Improved modelling of hydrogen explosions

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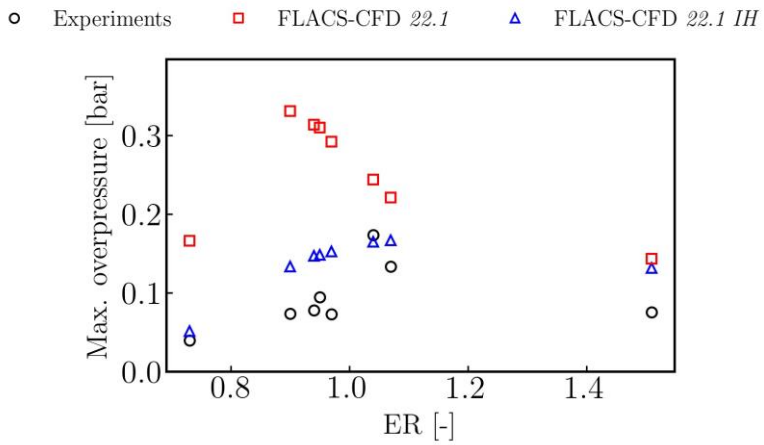
Introduction

The consequence model system FLACS, developed by Gexcon, is based on computational fluid dynamics. The capability of FLACS to represent the consequences of accident scenarios involving hydrogen has been developed as part of several research programs. However, several of these initiatives have also uncovered limitations in the predictive capabilities of the model. For example, the predicted reactivity for a range of concentrations of hydrogen-air mixtures has been found to be overly conservative. A combustion model that alleviates this problem exists in-house in Gexcon, however, this model requires further development to be sufficiently general. Furthermore, the present version of FLACS can only account for the mitigating effect by introducing additional nitrogen to the atmosphere, while it would be highly relevant to also represent the effect of water, CO2, and various types of chemical inhibitors.



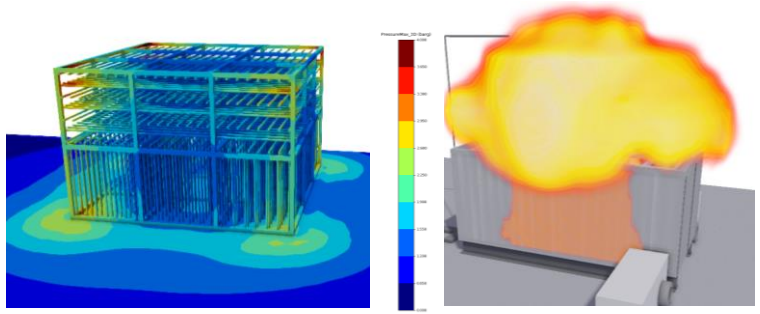
Simulation and experimental results for one experimental campaign testing different hydrogen concentrations. FLACS-CFD 22.1 IH is the version under development.

Primary objective

- To develop a general framework for modelling burning velocities of gas mixtures containing hydrogen in the CFD tool FLACS.

Secondary objectives

- Establish a validation database.
- Develop scripts and establish model evaluation criteria.
- Generate a library of the relevant properties of hydrogen mixtures.
- Demonstrate the practical effect of improved model capabilities for one hypothetical risk assessment study.



Pressure load on surfaces (right). Products fraction (left)

I have been working within gas explosions modelling development and validation for FLACS-CFD software since 2018.

Estimated progress of the PhD project:

Just started ...	< 50 %	> 50 %	Almost done ☺

Publications

- Lucas, M., Hisken, H., Skjold, T., Arntzen, B.J., van Wingerden, Kees, 2023, CFD modelling of hydrogen and hydrogen-methane explosions – Analysis of varying concentration and reduced oxygen atmospheres, Journal of Loss Prevention in the Process Industries, 83 : 105012.
- Lucas, M., Atanga, G., Hisken, H., Mauri, L., Skjold, T., 2021, Simulating vented hydrogen deflagrations: Improved modelling in the CFD tool FLACS-hydrogen, International Journal of Hydrogen Energy, 46(23) : 12464-12473
- Lucas, M., Skjold, T. & Hisken, H., 2020, Computational fluid dynamics simulations of hydrogen releases and vented deflagrations in large enclosures, Journal of Loss Prevention in the Process Industries, 63 : 103999.

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