ABSTRACT

The dust explosion is a process of combustion of the fine dust particle with rapid rate. In this process of combustion, system pressure increases several times then the operating pressure (initial pressure). This process mainly depends on the material of dust particle and size of the dust. Combustible dust not only include coal or wood but many other materials that we use daily like plastic, chemical, agricultural product or metal, etc. Many industries are handling and processing such materials which include pharmaceuticals, food processing, agricultural industries, defense, etc. so there is always a risk of dust explosion for industries where operations like transportation, grinding or storage of this particles carried out which increases the probability of dust explosion. Out of this materials, metal contributes higher percentage in the dust explosion and in metal, aluminum is considered as the most explosive metal dust.

For the design of any protective or preventing system, in-depth study of dust explosion process is required. For such purpose, some parameters are used which are related to dust explosion and determined from 20-L spherical explosion apparatus (for estimation of maximum pressure and maximum rate of pressure rise). In addition to experiments, some empirical relations are used for determination of such parameters. But the applicability of such relations is limited because of assumptions and simplicity.

In the present study, Computational Fluid Dynamics (CFD) platform is used to understand the dynamics of dust explosion because it is difficult to understand the physics in experiments as explosion process is completed in fractions of the second. Basic concepts of dust explosion modeling are adopted from premixed gas explosion theory. So as a primary case, it assumed that dust cloud as an effective gas which is the mixture of aluminum, oxygen, nitrogen, and alumina. But as this model is not realist so this model is extended to complex multiphase explosion model. In which two distinct phases present in the system that are dispersed particle phase (fuel) and continuous fluid or carrier phase (air). This model addresses the real explosion test scenario.

The multiphase explosion flow is solved by conservation of mass (species conservation), conservation of energy, and conservation of momentum. All this conservation law are solved simultaneously along with the equation of state.

To simulate multiphase explosion process, the explicit approach of finite difference method is used for discretization, and as a mathematical tool, MATLAB R2017a is used. Simpler cases are considered, to verify the methodology, grid, scheme, discretization used in the model, and the results of the model are compared with the ANSYS Fluent predictions which are used as a reference. The verification plots are showing very-good agreement with the ANSYS Fluent prediction.

The final results show that multiphase model gives better predictions of maximum pressure than the multispecies model on comparing with the experiment result.