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ADMISSION TO PHD STUDIES FOR THE YEAR 2021

DOCTORAL RESEARCH TOPIC:

Numerical investigation of premixed flame-turbulence interaction

RESEARCH FIELD:

Energetics and Power Engineering (T 006)

BRIEF DESCRIPTION OF RESEARCH TOPIC:

Premixed mixture flame propagation and turbulence are two unresolved problems of great relevance in science and engineering. Studies of turbulent premixed combustion combine them into a multidisciplinary research area with a number of unanswered questions and widely varied phenomenology.

Interaction between the flame and turbulence is as much important in turbulent premixed combustion research as both of these phenomena themselves. One the principal issues being solved at present is the premixed turbulent flame propagation velocity, which mainly depends on the flame-turbulence interaction. However, this interaction is important not only as an object of scientific inquiry. Turbulent premixed flame propagation velocity determines evolution of the whole premixed combustion process in the practical applications, be they exploiting combustion as technical process (engines, combustion turbines), or be they threatened by the combustion as safety issue, where flame acceleration poses the risk of explosion (fission and fusion power plants).

Multidisciplinarity of the area stems from the chemical, physical and engineering phenomena occurring during the flame-turbulence interaction. Even when considering simplified cases, e.g., interaction between the laminar flame and a vortex pair, it can be studied as a problem of chemical kinetics, thermodynamics, molecular mass transfer, fluid dynamics or any combination of these. As a result, it is possible for the research area to formulate both multidisciplinary topics and those more limited to a certain aspect of flame-turbulence interaction.

Flame-turbulence interaction is challenging due to a number of reasons, including:

- it is bidirectional and diverse – can be self-accelerating, self-suppressing or self-stabilizing
- turbulence is manifested at a range of scales, from large-scale eddies to Kolmogorov scale, and different size structures may physically impact flame in different ways, which are not yet fully understood
- different intensities of turbulence may have different effect on flame, from greatly accelerating to partially or fully quenching
- turbulent combustion is classified into different regimes to account for varied flame-turbulence interactions, however, regime boundaries are rather qualitative, due to a limited fundamental understanding of corresponding physics
- flame can create turbulence in front of itself and create non-linear feedback loop, resulting in fast acceleration or even detonation

The aim of the PhD thesis in this research area would be to numerically investigate selected aspects of flame-turbulence interaction, e.g.:

- relationship between the flame-turbulence interaction and flame propagation velocity
- influence of turbulence on flame dynamics and morphology and vice versa
- turbulent coherent structures generated by the premixed flame propagation and their impact on the flame
- influence of different mixture properties and conditions on the combustion process

The simulation of combustion process for the PhD research would be performed using the state-of-the-art turbulent premixed combustion solver flameFoam, possibly improving it according to the actual research needs.

Results of the thesis would be new physical and phenomenological knowledge about the flame-turbulence interaction, as well as improvements of combustion simulation relevant for practical applications.

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