More on High Pressure Ignition Kernel Development and Minimum Ignition Energy Measurements in Different Regimes of Premixed Turbulent Combustion

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Abstracts

Spark ignition kernel development and minimum ignition energy (MIE) measurements in different regimes of lean premixed turbulent combustion from laminar and turbulent-flamelet to turbulent-distributed under elevated pressure conditions up to 5 atm are reported. This is a continuous work emanating from a series of experiments designed to measure quantitatively values of MIE of turbulent premixed combustion from a large fan-stirred 3D cruciform explosion facility capable of generating intense isotropic turbulence over a very wide range of turbulent intensities (u'/S_L) up to 100, where S_L is the laminar burning velocity. MIE is a probabilistic variable (not a threshold value) for a given combustible mixture that can be only determined statistically by repeating many ignition experiments under the same experimental conditions. In the past, several different ignition probabilities, such as 1%, 10%, 50%, and 80% ignition probabilities, have been proposed to determine the statistical value of MIE. Among them, the 50% successful ignitability was the most commonly used one. The selection of 50% ignitability to define MIE is simply due to the nature of statistics. In some situations like in dangerous powder factories and storages, MIE information using 1% or 10% ignitability is more valuable than that using 50% or 80% ignitability. This paper presents two recent statistical methods, a midpoint approximation method and a logistic regression method, for MIE measurements. All MIE = $E_{ig(50\%)}$ data reported are measured statistically using 50% ignitability. Previously, we have reported a complete turbulent MIE data set for methane-air mixtures at 1 atm for six different equivalence ratios (ϕ = 0.6, 07, 0.8, 1.0, 1.2, 1.3) via conventional spark ignition. We found a turbulent ignition transition across which the increase of MIE with u'/S_L changes drastically from linear to exponential at some critical values of u'/S_L depending on ϕ [see CNF 157 (2010) 341-350]. MIE data of lean methane/air mixtures measured at 3 atm and at ϕ = 07 were also reported [see CNF 160 (2013) 1755-1766], showing similar turbulent ignition transition. In this work we present a physical model based on a reaction zone Péclet number with the pressure correction to explain these MIE results at normal and elevated pressures up to 5 atm.

Keyword: High pressure turbulent ignition, minimum ignition energy, ignition transition, reaction zone Péclet number, thin and broken reaction zones

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