Statistical model for prediction of Ash Fusion Temperatures from additive doped biomass

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One of the important research topics of biomass combustion process is the prediction of phase transformation of ashes. The prediction of phase transformation of biomass ashes is challenging due to the highly variable composition of these fuels as well as complex processes accompanying phase transformations. Until now, a model with high prediction reliability for biomass samples has not been developed.

The AFT model (Ash Fusion Temperature) presented in this work was performed in the STATISTICA 13.1 software. This model is divided into 3 separate models which are designed to predict the characteristic ash melting temperatures: IDT - deformation temperature, HT - hemisphere temperature, FT - flow temperature, and it is based on the chemical composition of fuel and ash as obtained using ash analysis standards. For discussed models (IDT, HT, FT) a number of coefficients describing multiple regression parameters are presented, such as F - statistical significance level by Fisher-Snedecor test and p - corresponding probability level, R² - model determination coefficient, and Sₑ - standard error of estimation. The models are designed to predict AFT for raw and modified biomass by means of fuel additive.

To build the AFT model, a database describing 104 biomass samples of various types was populated. Each sample is characterized by complete data set (complete ash oxide analysis, AFT experiment results for IDT, HT, FT, sulfur and chlorine contents in fuel). Incomplete analysis of samples was omitted. In addition, the database was extended by 4 samples of biomass tested specifically in this work without the addition of halloysite: DS0, BZ0, SPK0, DM0, and also 4 with the addition of halloysite: DS4, BZ2, SPK4, DM4.

For all models, the value of the statistics designated with the Fisher-Snedecor Femp test is in the range of 11.10-10.20 above Fcrit with probability levels p <0.05. Obtained R² determination coefficients for IDT, HT, FT are respectively 0.907; 0.906; 0.897. The Rₑ² parameter was obtained at the level of 0.825 for IDT and HT and 0.816 for FT. Temperatures predicted with models IDT, HT and FT are characterized by the following standard estimation errors: 70.05; 51.98; 47.52. One can conclude that the use of the AFT model allows for the prediction of the temperature with an average error of ±70.5°C for IDT, ±51.98°C for HT and ±47.52°C for HT. For DS0 and SPK0 with IDT prediction, quite significant absolute errors of 88.5°C and 77.4°C were obtained. They are higher than the average difference between the measured temperature and the designated model (Sₑ(IDT) = 70.05°C). For the predicted HT temperature, SPK0 also exceeds the standard error of 51.98°C and the absolute error equals 88.4°C. For the last projected HT temperature, values greater than the average difference between Sₑ values were determined for DS0, SPK0 and BZ2.

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