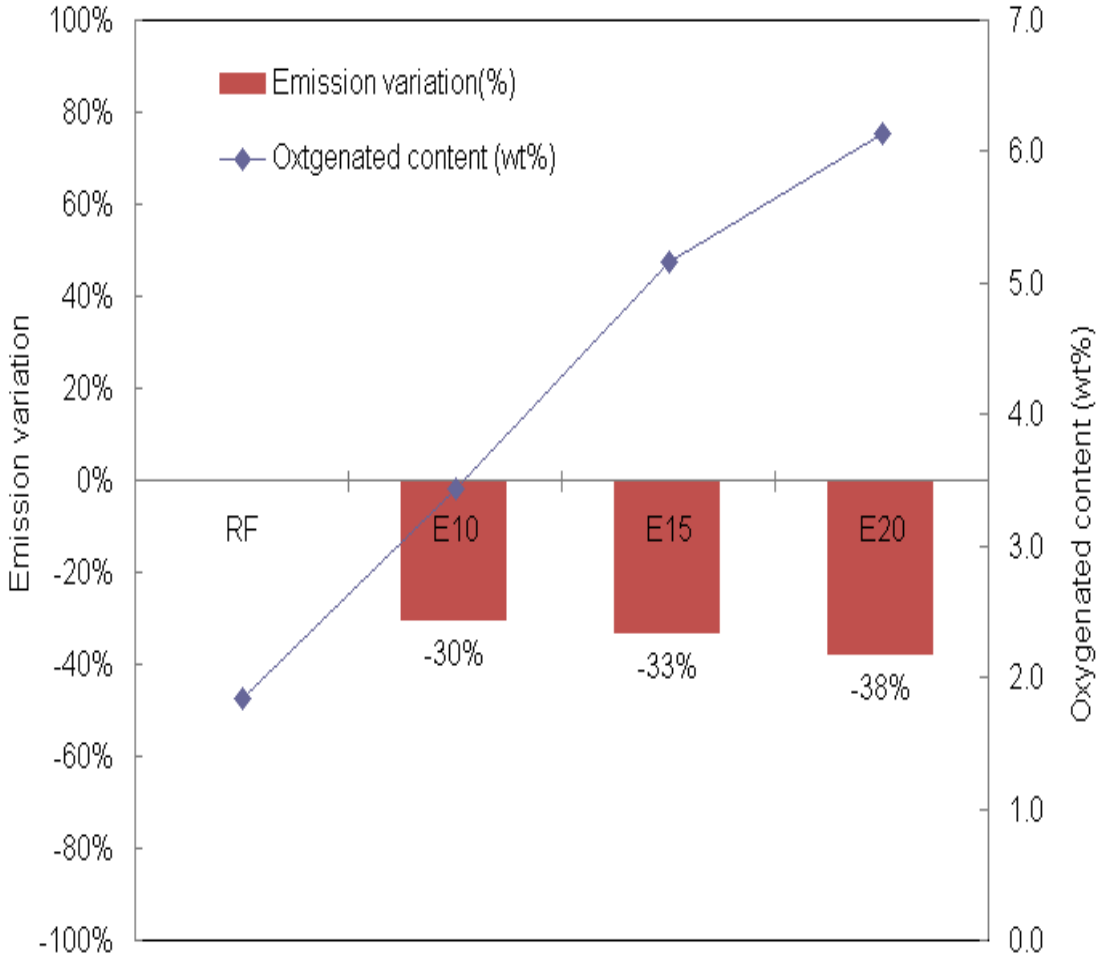


- CO emissions decreased by about 45-55% for ethanol-gasoline blends compared to RF
- The **E20 fuel** had the highest emission reduction compared to the RF

Results

Emissions of Criteria Air Pollutants

-- THC

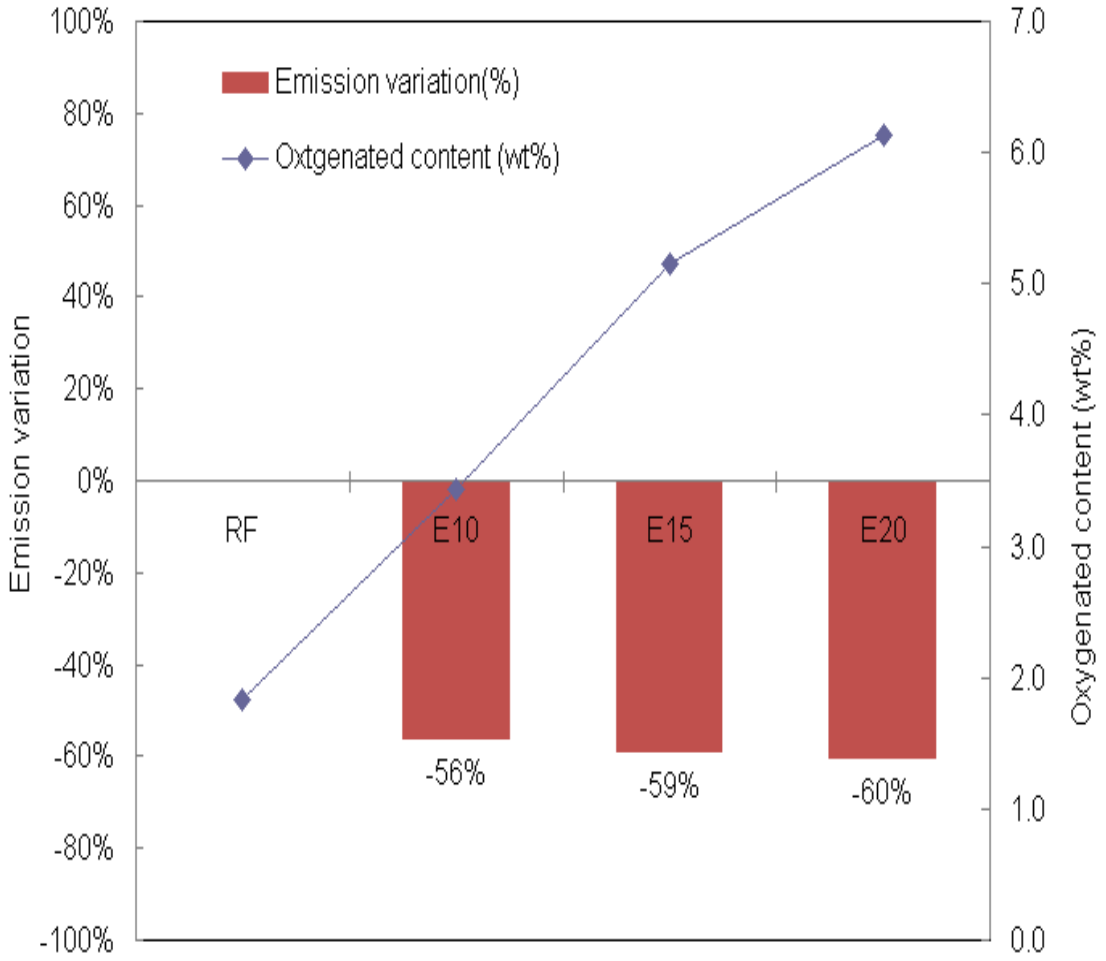


- THC emissions decreased by about 30-38% for ethanol-gasoline blends compared to RF
- THC emissions decreases as the E% increases
- The **E20 fuel** had the highest emission reductions relative to the RF

Results

Emissions of Criteria Air Pollutants

-- NOx



- NOx emissions decreased by about 56-60% for ethanol-gasoline blends compared to RF
- NOx emissions decreases as the ethanol content increases
- The **E20 fuel** had the highest emission reductions relative to the RF

Other Fuel Compositions Effect (1/2)

- It is very difficult to prepare fuels which only change the oxygen content while keeping the other parameters constant and maintaining a constant RON.
- Other fuel compositions may also influence emissions.
- The relationship between pollution level in the exhaust and fuel compositions (oxygenated, aromatics, benzene, naphthenes, olefins, and paraffins contents in fuel) are also evaluated.

Other Fuel Compositions Effect (2/2)

Correlation coefficients (r)	CO	THC	NOx
Oxygenated content	-0.83	-0.90	-0.84
Paraffin content	**0.97**	**1.00**	**0.98**
Olefins content	-0.49	-0.58	**-0.60**
Naphthene content	0.11	0.06	0.18
Aromatics content	0.48	**0.60**	0.51
Benzene content	-0.06	0.05	-0.06

Conclusions (1/3)

- Three ethanol-gasoline blends with various ethanol content (10, 15, and 20% v/v) and a commercial gasoline (with MTBE) with RON (95) were applied in a new 2 stroke engine motorcycle in this study.

Ethanol-gasoline blends could improve emissions of criteria air pollutants (CO, THC and NOx) as the content of ethanol increasing.

Conclusions (2/3)

- The E20 blend performed the greatest improvement of emission reduction among these three blends. The emission reduction is 30 % for CO and 8% for THC.

Emissions of CO, THC and NOx are strongly correlated with the contents of oxygenated compounds.

Conclusions (3/3)

- Besides, the other parameters of blended fuel may also influence emissions of criteria pollutants in the exhaust even applying a blended fuel with constant octane number .
  - the paraffin content affected CO emissions
  - the paraffin and aromatic contents affected THC emissions
  - The paraffin and olefins contents affected NOx emissions

Thank You for Your Attention