EFFECT OF COMBUSTION ON THE FREQUENCY RESPONSE OF JETS IN CROSSFLOW

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Reacting flows are a recurring flow phenomenon in engineering applications. In order to devise control strategies to optimize and influence their behavior, it is of great importance to understand the character of instabilities such flows are prone to. The objective of this paper is therefore to determine the effect of combustion on these instabilities. To this end, frequency response analysis is performed on reacting and non-reacting jets in crossflow, and their resulting dynamic behavior is compared. In order to perform the parametric sensitivity analysis the method proposed by [1] is employed. The spatial distribution of the optimal forcing field, yielding maximum energy gain at various forcing frequencies, is extracted, and the response map is compared between the two reactive and non-reactive cases. The range of frequencies to be investigated are determined using the energy spectra from the nonlinear simulations.

Apart from a frequency response analysis, in which we find the response of the entire state to forcing in all components of the system, we also perform component-wise input-output analysis which gives us insight into which input-output combinations are specially amplified (or suppressed) by combustion in the flow. This will provide a more mechanistic viewpoint of the role of combustion in the energy transfer processes of the fluid system.

The optimal forcing frequency and fields are extracted using adjoint-based optimization following the approach of [2]. This framework is particularly efficient, since the linearized operators are computed simply by using a local differentiation technique, without explicitly forming the resulting matrices for both forward and adjoint operators.

References

[1] de Pando, M. Fosas, P. J. Schmid, and S. K. Lele. Parametric sensitivity for large-scale aeroacoustic flows. *Proceedings of the Summer Program*, 2014.

[2] de Pando, M. Fosas, D. Sipp, and P. J. Schmid. Efficient evaluation of the direct and adjoint linearized dynamics from compressible flow solvers. *J. Comput. Phys.*, vol. 231, no. 23, pp. 7739-7755, 2012.