Connecting Standards and Theoretical Models for Minimum Ignition Energy estimation: a procedure to optimize the number of experimental tests

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Abstract:

European Directive 1999/92/CE is the main reference for industries to evaluate and control the extent of dust explosions. A proper dust risk assessment requires the characterization of many chemical-physical properties of each dust used by the specific company, including dust resistivity, Minimum Ignition Energy (MIE), deflagration index (K_{St}) and granulometry. In particular, in Europe, the reference standard for MIE estimation is the EN ISO/IEC 80079-20-2:2016. Actually, the whole procedure may require high quantities of combustible material, related to the high number of conditions and repetitions to be tested, up to 1 kg of material. Moreover, the standard does not give any indication on the choice of the best conditions to minimize the number of tests to be carried out, leaving to the analyst freedom in identifying the ignition and not-ignition regions. Currently, theoretical and semi-empirical models for MIE predictions are available for many dust types. Despite not being generally accepted or indicated by technical standards, these models can provide insights into the optimization of MIE testing. In this work, a theoretical model for MIE estimation, which simulates the pyrolysis of a combustible dust in a MIKE 3.0 apparatus and identifies the ignition or non-ignition region based on the production of volatiles is used to identify either the highest energy value at which the ignition of the dust always fails or the lowest energy value at which the ignition effectively occurs. The model requires only a Thermo-Gravimetric Analysis (TGA) at 5 K/min and a granulometric analysis (both tests require about 10-20 mg of material). The theoretical predictions are capable of identifying both ignition and non-ignition regions as a function of either energy or dust mass loaded in a MIKE 3.0 apparatus, along with a MIE prediction value. This will allow to strongly reduce the number of experimental tests to be carried out to calculate the MIE and, therefore, the required amount of dust to be used. An experimental campaign, carried out in accordance with EN ISO/IEC 80079-20-2:2016, was used to validate the applicability of the optimized testing procedure.

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