Helmholtz - OCPC - Programme 2017-2021
for the Involvement of Postdocs in Bilateral Collaboration Projects with China

PART A

Title of the project: Theoretical Study of History Effect on Flame Stabilization near Ignition limit

Helmholtz Centre and institute: Karlsruhe Institute of Technology (KIT), Engler-Bunte-Institute/Division for Combustion Technology (EBI-VBT)

Project leader: Prof. Dr. Dimosthenis Trimis, Dr. Feichi Zhang

Web-address: http://vbt.ebi.kit.edu/index.pl/en/Haupt_Menu_Institut_M01/html/uebersicht.html

Description of the project (max. 1 page)**:**
The world energy consumption is continuously increased in past and will strongly increase in the future. In this context, combustion remains the most important process for the conversion of either renewable or fossil fuels to useful energy. To improve efficiency and to reduce pollutant emission, advanced combustion technologies for industrial applications tend to be operated near fuel-lean ignition limit and under highly turbulent conditions. This result in a significantly increased risk that the flame may become unstable or even extinguished during the combustion (lean blowout). The effect of flame stabilization is controlled by a balancing process between underlying turbulent flow stretch and flame's intrinsic dynamics, which interact with each other over a wide range of length and time scales. Previous experimental and numerical studies on the flame-turbulence interaction, which represents the main mechanism for flame stabilization, are mostly restricted to single snapshot or time mean flame structures, which neglect the effect of time history of the unsteady flow. In this case, a relaxation time depending on the chemo-thermal characteristics of the ignitable mixture is required for the flame to be able to respond to the unsteady flow stretch. This issue is of particular importance for flame stabilization near ignition limit, because the flame may turn around suddenly from burnt to unburnt or vice versa, depending on the flow condition.

Until now, the time history effect of flow stretch on flame stabilization is still not well understood and there is no reliable computational tools for modelling it. Objective of this project is therefore to study theoretically the effect of flame stabilization and to derive a correlation of flame dynamics in dependence of unsteadiness of the flow, which should

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be suited for practical applications near the lean ignition limit. For that purpose, quasi-direct numerical simulations (q-DNS) will be performed for an academic plane-jet flame configuration, using detailed chemical reaction kinetics and transport models. The computational grid has a resolution of 20 – 40 µm, which is sufficiently fine to resolve the smallest length scale of the reacting flow. Preliminary works using this setup have shown that the oscillating amplitude of flame surface decreases in high frequency range and is dependent on the mixture stoichiometry, indicating the importance of flow unsteadiness on the flame stabilization and the applicability of the proposed flame setup for studying flame response to unsteady flow.

For the current project, q-DNS will be applied to a series of fuel/air mixtures near lean ignition limit with large time-mean flow stretch, at which the flames would extinguish in steady state case. By increasing the excitation frequency of the inflow, it is expected that the flame will re-ignite and re-attach to the inlet plane, leading to a stable flame. The behaviour of flame stabilization with varying turnover time of the flow will be recast to an analytical sub-model considering the influence of time history of turbulent flow on the local and global burning velocity. The model will be applied to well-documented experimental flame cases from literature, utilizing subordinate numerical tool such as the large eddy simulation (LES) technique on relatively coarse computational mesh. Parameters of the new models may be adjusted based on comparison of the simulation results with corresponding experiment, so that the model can straightforwardly be adopted for computer-assisted design of future industrial combustion systems.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**
The institute EBI-VBT at KIT has already hosted a number of guest researchers from different institutes in China, among them the Peking University, Jiangsu University and Changzhou University. The guest scientists have received financial support from the Chinese Scholarship Council (CSC) or the internship grant from KIT (KHYS) and helped in working on our on-going projects. In 2015, Prof. Bockhorn (former head of institute) and Dr. Zhang were invited to visit several universities in the Jiangsu province in China for two weeks, there we presented research activities of our institute and discussed for possible collaboration. Prof. Trimis and Prof. Bockhorn are further involved in the collaborative project “Introducing Intelligence and Innovation base for Protection and Utilization of Underground Coal Fire” funded by the State Administration of Foreign Experts Affairs in China.
In framework of the Helmholtz - OCPC - Program, we would pursue cooperation with high-level groups from China in the research field of energy or combustion science, for instance, the Peking University or the Shanghai Jiao Tong University in China.

Required qualification of the post-doc:

- PhD in Mechanical, Chemical or Process Engineering
- Experience with Numerical Simulation of Turbulent Reactive Flow
- Additional skills in programing language C++, script language Python, operation system Linux, CFD code OpenFOAM, CAD programs, mesh generation tools like ICEMCFD

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PART B

Documents to be provided by the post-doc, necessary for an application to OCPC via a postdoc-station in China, which is affiliated to a research institution like a university:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation
- Proof of command of English language

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team

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