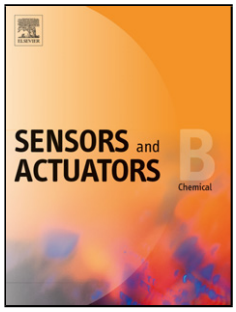

Title: In situ, multiparameter optical sensor for monitoring the selective catalytic reduction process of diesel engines

Authors: Zhenhui Du, Yue Yan, Jinyi Li, Shuai Zhang, Xiaotao Yang, Youhong Xiao

PII: S0925-4005(18)30731-7
DOI: https://doi.org/10.1016/j.snb.2018.04.035
Reference: SNB 24510

To appear in: *Sensors and Actuators B*

Received date: 24-10-2017
Revised date: 4-4-2018
Accepted date: 6-4-2018

Please cite this article as: Zhenhui Du, Yue Yan, Jinyi Li, Shuai Zhang, Xiaotao Yang, Youhong Xiao, In situ, multiparameter optical sensor for monitoring the selective catalytic reduction process of diesel engines, Sensors and Actuators B: Chemical https://doi.org/10.1016/j.snb.2018.04.035

In situ, multiparameter optical sensor for monitoring the selective catalytic reduction process of diesel engines

Zhenhui Du[a*], Yue Yan[a], Jinyi Li[b], Shuai Zhang[a], Xiaotao Yang[c], Youhong Xiao[c]

a. State Key Laboratory of Precision Measuring Technology and Instruments, Tianjin University, Tianjin, China

b. Key Laboratory of Advanced Electrical Engineering and Energy Technology, Tianjin Polytechnic University, Tianjin, China

c. College of Power and Energy Engineering, Harbin Engineering University, Harbin, China

Highlights

- A multi-parameter optical sensor with a single NIR diode laser was proposed for monitoring the SCR process of diesel engines.
- Wavelength modulation spectroscopy (WMS) with varied and optimized modulation amplitude was presented for multispectral line detection.
- Optimized multispectral fitting method was presented for simultaneously measurement of NH_3, H_2O, gas temperature and pressure.
- Method of the multi-parameter analysis can be used for the diagnosis of combustion and chemical reaction process.

Abstract

Selective catalytic reduction (SCR) is an effective technique to reduce nitrogen oxide (NO_X) emission in high-temperature combustion processes. SCR requires strict reaction conditions, including proper temperature and ammonia (NH_3) injection volume. To satisfy SCR conditions, we present a low-cost, in situ optical sensor for multiparameter measurement during SCR processes. The sensor simultaneously detected NH_3 concentration, water (H_2O) concentration, temperature, and pressure by using a single near-infrared diode laser. To ensure the high-quality multiparameter measurement, we realized two novel ideas: (1) wavelength modulation spectroscopy (WMS) with varied modulation amplitude and (2) an optimized multispectral fitting algorithm. We demonstrated the method by theory analysis, model simulation, laboratory verification, and field-testing with a diesel engine. The relative measurement uncertainty of NH_3 concentration, H_2O concentration, temperature, and pressure were 8.4%, 8.0%, 5.3% and 7.0 %, respectively. The results of the field test were consistent with those obtained by thermocouples and electrochemical sensors. The presented sensor is quite suitable for SCR processes and other harsh-environment applications because of its low cost and robustness. The proposed multispectral detection method also can be used for other WMS applications.

Keywords: optical sensor; selective catalytic reduction (SCR); diesel engine; wavelength modulation spectroscopy (WMS); varied modulation amplitude (VMA); multispectral fitting

*Corresponding author. E-mail address: duzhenhui@tju.edu.cn (Zhenhui Du)