# Case Study Template

**Please complete 3 short case studies (max. 2 pages each). These case studies can be updates of the ones submitted as part of the review in February 2015 or new case studies that have been developed in the current reporting period.**

**1. Title of Case Study:** Large Eddy Simulation of the dual-swirler DLR gas turbine combustor

**2. Grant Reference Number:** EP/K025791/1

**3. One sentence summary:** Partially premixed combustion modelling for LES is used to simulate combustion inside a model gas turbine combustor

**4. One paragraph summary:**

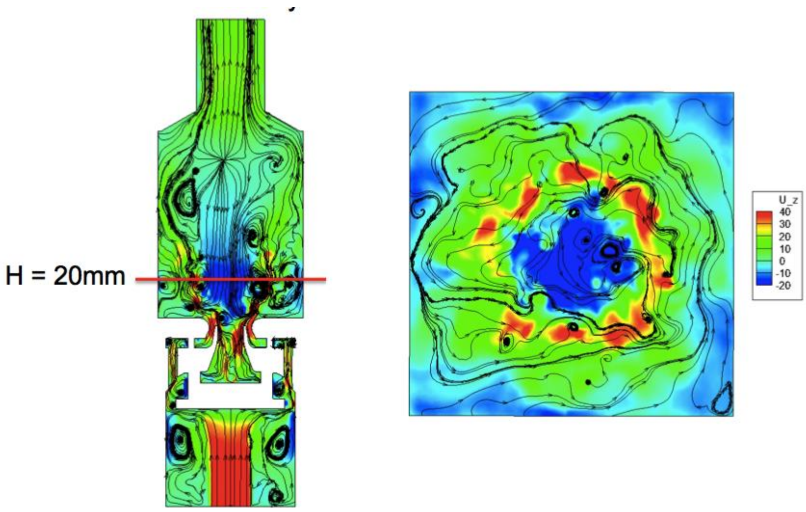
A sub-grid model for partially premixed combustion involving both premixed and non-premixed contribution is used for a gas turbine burner configuration with dual swirler. The objective of this study is to test this model's efficacy to capture turbulent combustion inside a gas turbine combustor with complex geometry and flow conditions. The individual effects and contributions of premixed and non-premixed combustion modes are also of interest.

**5. Key outputs in bullet points:**

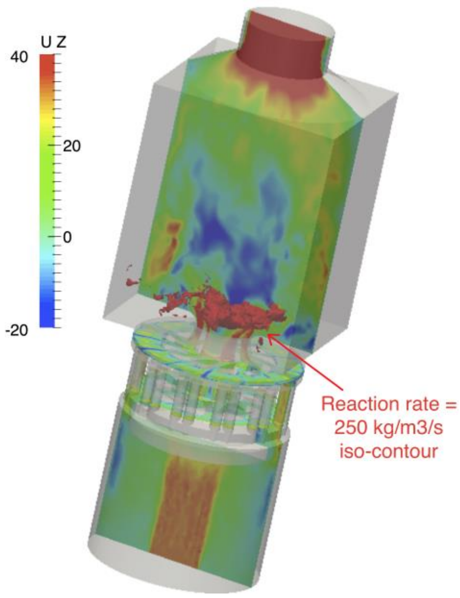
- A validated sub-grid model for LES of partially premixed combustion inside a model gas turbine combustor
- A journal paper is being prepared

**6. Main body text:**

There is an increasing interest for computational techniques applied to fluid flow problems aimed to help design gas turbine combustor systems for high efficiency, low emissions and maintenance cost. The complexities of geometry, flow, thermo-chemical processes and interaction of these factors limit the use of LES for gas turbine combustors. This is also compounded further by the interaction of acoustics generated by the flame with the geometry and the flame itself. Capturing these processes accurately requires robust, reliable and accurate combustion models and the geometry. These factors pose considerable challenges for LES of combustion at elevated pressures. This project aims to alleviate some of these challenges by developing a robust and reliable sub-grid scale combustion model for partially premixed combustion. In most gas turbine burners, the flame is not attached to the injection nozzle but lifted by a lift-off height. The swirling flow introduces further complexity and thus a robust model is required to represent these physical processes. Some examples of these flow complexities are shown in the figure below which depicts the computed axial velocity field in the middle plane and a cross-sectional plane at a height of H = 20 mm. As can be seen, the flow field is rather complex with a number of eddies resulting from the flow-path geometry and vortex breakdown in the swirling flow.




The next figure presents a 3D illustration of the combustor along with the middle plane axial velocity and reaction rate iso-surface. It is shown that the main reaction zone is located in the lower region of the inner recirculation zone and there is a small part occurring in the outer recirculation zone close to the exit plane. These kind of detailed insights are important during the design process so that the flame flash-back or flame residing near the metal parts can be avoided in practical combustor. Elaborate analysis and validation are to be performed by comparing the numerical results with experimental measurements at DLR, Germany. These analysis will be reported in a journal paper under preparation and also these validated models is expected to be implemented in Rolls-Royce (RR) in-house CFD (computational Fluid dynamics) code for their use through a project supported by RR and European Commission funding.




**7. Names of key academics and any collaborators:** DLR (The German Aerospace Centre), Stuttgart

**8. Sources of significant sponsorship (if applicable):** Cambridge Common-Wealth Trust and China Scholarship Council

**9. Who should we contact for more information?**

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