Potential of portable on-board FTIR analyzers for real driving emissions and chase vehicle monitoring

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This presentation reviews the possibilities of using a mobile, in-vehicle FTIR analyzer as a single on-board instrument for the measurement of exhaust emissions all principal gaseous pollutants of interest, and, in a chase vehicle configuration, for remote check of NOx aftertreatment functionality on individual vehicles. Outdoor air pollution remains one of the leading causes of premature deaths, with particulate matter, nitrogen oxides and tropospheric ozone being of principal concern. Historically, only nitrogen oxide (NO), formed at high temperatures in the combustion chamber, was emitted, with subsequent formation of NO2, and formation of ozone by photodecomposition of NO2, happening after considerable dilution. The beneficial role of NO2 in diesel particle filter regeneration and fast NOx reduction in selective catalytic reduction (SCR) devices has promoted an increased conversion of NO into NO2 in diesel oxidation catalysts, under the assumption that most of the NO2 will be reduced by subsequent aftertreatment. The drive to achieve high NOx conversion rates has lead to both three-way catalysts (TWC) and SCR running close to the limit, leading to NH3 formation in TWC and NH3 slip in SCR. The drive to realize modest savings on operating costs has motivated the SCR functionality, in many cases, to be limited. These developments provide for a strong motivaton to monitor, at a minimum, NO, NO2 and NH3 during a range of operating conditions, including "real- real driving emissions" (real-RDE), defined as emissions in typical everyday operation, both in and out of the boundary set in "real driving emissions" legislation. In addition, the emissions of two potent greenhouse gases, nitrous oxide from SCR and methane from lean NOx traps and methane based fuels, are of additional concern, and should be considered together with CO2 emissions.

The concentrations of all of the mentioned compounds, plus many others, can be inferred from absorption spectra in mid-infrared regions. While CO and CO2 have strong absorption regions with very little interference, resolving the spectra for NO and NO2 requires either removal of nearly all water in the sample or high spectral resolution. Removal of water, however, prevents the measurement of water-soluble compounds NH3 and formaldehyde. FTIR spectrometer, using a Michelson interferometer to produce two infrared beams with variable optical path length difference which pass through a multipass cell filled with exhaust, and a Fourier transform to convert the absorption measured in the space domain to the frequency domain, is advantageous over discrete wavelenghts both due to better signal to noise ratio and due to the fact that optical distortions due to vibrations affect the entire spectra.

Three FTIR instruments have been successfully used, over the last fifteen years, by this group on the road. All have mercury cadmium telluride detectors cooled by liquid nitrogen, 0.2-0.3 liter multipass optical cells with 5-6 meter pathlength, and operate at optical resolution 0.5 cm-1 and around 130 C sample temperature. Examples of validation in the laboratory and on the road and examples of installation on a variety of machines, from small cars to diesel lomocotives, will be presented.

One of the instruments, temporarily mounted in an ordinary highway patrol vehicle, has been used to assess NOx emissions on over 200 heavy-duty diesel trucks in the Czech Republic over one week, offering a practical solution for enforcement agencies to detect suspect NOx high emitters.