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Title

Surrogate Model-Based Acoustic Optimisation of Jet Nozzle Exit Geometries using Large Eddy Simulation

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Abstract

Aircraft noise has remained a problem over decades, and it is widely acknowledged as a limit to airline fleet growth and as a major concern for airport regulations. It is also acknowledged that aircraft noise can lead to detrimental effects on population health and thus incur enormous social cost in the long term. As a result, a considerable amount of research is directed by major aviation industries and also conducted in academia, towards better understanding of the noise generation mechanism and development of tailored flow and noise control methods.

Engine noise is recognised as one of the major components of aircraft noise, and the technological advances in the design of the jet engines have led to significant reduction of jet mixing noise. It has been verified both experimentally [1] and computationally [2] that modifications of the nozzle exit geometry, such as the use of chevron nozzles and non-concentric dual-stream nozzles can lead to jet mixing noise reduction.

In this paper, a surrogate model-based optimisation framework is developed and applied to jet nozzle exit geometries, with the aim of minimising acoustic signatures. The optimisation package is wrapped around a Large-Eddy Simulation (LES) solver, which is based on the Compact Accurately Boundary-Adjusting High-Resolution Technique (CABARET) scheme and is implemented on graphics processing units. The CABARET LES solutions are further coupled with the Ffowcs Williams-Hawkings method for noise predictions. Efficient geometric shape control and volume mesh deformation is achieved via a radial basis function approach. A surrogate model is developed and applied to nozzle shape optimisations. Preliminary results for a single-point optimisation case had been presented in the past AIAA SciTech forum [3]. Ongoing work is focused on further developing the optimisation framework and applying to more general multi-point optimisations for a number of nozzle cases with different exit geometries. The results will be included in the final manuscript of this paper.

References

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