Validation of FLACS-Fire for large scale fires of natural gas/hydrogen mixtures

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A release of a combustible gas into the surrounding may get ignited. The outcome after the ignition depends on the type of fuel, amount, mixing with surrounding air, degree of congestion and confinement, and time of ignition. The worst-case scenario is a major explosion, but fire is a more probable scenario than explosion. Heat loads arising from the fire are a crucial design parameter for determining safe distances and required thermal protection for equipment and structures in the vicinity. The characteristics of the flame (shape, height, inclination due to the wind) and combustion properties have direct influence on the heat loads and temperature field around the flame. Radiative heat including the influence of adjacent geometries is the primary heat transmission mechanism away from the flame. Accurate prediction of all of these phenomena is therefore required for design.

FLACS is currently a leading CFD-tool for gas explosion modelling, dispersion and fire. In FLACS-Fire, turbulence is modelled using the standard k-ε model and the eddy dissipation concept (EDC) is used as the combustion model. The soot is handled with a formation-oxidation model (FOX). The discrete transfer radiation model (DTM) together with the weighted sum of gray gas (WSGGM) model for near field and multi-point source model for far-field region is used to model radiative heat transfer. Radiation calculations are coupled with the transient simulations of fluid flow and heat transfer.

The objective of this work is to validate the CFD-tool FLACS-Fire for large scale fires of natural gas/hydrogen mixtures and to demonstrate the capability of the tool for use in quantitative risk assessment studies. Two types of fire cases validated are: high pressure jet releases representing punctures in above ground plant and pipework and releases representing the rupture of an underground high pressure pipeline. These represent scenarios pertinent to natural gas infrastructures and have been studied previously for natural gas only releases.

A comparison between FLACS-Fire simulations and experimental data is presented for high pressure jet fires involving natural gas and mixtures of natural gas and hydrogen containing approximately 25% hydrogen. The predicted flame temperature, flame length and incident radiation field are found to be in good agreement with experimental data. Additionally, simulations are performed for pipeline fires. Again, predictions were compared with large scale experimental data.