Rapid Determination of Selected Compounds in Waste-based Fuel by Near Infrared Spectroscopy

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Composition of the waste-based fuel intended for incineration has substantial effect on combustion process performance and formation of environmentally harmful emissions. Fuel composition vary significantly depending on the material source, waste sorting and recycling procedures and other waste pretreatment methods. In general, it typically contains paper, plastics, wood, textile, other organic material and further undesired substances including glass and metals. The knowledge of actual composition of the material fed into the boiler is limited to the direct or indirect continuous moisture content measurements and periodic fuel sampling providing elementary composition. This information is not sufficient for process control and performance optimization, particularly when considering strongly heterogeneous fuel feed. Therefore a rapid and reliable technique for fuel characterization is needed. The work presented here is focused to the quantitative determination of selected plastic materials and glass content. Incomplete combustion of different plastics may lead to the formation of carbon monoxide, hydrogen-cyanides, acid compounds and aromatic hydrocarbons etc. If the waste contains chlorine then highly chlorinated polycyclic compounds such as dioxins and furans may be formed. Plastics often contain flame retardants which can also contribute to production of harmful emissions. On the other hand, the highly corrosive deposits of alkali chlorides and other compounds may be formed on the heat exchangers, this lowers the heat transfer and boiler efficiency and decrease life-time of the equipment. Moreover, increased content of glass in the fuel supports the formation of agglomerates in the fuel bed, defluidization of the bed or ash removal problems which result in malfunction or failure of the combustion equipment. Near infrared (NIR) spectroscopy can be used for non-destructive quantitative determination of plastics and glass in waste-based fuel. Experimental work was performed on two types of spectrophotometers i.e. grating and Fourier transform instruments. Samples of known content of glass and different plastics were placed on a moving tray that reciprocated horizontally back and forth underneath the NIR sensor. This was done in order to replicate online application where the NIR spectrophotometer is places above the conveyor belt that transport the fuel to the boiler. Spectra were recorded in the range between 700 and 2500 nm. Acquired spectral data were pretreated with different methods such as normalization, scatter correction, smoothing, first and second derivative (Savitzky-Golay algorithm), selection of different spectral ranges and its combinations. Mathematical models to estimate content of glass and different plastics were constructed using Partial Least Square Regression (PLS-R) and Principle component regression (PCR) statistical methods. Different combinations of spectrophotometer type, pre-treatment methods and statistical methods were evaluated in order to find the model with the best prediction performance. Results prove the potential of the method to quantitatively determine the content of different types of plastics as well as glass with reasonable prediction accuracy. The ultimate goal of this research is to test the method at a real industrial boiler in order to improve process monitoring and control.

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