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Evaluation of the Boiling Liquid Expanding Vapor Explosion Thermal Effects in Hassi R'Mel Gas Processing Plant Using Fire Dynamics Simulator

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Abstract : During a fire in an oil and gas refinery, several thermal accidents can occur and cause serious damage to people and environment. Among these accidents, the BLEVE (Boiling Liquid Expanding Vapor Explosion) is most observed and remains a major concern for risk decision-makers. It corresponds to a violent vaporization of explosive nature following the rupture of a vessel containing a liquid at a temperature significantly higher than its normal boiling point at atmospheric pressure. Their effects on the environment generally appear in three ways: blast overpressure, radiation from the fireball if the liquid involved is flammable and fragment hazards. In order to estimate the potential damage that would be caused by such an explosion, risk decision-makers often use quantitative risk analysis (QRA). This analysis is a rigorous and advanced approach that requires a reliable data in order to obtain a good estimate and control of risks. However, in most cases, the data used in QRA are obtained from the empirical correlations. These empirical correlations generally overestimate BLEVE effects because they are based on simplifications and do not take into account real parameters like the geometry effect. Considering that these risk analyses are based on an assessment of BLEVE effects on human life and plant equipment, more precise and reliable data should be provided. From this point of view, the CFD modeling of BLEVE effects appears as a solution to the empirical law limitations. In this context, the main objective is to develop a numerical tool in order to predict BLEVE thermal effects using the CFD code FDS version 6. Simulations are carried out with a mesh size of 1 m. The fireball source is modeled as a vertical release of hot fuel in a short time. The modeling of fireball dynamics is based on a single step combustion using an EDC model coupled with the default LES turbulence model. Fireball characteristics (diameter, height, heat flux and lifetime) issued from the large scale BAM experiment are used to demonstrate the ability of FDS to simulate the various steps of the BLEVE phenomenon from ignition up to total burnout. The influence of release parameters such as the injection rate and the radiative fraction on the fireball heat flux is also presented. Predictions are very encouraging and show good agreement in comparison with BAM experiment data. In addition, a numerical study is carried out on an operational propane accumulator in an Algerian gas processing plant of SONATRACH company located in the Hassi R’Mel Gas Field (the largest gas field in Algeria).

Keywords : BLEVE effects, CFD, FDS, fireball, LES, QRA
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