

Application of Critical Energy Density Concept for Minimum Ignition Energy Determination

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Abstract:

This study introduces an innovative analytical framework, termed Critical Energy Density (CED), aimed at estimating the Minimum Ignition Energy (MIE) of organic powders. The proposed methodology relies exclusively on experimental data that are readily obtainable through standard laboratory techniques, including granulometric analysis, thermogravimetric analysis (TGA), and differential scanning calorimetry (DSC). These empirical inputs serve as the foundational parameters for the mathematical model employed.

The computational algorithm replicates the thermal response of a suspended dust cloud subjected to an electrical spark, simulating the transient heat transfer and subsequent release of volatiles. Ignition is identified by evaluating the balance between the energy liberated from the homogeneous combustion of evolved volatiles and a predetermined threshold value, which corresponds to the minimum energy density necessary to initiate and sustain flame propagation—this threshold is defined as the Critical Energy Density (CED).

The model underwent validation through its application to six distinct types of organic powders. The MIE values predicted by the algorithm demonstrated a strong correlation with experimental measurements, indicating the reliability and practical relevance of the proposed approach. As a result, the methodology offers a robust and economically viable solution for preliminary hazard assessment in industrial settings where combustible dusts are handled. Furthermore, it contributes to the advancement of inherently safer process designs by enabling early identification of ignition risks associated with particulate organic materials.

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