RECENT DEVELOPMENTS IN COMBUSTION RESEARCH
Webinars 11-14 of the Dutch Section of the Combustion Institute (DSCI)

The Combustion Institute is an educational, non-profit, international and scientific society whose purpose is to promote and disseminate research in combustion science. The aim of the Dutch Section is to assist in accomplishing this broad objective by providing closer and frequent contacts between the members residing in the Netherlands: active at universities, companies, technological institutes, or as independent expert.

Since January 2021 we have added webinars as an efficient way of meeting each other. Starting from the fifth webinar, they have been recorded and can be viewed on YouTube. For more information check our website www.combustioninstitute.nl.

The forthcoming four webinars again show how broad the area of combustion is. We shall hear about **explosion and detonation, design optimisation for hydrogen boilers and plasma-assisted combustion**. Or in other words, we shall learn how the knowledge gained in combustion research can lead to **better safety by better understanding of risks, better design of clean and efficient combustion devices and better control of ignition and flame stability**.

Pre-registration is not required. The webinar is open for attendance by non-members. Please follow instructions of the moderator. After the presentation there is possibility to ask questions or raise discussion points, but this part will not be recorded. Zoom links are given below.

The board: Rob Bastiaans, Jim Kok, Arvind Gangoli Rao, Dirk Roekaerts

PROGRAM

Friday September 23, 2022, 13:00-14:00
Detonation-diffuse interface interactions: failure, re-initiation and propagation limits
By dr. Josué Melguizo Gavilanes
CNRS, PPrime Institute / ENSMA, Poitiers

Join Zoom Meeting: https://tudelft.zoom.us/j/99787008705

Friday October 28, 2022, 13:00-14:00
Automatic design optimization for hydrogen boilers
By dr. ir. Nijso Beishuizen,
Bosch Thermotechniek B.V. and Eindhoven University of Technology

Join Zoom Meeting: https://tudelft.zoom.us/j/92523181485

Friday November 25, 2022, 13:00-14:00
Plasma-assisted combustion: fundamentals
By Ir. Thijs Hazenberg, Eindhoven University of Technology

Join Zoom Meeting: https://tudelft.zoom.us/j/99724605491

Friday December 16, 2022, 13:00-14:00
Plasma-assisted combustion: modeling and simulation
By prof. dr. Bénédicte Cuenot
CERFACS, Toulouse and Eindhoven University of Technology

Join Zoom Meeting: https://tudelft.zoom.us/j/97374353298

The next pages provide abstracts and cv of the speakers.

Friday September 23, 2022, 13:00-14:00

Detonation-diffuse interface interactions: failure, re-initiation and propagation limits

By dr. Josué Melguizo Gavilanes
CNRS, PPrime Institute / ENSMA, Poitiers

CV

Currently a CNRS Chargé de Recherche (HDR) at the P Prime Institute (Poitiers, FRA). I am part of the Fluides, Thermique et Combustion Department - Axe Détonique working on fundamental and applied combustion research including shock-/thermal-ignition, flame acceleration, DDT, detonative propulsion, chemical kinetics, and H2 safety. Previously a Senior Postdoctoral Scholar in Aerospace at Caltech (Pasadena, CA USA). I received my Ph.D in Mech. Engineering from the University of Calgary in Canada in 2012, and worked as a researcher for Royal Dutch Shell (Aug 2012- Dec 2013) in the same city before going to Caltech. While my research experience is primarily in CFD and analytical modeling of reacting flows I am always working very closely with experimentalists.

Abstract: see next page

Detonation-diffuse interface interactions: failure, re-initiation and propagation limits

Josué Melguizo-Gavilanes
Tenured research scientist
Centre National de la Recherche Scientifique (CNRS)
Institut Pprime, Poitiers, FRA

Detonation-interface interactions is relevant to industrial safety where upon accidental leaks/releases, layers of reactive and inert gases may form due to differences in molecular weight of the gases and/or insufficient mixing. The highly non-uniform conditions generated within the combustible cloud, as well as along its boundaries impose limitations on detonation propagation. Particularly, the presence of a diffusion layer at the edge of the cloud has been reported to increase the height of reactive layer required for successful propagation.

Detonation propagation limits in uniform mixtures has been studied extensively, however non-uniform mixtures have received less attention. This is mainly due to the experimental challenges associated with defining critical conditions for the latter. The characterization of the layer thickness at the interface where strong variations in equivalence ratio and dilution exist, as well as the specification of a unique cell width, λ (an important experimental length scale in detonations) is not straightforward; λ is directly correlated to the reactivity of the mixture where smaller λ values are associated to faster reaction rates.

Detonation-interface interactions can be classified by comparing λ with the interface thickness, δ. A sharp interface occurs when $\lambda \gg \delta$ whereas a diffuse interface occurs when $\lambda \ll \delta$ or $\lambda \sim \delta$. In this talk, we will be discussing the dynamics of detonation-diffuse interface interactions using the CLEM-LES[1] methodology (following experiments in which industrially relevant scales are considered) to investigate failure/re-initiation mechanisms and report critical conditions for quenching within gravity-driven diffuse layers.

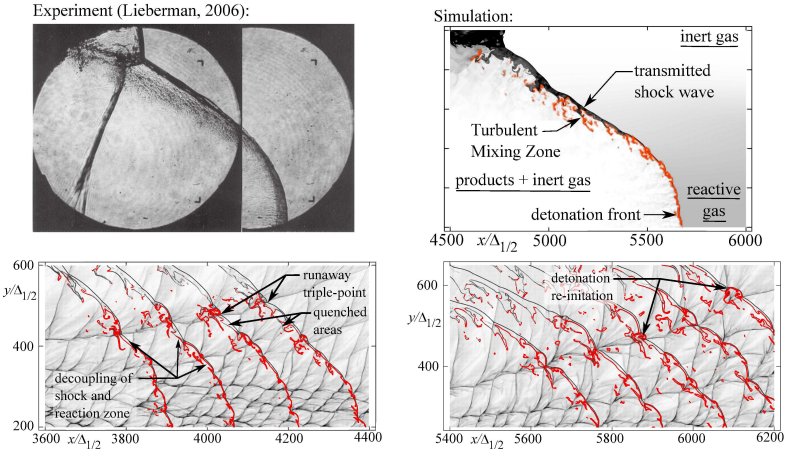

Figure 1: Experimental vs. numerical flow field (top). Schlieren fields superimposed on sootfoils showing quenching and re-initiation dynamics (bottom).

[1] Compressible Linear Eddy Model for Large Eddy Simulation

Friday October 28, 2022, 13:00-14:00

Automatic design optimization for hydrogen boilers

By dr. ir. Nijso Beishuizen,
Bosch Thermotechniek B.V. and Eindhoven University of Technology

ABSTRACT

In the combustion community, a transition from fossil fuels towards hydrogen as a fuel for heating and power can be observed. This transition poses new challenges in the design of appliances in the chemical industry, in transport, heating and power. Often, design requirements are competing with each other and Computational Fluid Dynamics is a necessary (but not always sufficient) tool to come to a final design.
In this presentation, we discuss the challenges in hydrogen combustion for heating appliances and present an automatic design optimization method that can aid in the design process.

CV

Nijso Beishuizen studied aerospace engineering at TU Delft, and then subsequently did a PhD research at applied physics at TU Delft, investigating “PDF modeling and particle turbulence interaction in turbulent spray flames”.
After a post-doc at university of Twente he did a 3-year Marie-Curie exchange program between TU Eindhoven and Numeca Brussels, where he worked on implementing Lagrangian spray models and combustion models in Numeca’s CFD software. He has been working at Bosch Thermotechnology in Deventer now for 10 years, focusing on CFD modeling of flow and combustion problems of domestic and industrial boilers. Since 2020 he is also a part-time assistant professor in the Power and Flow group at Mechanical Engineering at TU Eindhoven,

Friday November 25, 2022, 13:00-14:00

Plasma-assisted combustion: fundamentals

By Ir. Thijs Hazenberg, Eindhoven University of Technology

ABSTRACT

Conventional ignition, via a spark, is achieved by significantly heating the gas. As the temperature is increased, the rates of chemical reactions increase until thermal runaway occurs, i.e., ignition. A spark is a thermal plasma, more specifically, a plasma that achieves high temperatures and is close to thermal equilibrium. In contrast, a cold plasma remains much cooler (room temperature) and can be far from thermal equilibrium. When a cold plasma is used for ignition, the chemistry is directly activated via electrons. Ignition via cold plasma can therefore be more efficient for combustion chemistry activation. In a plasma, electrons are accelerated via a user-applied electric field. Identifying optimal plasma conditions for the activation of combustion chemistry requires a thorough understanding of both plasmas and combustion. In this presentation, I will start by introducing the basics of plasma physics. After which I will introduce plasma chemistry and finally, plasma-assisted combustion is covered. As you will see, the introduction of plasma chemistry to combustion introduces several modeling challenges.

CV

Thijs Hazenberg obtained his master's degree at Eindhoven University of Technology (TU/e) in 2019. As part of the master's program, he did his internship at Rolls-Royce Deutschland, where he worked on the development of fuel injectors for aerospace engines. Afterward, he started his graduation project under the supervision of Jeroen van Oijen. His master thesis is about model development for metal flames. This work was awarded the NVV combustion award and the KNCV Golden Master Award. Directly after graduation, Thijs joined the Power and Flow group as a Doctoral Candidate. In this position, he is now working on model development for plasma-assisted combustion.

Friday December 16, 2022, 13:00-14:00

Plasma-assisted combustion: modeling and simulation

By prof. dr. Bénédicte Cuenot
CERFACS, Toulouse, and Eindhoven University of Technology

ABSTRACT

Plasma-assisted combustion (PAC) has the ability to ignite and maintain a sustainable flame under adverse conditions, i.e., near lean flammability limits or in low pressure and low temperature environments. Applying this attractive technique to the design of future combustion chambers requires understanding the mechanical, thermal and kinetic interactions of the non-equilibrium plasma with the reactive gas mixture, in order to develop adequate models to be integrated into design tools. The focus here is on Nanosecond Repetitively Pulsed (NRP) discharges which have proven effective even with low electrical power.

In this presentation, the modeling and numerical issues related to PAC will first be addressed. This includes the resolution of the electric field, non-equilibrium plasma phenomena and their interaction with the flame. In particular, a detailed chemistry of PAC will be presented and validated against experimental data obtained in simple lab-scale configurations.

The resulting detailed model is very demanding in computing time and the presentation will continue with the description of simplification methodologies. A reduction of the chemical scheme and a phenomenological model will be shown to obtain accurate results at a much lower cost, suitable for application in 3D simulations of combustion chambers.

CV

Dr. HdR Benedicte Cuenot obtained her engineering and master's degree from Ecole Centrale de Paris in 1990. After one year as a research engineer in the University of Boulder (CO, USA), she returned to France, where she defended her Ph.D. in 1995 and HdR in 2000, both in the field of numerical combustion. She is now the leader of the combustion research group at CERFACS, developing advanced and massively parallel software for the numerical simulation (DNS and LES) of turbulent combustion and heat transfer (including thermal radiation) in industrial systems. With these tools, she addresses various topics such as pollutant emissions, ignition and extinction, combustion efficiency or thermal fatigue of combustion chambers. In September 2021, Dr. Cuenot also started as a part-time Professor at the University of Eindhoven, Netherlands.

Dr. Cuenot teaches combustion and fluid mechanics in various universities and has authored more than 100 peer-reviewed journal papers. She has participated in many collaborative projects at the national and international levels. In addition, she is much experienced in coordinating European projects, financed mainly by the European Commission, where she also acts as an expert evaluator. She has been distinguished as a Fellow of the Combustion Institute in 2018, a member of the Editorial Board of Combustion and Flame since 2018 and a Program Co-chair of the 39th International Symposium on Combustion held in Vancouver, July 2022.

Source: https://coec-project.eu/news/interview-with-coec-women-in-science-benedicte-cuenot/