Streszczenie / Summary

Identification system of additives and admixtures in fuels and furnace waste generated from their combustion

Poland's very poor air quality is a well-known and ever current environmental issue posing a significant short and long term threat to the health and wellbeing of Poland's citizens. Air pollution has been thoroughly documented as the cause of numerous diseases, the most common being chronic obstructive pulmonary disease (COPD), ischemic heart disease, stroke, lung cancer and acute lower respiratory infections. Most common air pollutants are sulphur dioxide (SO_2), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), ammonia (NH_3), carbon monoxide (CO), hydrocarbons (CH), particulate matter (PM10 and PM2.5), total suspended particulates (TSP), persistent organic pollutants (POPs) and heavy metals.

While industry related pollution emissions are constantly decreasing due to subsequent stricter national and international regulations, low-stack emissions of municipal and household origin remain a significant and unresolved pollution source. One of the issues involved with low-stack emissions is the combustion of low quality fuels as well as using various municipal waste as part of the furnace feed which often combined with poor incineration conditions results in gaseous emissions loaded with various pollutants and hazardous solid furnace waste.

To address the above mentioned the main objective of the presented work was to define a group of physicochemical, macroscopic and microscopic properties of furnace waste and solid fuels which would allow for easy and reliable determination whether the fuel or furnace feed in question was waste free. The identification system was developed on the premises that the occurring waste might be of various origin, their addition could have been deliberate and that it could have taken place during fuel production as well as during furnace feed composing and loading.

In order to achieve the adopted objective physicochemical and morphological analyses were carried out for a vast selection of solid fuels such as hard coal, lignite, biomass, commercial products derived from the aforementioned. To thoroughly characterize these

materials in regard to their fuel character, all underwent combustion in laboratory conditions and the generated furnace waste were also characterized within applicable scope. The acquired knowledge would however characterize only waste free fuels therefore furnace waste from end-users of individual heating devices obtained by local law authorities responsible for the execution of investigative actions also underwent the aforementioned analyses. The samples from individual heating devices were collected in accordance with valid and corresponding legal regulations assuring they're representative for the entire gathered material and were expertly assessed in regard to whether the furnace feed contained waste materials.

Results acquired from morphological analyses allowed for discerning and defining physical traces of burnt materials which with utmost certainty confirm waste presence in the furnace feed (referred to as "strong" morphology) and elements which suggest that illegal waste incineration might have taken place but requires additional evidence ("weak" morphology). These findings were incorporated in the Identification System as follows. If morphological analysis reveals even a single representative of "strong" morphology it is assumed that the furnace feed contained waste materials and no further analyses are needed. In all other cases, including multiple findings of "weak" morphology element, the sample is further investigated using other methods.

Results obtained from physicochemical characterization of furnace waste generated during combustion of uncontaminated fuels and furnace waste from individual heating devices for which waste (co-)incineration has been confirmed underwent statistical analyses to determine which of the parameters differ in a statistically significant manner. Such parameters then were analyzed in scope of their variation between samples and discrepancy between uncontaminated fuel derived furnace waste and furnace waste resulting from (co-)incineration of municipal waste. This allowed to designate "waste presence indicators", namely barium, chlorine, zinc, copper, titanium and its oxide TiO_2.

These "indicators" were incorporated in the Identification System twofold, namely in the form of conditional and absolute thresholds. In the developed decision model it is assumed that waste material was presence in the furnace feed if the absolute threshold for any of the indicators is exceeded or if conditional thresholds for at least two indicators are exceeded. The initial value of conditional and absolute thresholds were set for each indicator as $\bar{x} + 3\sigma$ and $\bar{x} + 5\sigma$ respectively.

The developed Identification System was verified by running a total of 100 previously assessed samples through it. The morphological assessment stage had an efficiency of about 63% with no false results. However a high percentage of falsely positive assessments in the physicochemical stage was found – namely every third sample assessed resulted in a falsely positive indication. Due to this the thresholds underwent modification up until falsely positive assessments were reduced to zero and efficiency of no less than 90% was achieved.

After the aforementioned modifications the resulting Identification System had a 100% efficiency and reliability allowing for taking it to the implementation stage.