europass

Francesco D'Alessio

POSIZIONE PER LA QUALE SI CONCORRE

COLLABORATORE AD ATTIVITA' DI RICERCA CAT. B TIPOLOGIA I

Simulazione numerica diretta e a fedeltà variabile di fiamme ad idrogeno e ammoniaca tramite l'utilizzo di

infrastrutture HPC. Analisi dei dataset generati tramite le simulazioni con tecniche di tipo data-driven e sviluppo di

tool basti sul machine learning per simulazioni di larga scala con interesse pratico.

ESPERIENZA LAVORATIVA

[01/06/2024 – 31/10/2024]

Contractor Ph.D Student as CFD Methodologist

Baker Hughes

Città: Firenze | **Paese:** Italia

Sviluppo di modelli avanzati per l'interazione tra turbolenza e cinetica chimica in presenza di instabilità intrinseche di fiamma (IFIs) in miscele Idrogeno/Aria e Idrogeno/Ammoniaca/Aria

ISTRUZIONE E FORMAZIONE

[01/01/2022 – Attuale]

Ph.D. in Ingegneria Aeronautica e Spaziale

"La Sapienza" - Università di Roma

Città: Roma | **Paese:** Italia | **Campi di studio:** Combustione | **Livello EQF:** Livello 8 EQF

Sviluppo di modelli avanzati di combustione per l'utilizzo di vettori energetici "green" in turbine a gas: modelli di cinetica chimica e di fluidodinamica computazionale.

[29/10/2021]

Laurea Magistrale in Ingegneria Spaziale e Astronautica

"La Sapienza" - Università di Roma

Città: Roma | **Paese:** Italia | | **Voto finale:** 98/110 | **Livello EQF:** Livello 7 EQF | **Tesi:** Direct numerical simulation of hydrogen-enriched premixed flames

[23/03/2018]

Laurea Triennale in Ingegneria Aerospaziale

Università degli studi di Napoli - Federico II

Città: Napoli | **Paese:** Italia | | **Voto finale:** 101/110 | **Livello EQF:** Livello 6 EQF | **Tesi:** Kinect Multi-Camera Control Procedures for Autonomous Navigation Applications.

COMPETENZE LINGUISTICHE

Lingua madre: italiano

Altre lingue:

Inglese

ASCOLTO C1 **LETTURA** C1 **SCRITTURA** B2

PRODUZIONE ORALE C1 **INTERAZIONE ORALE** C1

Livelli: A1 e A2: Livello elementare B1 e B2: Livello intermedio C1 e C2: Livello avanzato

COMPETENZE COMUNICATIVE E INTERPERSONALI

Presentazione Pubblica

Buone capacità di presentare lavori di interesse scientifico ad un pubblico eterogeneo acquisita durante le conferenze a cui ho partecipato durante il periodo di Dottorato.

Scrittura scientifica

Capacità di scrivere in maniera accurata letteratura scientifica e report tecnici acquisita durante il mio periodo di Dottorato e durante il periodo di stage aziendale presso Baker Huges

COMPETENZE PROFESSIONALI

Competenze professionali aggiuntive

- Conoscenza avanzata dei processi di combustione, specialmente quelli relativi alle miscele di combustibili a idrogeno e ammoniaca Esperienza in Dinamica dei Fluidi Computazionale (CFD), incluse le Simulazioni Numeriche Dirette (DNS).
- Esperto nell'utilizzo di Nek5000.
- Abilità nell'analisi avanzata dei dati e nelle tecniche di post-elaborazione.
- Esperienza nelle tecniche di machine learning.
- Esperienza nella programmazione parallela e nei sistemi HPC.
- Esperienza nella programmazione Python, C, Matlab e Fortran77.
- Utente Linux con abilità nello scripting bash.
- Familiarità con i programmi CAD.
- Controllo delle versioni con Git.

COMPETENZE DIGITALI

Le mie competenze digitali

Competenze di base

Comunicazione e collaborazione | Creazione di contenuti digitali | Sicurezza | Alfabetizzazione informatica e digitale | Risoluzione dei problemi

Competenze avanzate

Linguaggi di Programmazione: C/C++, Python, Fortran77, bashscripting | - Elaborazione delle informazioni; | LaTex | machine learning | Linux

PUBBLICAZIONI

[2024] **Intrinsic instability of lean hydrogen/ammonia premixed flames: Influence of Soret effect and pressure.**

Riferimento: D'Alessio, F., Matteucci, C., Lapenna, P. E., & Creta, F. , Fuel Communications, 19, 100110.

The addition of hydrogen in ammonia/air mixtures can lead to the onset of intrinsic flame instabilities at conditions of technical relevance. The length and time scales of intrinsic instabilities can be estimated by means of linear stability analysis of planar premixed flames by evaluating the dispersion relation. In this work, we perform such linear stability analysis for hydrogen-enriched ammonia/air flames (50%H2-50%NH3 by volume) using direct numerical simulation with a detailed chemical kinetic mechanism. The impact of pressure and the inclusion of the Soret effect in the governing equations is assessed by comparing the resulting dispersion relation at atmospheric pressure and 10 atm. Our data indicate that both pressure and the Soret effects promote the onset of intrinsic instabilities. Comparisons with available numerical literature data as well as theoretical models are also discussed.

[2024] **Intrinsically unstable hydrogen-enriched premixed ammonia flames: Analysis and modeling of NO formation**

Riferimento: D'Alessio, F., Lapenna, P. E., Bottari, S., & Creta, F., PROCI, 40(1–4), 105485.

Enriching a lean ammonia/air mixture with hydrogen can increase the reactivity of pure ammonia flames. However, this may lead to the onset of intrinsic flame instabilities, which in turn affect flame characteristics such as heat release rates, morphology, propagation and pollutant formation. In this study, we examine the propagation characteristics and NO production in lean premixed hydrogen-enriched ammonia/air flames (50% H2%–50% NH3 by volume) using direct numerical simulations with a detailed chemical kinetic mechanism. The individual effects of pressure and thermodiffusion (Soret effect) are assessed by comparing results with an atmospheric pressure flame. Statistics on the rate of NO production are presented and analyzed. NO production is decomposed into its main production/depletion pathways (thermal, HNO, DeNOx, isomerization and fuel), revealing that NO production is promoted, mainly through the fuel pathway, due to the presence of superadiabatic cells, typical of thermo-diffusively unstable flames. At atmospheric pressure, the Soret effect is observed to play only a marginal role in NO production. To further understand NO production, the NO rate is split into two contributions, respectively due to area increase and change in flame reactivity. At high pressure, while NO production is overall mitigated compared to the atmospheric pressure flame, the wrinkled flame is found to produce more NO than its one-dimensional counterpart. A data-driven approach is finally used to address the issue of flame structure dimensionality of hydrogen-enriched ammonia flames. An irreducible error analysis reveals that at least three progress variables are required to correctly reconstruct the flame structure.

[2023] **Turbulent flame speed of thermodiffusively unstable flames: experimental investigation and scaling.**

Riferimento: Troiani, G., Lapenna, P. E., D'Alessio, F., & Creta, F.

This work presents an experimental set of Bunsen flames characterized by a moderate Reynolds number and a variable turbulence intensity. Ten lean hydrogen-enriched methane-air mixtures at three levels of turbulence are investigated, ranging from pure methane-air to pure hydrogen-air. Such mixtures are selected in order to have an almost constant laminar flame speed while inducing the onset of thermal-diffusive (TD) instability by gradually increasing the hydrogen content of the blend. The flames are analyzed in terms of global consumption speed, stretch factor, and flame surface area. Results indicate an interplay between TD instability and turbulence that enhances the overall flame propagation. In particular, below a transitional Lewis number, flame propagation is observed to be particularly sensitive to external turbulent forcing, expressed in terms of the Karlovitz number. A parameterization is thus proposed, based on a functional form depending on both Karlovitz and Lewis numbers, able to fit the experimental results at different turbulence levels and capture the steep transition across the transitional Lewis number.

[2024] **Synergistic interplay of thermodiffusive instability and turbulence in premixed flames.**

Riferimento: Lapenna, P. E., Troiani, G., D'Alessio, F., & Creta, F., PROCI, 40(1–4), 105499.

In this work, we experimentally analyze the interplay of thermo-diffusive (TD) intrinsic flame instabilities and turbulence in premixed flame propagation. We utilize methane/hydrogen/air Bunsen flames at atmospheric pressure and variable hydrogen content, and variable turbulence intensity. Experiments are designed to maintain the laminar unstretched premixed flame speed constant by adjusting the equivalence ratio [illegible] for each flame. As the hydrogen content is increased and [illegible] is decreased, thermo-diffusive intrinsic flame instabilities are gradually promoted. We study the effect of thermo-diffusive instability on the global consumption speed

by analyzing the contribution of flame surface area increase and flame mean reactivity measured via a stretch factor. We observe that the turbulence-instability interplay mainly occurs through an enhancement of flame reactivity and not flame area. In addition, a power spectral density (PSD) analysis of the flame curvature reveals that the spectra of unstable flames are consistently more energetic due to the wider range of linearly unstable scales interacting with the turbulent integral scale. A forced weakly nonlinear numerical model is also utilized to aid in the understanding of the experimental findings. The model exhibits a characteristic unforced PSD, representing the energy content of the typical spatiotemporal chaotic TD-unstable solution. When forced, the model exhibits PSD that emerge from the interplay of the turbulent spectrum and the characteristic TD-unstable spectrum, and, as a result are consistently more energetic than the TD-stable spectra.

[2024] **Modeling Ammonia-Hydrogen-Air Combustion and Emission Characteristics of a Generic Swirl Burner**

Riferimento: Journal of Engineering for Gas Turbines and Power

The combustion process of both pure NH3 and a NH3/H2 fuel blends is here analyzed using two kinetics processors, i.e., Chemkin-Pro-and CANTERA: detailed kinetic mechanisms have been tested and compared in terms of laminar flame speed and ignition delay time (IDT) with the aim to identifying the most suitable ones for the evaluation of NOx emissions. The generic swirl burner being used in Cardiff University's Gas Turbine Research Center has been considered as validation test case. In addition, this paper presents an experimental campaign followed by a computational fluid dynamics (CFD) approach for the assessment of NOx emission using axisymmetric Reynolds-Averaged Navier–Stokes (RANS) simulations, leading to a significant reduction of the computational time. Different pressures and mass flow rates are evaluated to understand correlations of NOx formation for pollutants reduction purpose. A direct comparison between experimental and numerical results is carried out in terms of flow field, flame shape, and NOx emissions. Results show that the increase in pressure from 1.1 bar to 2 bar results in reduction of NOx emissions from 2515 ppmv to 885 ppmv, also indicating guidelines for using a simplified RANS analysis, which leads to improved computational efficiency, allowing wide sensitivity and optimization analysis to support the design development of an industrial combustion system.

PATENTE DI GUIDA

Motocicletta: A

Automobile: B

PROGETTI

E-COST GRANT - CA22151

CYPHER sostiene le collaborazioni tra ricercatori europei e stakeholder industriali per promuovere l'uso dei sistemi cyber-fisici (digital twins auto-aggiornabili) per aiutare la decarbonizzazione.

Link: https://www.cost.eu/actions/CA22151/

Unraveling the Interplay of Intrinsic Flame Instabilities and NOx Generation in NH3/ H2/air Combustion using DNS (INFUSE)

- CINECA Project (Spoke 6)
- 1'200'000 cpu/h

IsB28_NH3-NOx

- 3'600'000 cpu/h awarded

DATI PERSONALI

Dati personali

Autorizzo il trattamento dei miei dati personali ai sensi del Decreto Legislativo 30 giugno 2003, n. 196 "Codice in materia di protezione dei dati personali".

Autorizzo il trattamento dei miei dati personali presenti nel CV ai sensi dell'art. 13 d. lgs. 30 giugno 2003 n. 196 - "Codice in materia di protezione dei dati personali" e dell'art. 13 GDPR 679/16 - "Regolamento europeo sulla protezione dei dati personali".