Project Title: Development of a Gas and Dust Explosion Model

Organization: West Virginia University Research Corporation

Partnership: Worcester Polytechnic Institute

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Focus Area: Safety

SYNOPSIS

Problem Statement and Justification: Modern coal-mining machinery has significantly increased the portion of small-size coal dust collected in intake/return airways and the particle size provides a substantial impact in accidental gas and dust explosions representing a hazard to both personnel and equipment in coal mining industry. The modern knowledgebase about dust explosions does not provide an acceptable level of risk and therefore should be addressed, from a fundamental viewpoint. Consequently, a computational model capable of quantifying the probability and associated hazards of spontaneous ignition, deflagration as well as the likelihood of a deflagration-to-detonation transition (DDT) event is highly needed. The present project is a conceptual initiative step towards such a model.

Impact of Research: The primary goal of this project is the developing of a computational platform for modeling gas and dust explosions in applications of a serious hazard to life and property such as coal mines. The study is unique since the physical understanding of the controlling mechanisms associated with particle-air flames have not been explored in depth. The platform will be based on a robust CFD code solving fully compressible hydrodynamics and combustion equations in a turbulent environment. It is noted that the majority of CFD models for turbulent combustion and explosion utilize empirical correlations between the laminar and turbulent burning velocities, and the parameters describing the turbulent flow. Consequently, these models are linked to particular configurations and therefore require an experimental quantification of the phenomenological coefficients in each particular case. In contrast, the present research incorporate a turbulent flame speed model that is analytically developed from the first principles and should therefore work everywhere within its validity domain.

Objectives and Research Approach: We shall develop a computational platform to analyze combustion hydrodynamics and incorporate the capability of modeling of laminar and turbulent burning velocities including the consideration of dust particles. The model will account for such a state-of the art effects of turbulent combustion as flame-flow feedback, burning along the turbulent vortex axes, and turbulence-instability coupling. To complement the numerical modeling, we shall construct an experimental platform to validate the input parameters for the modeling efforts. Specifically, extensive experimental data of laminar and turbulent burning velocity for gaseous and particle-air flames as a function of particle type, size, concentration, turbulent intensity and length scale will be generated during this study. Consequently, in this project we shall bridge the gap between the turbulent flame formulations, based on the empirical considerations, and that obtained from the fundamental principles of combustion