Research project

Name and Surname: Elia Distaso

Title: Auto-ignition centres and combustion propagation regimes in hydrogen systems

Description:

<u>Application context</u>
The increasing interest in hydrogen exploitation has heightened safety concerns related to its production, transport, storage, and utilisation. Combustion systems often operate under conditions in which the reactive medium exhibits spatial and temporal non-uniformities in temperature and composition. For instance, internal combustion engines — whose future viability may depend on advances in hydrogen-based technologies — face significant challenges arising from the cyclic formation of zones with uneven preheating and non-uniform premixing. Likewise, in rocket engines and air-breathing propulsion systems, both the temperature and the composition of the reactants vary progressively along the combustion zone. Furthermore, in the event of a hydrogen leak or in emergency situations triggered by the operation of potential venting elements, zones may form in which the mixture components are unevenly distributed and preheated.

<u>Motivation</u>
Undesired inhomogeneities, once formed, constitute potential centres for the initiation of uncontrolled combustion events, as they create gradients in the auto-ignition delay time within the system. Various combustion modes may arise from these auto-ignition centres, including thermal explosions, supersonic auto-ignition propagation, detonation development, subsonic auto-ignition propagation, and laminar deflagration. Despite their significance, traditional analyses of energy conversion processes in technical devices often overlook these factors. Recently, considerable attention has been focused on applying this concept to real physical systems. A practical example is represented by the ongoing study of charge modifications in hydrogen-fuelled internal combustion engines. Among the possible causes, lubricant oil contamination is receiving increasing attention as a primary factor behind abnormal combustion modes, which currently hinder the development of this promising technology. Preliminary results have been achieved at the Polytechnic of Bari, also through the development of a dedicated chemical model—the so-called “HyLube” reaction mechanism—used to assess alterations in charge reactivity.

<u>Research objectives</u>
Successful candidates will collaborate in performing detailed investigations focused on different aspects of the topic, including: identifying potential sources of centres for spontaneous energy release and assessing the magnitude of gradients in the auto-ignition delay time of the reactive medium; analysing the propagation and quenching of spontaneous combustion modes originating from these centres; determining critical conditions for transitions between different combustion modes. The study will rely on one- and multi-dimensional computational fluid dynamics models, coupled with detailed, specifically developed chemical mechanisms. The outcomes will contribute to the advancement of more general classification theories and methodologies.

Candidates should provide detailed CV

Contacts

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