High-temperature measurement techniques for the monitoring of gas turbine combustion stability

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Combustion instabilities are critical when operating gas turbine combustion at high energy density levels. Under some conditions, a thermo-acoustic coupling can occur. So-called combustion-driven oscillations (CDO) are remarkable through noise and combustor vibrations. CDO can be triggered at lean conditions, where the combustion is extremely sensitive to the turbulence and mixture fraction fluctuations. CDO can also appear during transients where one particular acoustic mode of the combustor will suddenly be excited, or in case of partial failure such as a plugged injector changing drastically the ambient conditions. CDO are responsible for the degradation of the system performance, and in the worst case for structural damage. Trial-and-error testing is required to tune a combustor so that CDO do not appear within the operation envelope. This process of adapting the design is called passive combustion control. The two last decades of research and development have focussed on active combustion control, with the objective to damp in real time a CDO, as well as to extend the operation envelope of a GT combustor beyond conventional flammability limits.

In this context, Piezocryst and TU Graz worked together on the sensing aspects, with aim to monitor efficiently combustion stability during operation. Therefore a relevant signal must be directly related to the flame itself, and not being deformed by cooling artefacts or perturbations coming from other components of the turbine. This implies a placement of the sensing technique as near as possible to the flame. Two methods were tested: a wall-mounted high-temperature pressure designed for operation at elevated temperatures (sensor CP502 developed by Piezocryst), and a line-of-sight measurement technique aiming through the flame e.g. via the liner’s cooling holes (laser vibrometer). The CP502 was directly mounted on the liner wall of a 25 kW laboratory burner for atmospheric testing, as well as in the pressure casing of a 75 kW burner for testing at elevated pressure. Both burners are TU Graz design, and are acoustically excited by a pulsation device. As a result the flame undergoes a vortex-driven oscillation. While the CP502 sensor surveys the combustion noise, the laser vibrometer records the gas density fluctuations.

The set-ups are presented, as well as the measurement techniques and their validation.