IUTAM Symposium on Unsteady Separated Flows and their Control, June 18-22, 2007, Corfu, Greece

ON THE USE OF LES FOR FLOW CONTROL: THE COMPRESSIBLE CAVITY FLOW CASE

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Introduction

The presentation will present a survey a the results obtained over the last decades by the author and his coworkers dealing with the prediction of compressible cavity flow at very high Reynolds number with and without control devices. The main goal of the presentation will be to show how accurate LES results can be in these configurations and what insight into flow dynamics they can provide. Some issues related to LES methodology (wall modelling, synthetic turbulent inflow conditions) will also be emphasized.

Issues related to flow physics

The dynamics of turbulent compressible cavity flow is very complex, since it is sensitive to a wid range of geometrical and flow parameters. An impressive amount of experimental results has been accumulated over several decades, which show that the flow can exhibit dramatic bifurcation, even in the mean flow topology. The improvement of physical models, numerical method and the exponential growth of available computing power make the LES-type simulations a reliable and very accurate tool to analyze the flow dynamics. Recent numerical results dealing with the nature of the turbulent fluctuations will be presented, along with observations about bifurcations in the mean flow topology. A striking observation here is the existence of metastable solutions with asymmetric mean flows (in symmetric cavity) which have been sometimes observed (but not analyzed) in wind tunnel experiments.

Another set of results dealing with cavity flow control using passive control devices will be presented. Here, both rod- and spoiler-type devices will be considered. It will be shown that the controlled flows, while they exhibit a reduced aerodynamic load on the structure with respect to the uncontrolled case, are very different. It will also be shown that LES is able to capture very subtle differences in the non-linear couplings between physical modes that exist between the different configurations.

Issues related to LES methodology

The accuracy and the reliability of LES results is a difficult and important issue. It is now commonly agreed that the subgrid model used to model the interactions between resolved and unresolved turbulent scales of motion is not the sole parameter that governs the accuracy o the results. The adequacy of the numerical method, boundary conditions and computational grid are also key parameters. The sensitivity of the results to these parameters in the cavity flow case will be discussed, the main results being that, in some cases, very rough methods can provide very accurate results.

References

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