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Title

Transonic flow oscillations in cavity/store problems

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Abstract

Every wheel well, weapons bay, or cavity on an aircraft is susceptible to strong unsteady aerodynamic induced acoustic loading. The noise level is substantial, capable of causing damage to structures, instrumentation and stores held within a cavity. To safely operate modern aircraft cavities, or modify them to alleviate undesirable effects, a complete understanding of both the acoustic noise generation and the subsequent interaction with the contents of the cavity must be achieved.

A rigorous and comprehensive experimental campaign has been undertaken by Sandia National Laboratories to characterise the acoustic loading characteristics of increasingly complex open cavity geometries at a range of freestream conditions [1,2]. While this work has been an instrumental contribution to the emerging understanding of complex interactions in compressible open-cavity flows, relatively little research has been devoted to understanding the physical mechanisms by which protuberances within the cavity influence the unsteady loading environment of the flow. Such problems are of relevance to any internal store carriage, wherein there exists the possibility of amplification in the unsteady loads and exacerbation of structural vibrations. The goal of the present work is thus to identify the potential existence of amplification or attenuation mechanisms in these cavity/store configurations.

This study considers the transonic test condition of Mach number M = 0.79, with a simple square cavity geometry of length-to-depth ratio L/D = 3.33 as detailed by Wagner et al [2]. Numerical simulations are performed using the commercial, cell-centred finite volume code ANSYS Fluent 2021R1 with Wall-Modelled Large Eddy Simulation (WMLES). A grid and turbulence model sensitivity study has been performed to provide confidence in the applied solver numerics for an empty configuration. Comparisons between the computed and experimental acoustic spectra throughout the cavity indicate good correlation with the experiments. The tonal frequencies and spectral character are well-captured across the available frequency range and peak fluctuation magnitudes are also fairly well represented, with typical deviations from experiment within 2%.

The final paper will perform equivalent simulations for a with-store geometry. Comparisons will be made between the empty and with-store configurations with respect to spectral characteristics, pressure oscillation magnitudes and broader flow topologies. Higher-Order Dynamic Mode Decomposition, as employed in prior work by the authors' [3] will also be used to probe the spatial distribution of flow resonance within cavity and gain an understanding of any underlying amplification or attenuation mechanisms at play.

References

[1] Katya M Casper, Justin L Wagner, Steven J Beresh, John F Henfling, Russell W Spillers, and Brian OM Pruett. Complex geometry effects on cavity resonance. AIAA Journal, 54(1):320–330, 2016.
[2] Justin L Wagner, Katya M Casper, Steven J Beresh, Patrick S Hunter, Russell W Spillers, John F Henfling, and Randall L Mayes. Fluid-structure interactions in compressible cavity flows. Physics of Fluids, 27(6):066102, 2015.
[3] Nicholas F Giannelis, Oleg Levinski, and Gareth A Vio. Origins of atypical shock buffet motions on a supercritical aerofoil. Aerospace Science and Technology, 107:106304, 2020.