Abstract

Impact of factors of influence on an experimental protocol development and data collection optimisation

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Introduction

Nowadays, miniaturised sensors are developed in the automotive field. In this application, quality and reliability of information collected from a data basis depends on various factors, such as repeatability and reproducibility of the apparatus used. Different NIR sensors, dedicated to fuel quality determination, and designed in a similar technology, have been tested. To evaluate the consistence of the data collecting experimental protocol, it is necessary to determine the level of influence of easily controllable and adjustable parameters of those probes, their possible interactions, and to understand existent correlations, to be able to take them into account during modeling.

Materials and methods

An experimental design was established in terms of three factors, to each of which were allocated two levels, a minimum (-) and a maximum (+). A 2^3 plan experimental matrix was applied on two samples, absolute ethanol (EtOH) and a commercial Diesel (GO), with each of the three sensors. Chosen factors in this study were: source temperature of the probe (Ts), sample temperature (Te) and dark value of the measure (D). Values of factor levels were fixed at 18°C and 30°C for Ts, 15°C and 30°C for Te, and BB (Black Box) and LL (Lit Lamp) for conditions of illumination during the experiments. Data collection on each apparatus, for all the experiments defined in the matrix of experiments was carried out in a short time, so that time would not be an influencing parameter. Three NIR sensors were used in this study, consisting of 23 LEDs (sources) which emit towards two photodiodes (detectors) passing through the sample, with a 7 cm optical path, covering a spectral range between 850 nm and 970 nm. Two first generation probes and a second generation probe, in which the source feeding was regulated, were chosen for the experiments.

Table 1. Percent variation of interactions between factors.

	NIR sensor				NIR sensor		
Measurement conditions	V1.1	V1.2	V2	Measurement conditions	V1.1	V1.2	V2
Te15→Te30 / Ts18	0.5	0.5	0.0	Te15→Te30 / BB	0.0	0.0	0.3
Te15→Te30 / Ts30	0.4	0.4	0.2	Te15→Te30 / LL	1.0	1.0	0.1
Ts18→Ts30 / Te15	**4.7**	**4.7**	0.0	Ts18→Ts30 / BB	**5.8**	**5.8**	0.1
Ts18→Ts30 / Te30	**4.8**	**4.8**	0.1	Ts18→Ts30 / LL	**3.7**	**3.7**	0.0
BB→LL / Te15	1.3	1.3	**3.2**	BB→LL / Ts18	1.8	1.8	**3.0**
BB→LL / Te30	0.3	0.3	**2.7**	BB→LL / Ts30	0.3	0.3	**2.9**

(Te15→Te30 / Ts18 means in terms of experimentation conditions, from Te15 to Te30, remaining at Ts18)

Results and discussion

Values of the variations (in %) are gathered in Table 1.

The influential parameters are those corresponding to the highest values. Effects and interactions relative to sample behaviour were studied for each sensor used. The first generation sensors (V1.1 and V1.2) showed a similar behaviour, in that they were sensitive to temperature, and less sensitive to illumination conditions. The source temperature was the most important factor, with variations of signal intensity of about 10% on the whole spectra, and up to 23% (V1.1) or 30% (V1.2) at 930 nm. The second generation sensor (V2), showed important variations relative to the illumination conditions during the experiments. These variations reached up to 6% of the intensity for wavelengths at 890, 925 and 970 nm. The difference of the signal intensity provided by sensors was calculated for each factor concerned in the studied interactions. In this study, the RON and MON values were very well predicted (Table 2).

With the V2 sensor, the prediction errors obtained were divided by a factor of 2, compared to the sensors V1.1 and V1.2. So, it could be possible to minimise the biggest variations, working only under conditions of lowest illumination, i.e. a light free system.

Table 2. Prediction of MON and RON values on each NIR sensor.

MON	V1.1	V1.2	V2	RON	V1.1	V1.2	V2
Elements	22	22	22	Elements	22	22	22
Correlation	0.826	0.877	0.96	Correlation	0.892	0.833	0.987
RMSEP	2.137	1.789	1.028	RMSEP	2.305	2.882	0.81
SEP	2.185	1.816	1.043	SEP	2.338	2.939	0.819
Nb of PC	6	6	6	Nb of PC	6	6	6