GERG's 10th Young Researcher Awards

Acceleration of gaseous hydrocarbon/hydrogen premixed flames in industrial pipelines

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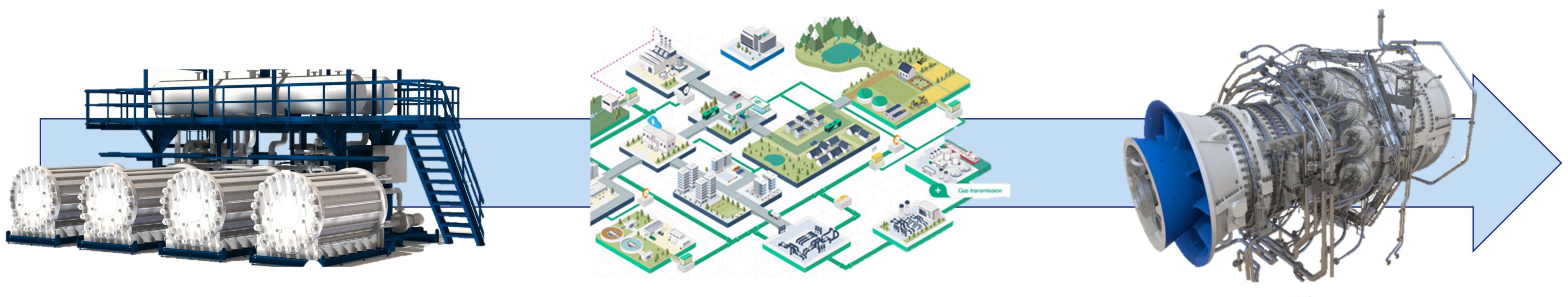
Context

- Increasing hydrogen use in gas industry (pure H_2, or blended with natural gas), through the entire value chain.



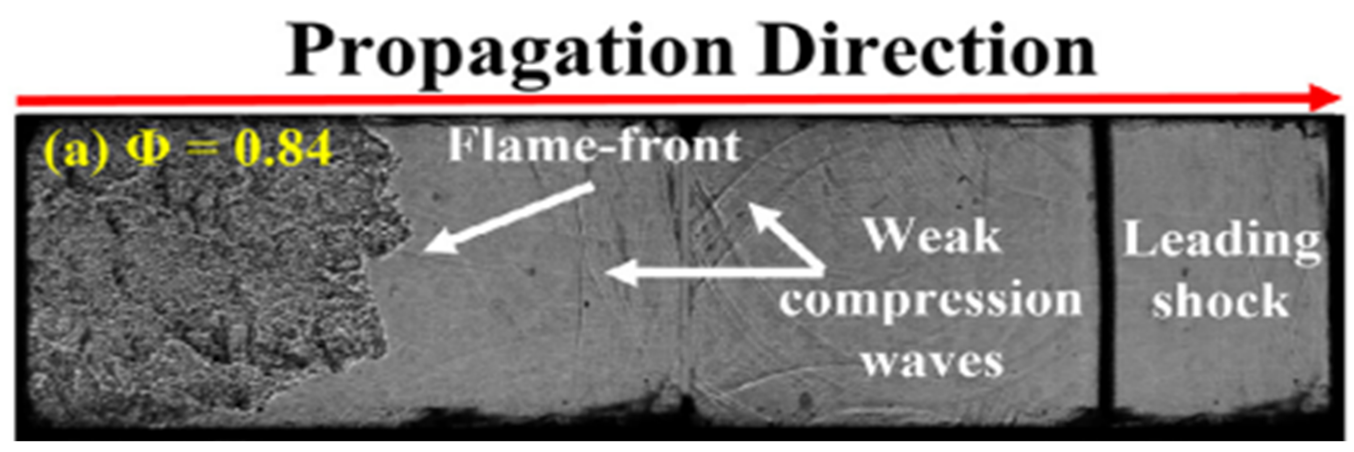
➔ **ATEX formation scenarios identified:**
- Hydrogen's flammable domain is larger than methane's [1];
- Hydrogen's laminar flame speed is 10 times higher than methane's [2].

➔ **Requires comprehensive scientific study for new safety criterion establishment.**

This PhD studies the flame acceleration in pipes to determine the **distance for deflagration to detonation transition**, and the **generated pressure field** for mechanical constraint assessment.

Phenomenology

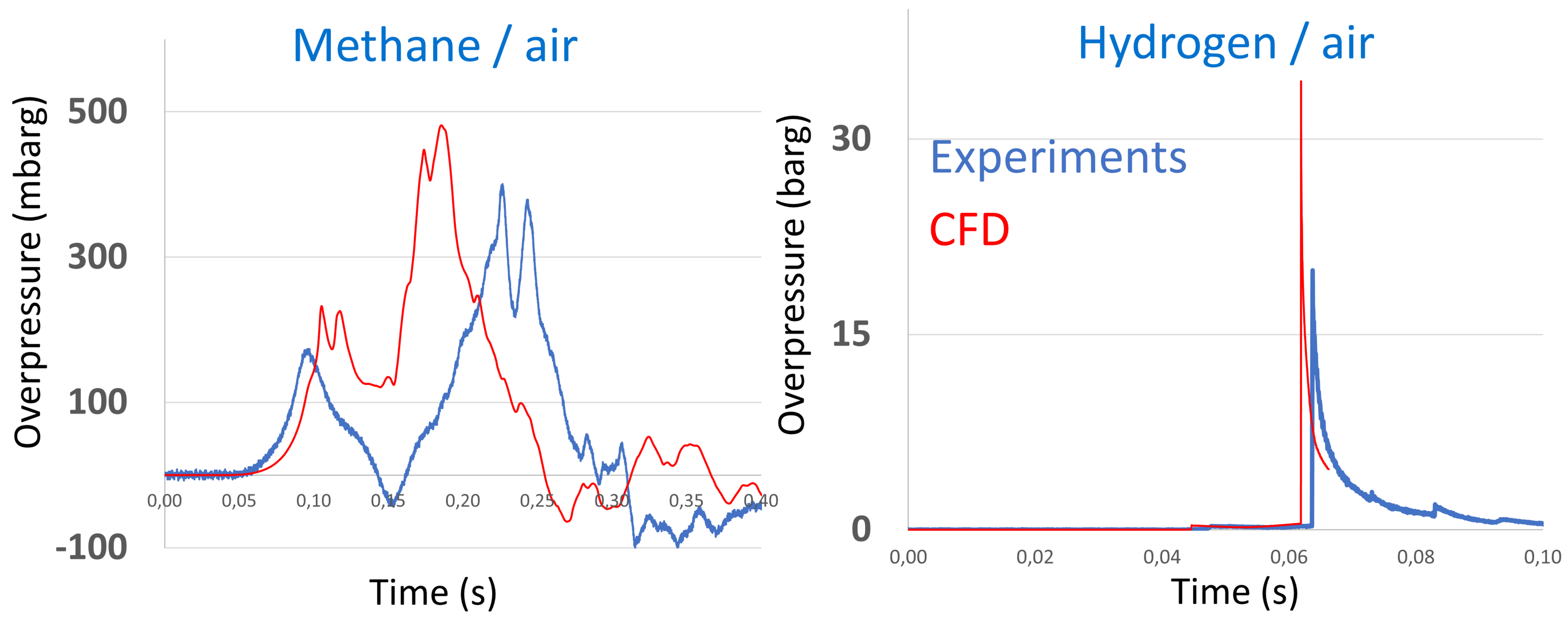
- Flame propagation in pipes is subject to a strong acceleration due to interaction with walls, and acoustic instabilities [3].
- The faster the flame propagates the higher the pressure peak is.



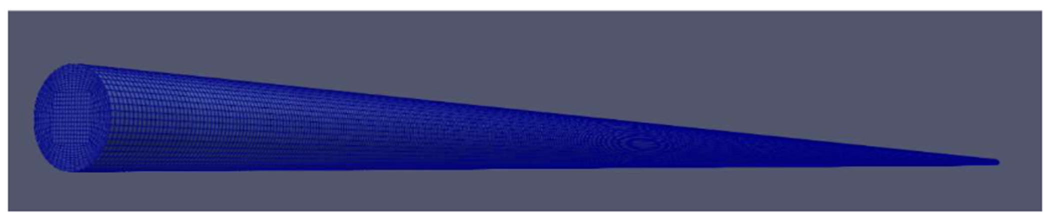
Hydrogen-air flame and pressure wave propagation [4]

Numerical model for overpressure prediction

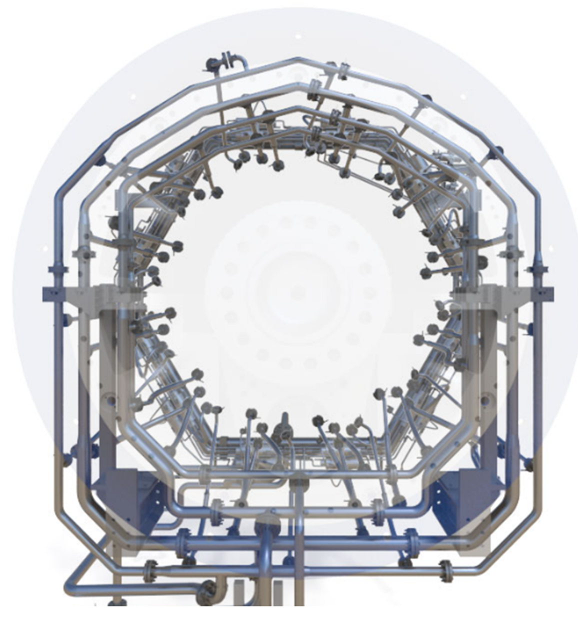
Existing model developped by the INERIS on OpenFOAM (CFD).



Comparison between modeled and measured pressure [5]


Computational meshed tube for model calculation [5]

- Recovers hydrogen/air and methane/air explosions features under **atmospheric conditions** for a **straight open tube**.


Gas turbine's manifold real configuration

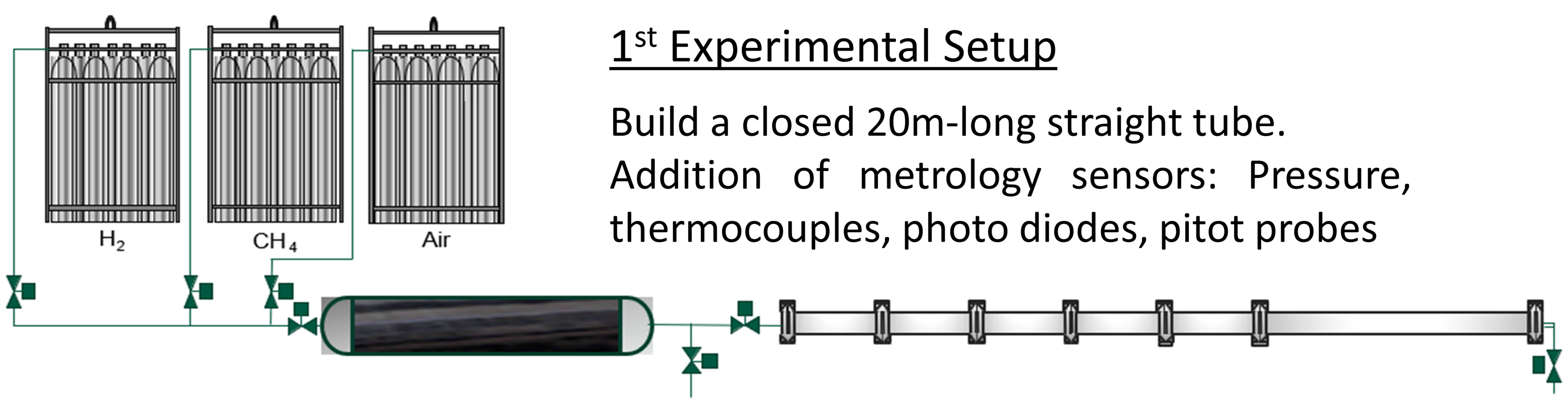
➔ **This existing model needs to be improved to meet industrial configurations:** high P high T, and complex geometry.

Experimental campaign for model adjustment

Scientific literature shows an important lack of data under the conditions of interest.

1. First experimental campaign with parametric study for:
   - **Influence of thermodynamics:** initial temperature and pressure
   - **Gas composition:** hydrogen / methane / carbon monoxide / oxygen / inerts

➔ **Prediction tool improvement**



1st Experimental Setup

Build a closed 20m-long straight tube.
Addition of metrology sensors: Pressure, thermocouples, photo diodes, pitot probes

2. Second experimental campaign will be carried for the study of **geometry** (diameter, length…) **and singularities** (bends, T shaped junctions…), with another setup.

➔ **Prediction tool final validation**

References

[1] R. Bounaceur & al, Prediction of flammability limits of gas mixtures containing inert gases under variable temperature and pressure conditions, Proceedings of ASME Turbo Expo, 2017
[2] J. Daubech, Les explosions non confinées de gaz et de vapeurs - Ω UVCE, INERIS report, 2015
[3] G.H. Markstein, Non-steady flame propagation, Pergamon Press, Oxford, U.K, 1964
[4] H.M. Chin & al, The evolution of pressure gain in turbulent fast flames, Combustion and Flame 234, 2021
[5] G. Lecocq & al, Experimental ad numerical study of the fuel effect on flame propagation in long open tubes, 14th ISHPMIE, 2022