Transformation Methods for the Time Marching Analysis of Flutter

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Abstract

This paper considers the impact of the transformation method between grid displaand loads on the time response of fluid-structure interaction when using the Euler equations to model the flow. This problem is important because frequently fluid and structure surface meshes do not lie on the same surface, introducing the possibility of shape distortion effects which would be detrimental to the fluid solution which is based on a conforming grid. Results are shown for four interpolation methods which are a combination of two treatments in and out of the structural plane. these are evaluated for two test problems, namely the AGARD 445.6 and the MDO wings.

1 Introduction

The demonstration of aeroelastic stability is a key part of the aircraft design and certification process. Linear methods are the standard industry analysis tool backed up by extensive flight testing. However, these flow models are inadequate to describe transonic flow effects due to the presence of finite amplitude shock motions. The application of these models for predicting flutter introduces an expensive uncertainty into the subsequent flight testing programme. Satisfactory modelling of transonic flows can however be made using nonlinear models. Strategies for using these models in a flutter analysis include carrying out time marching calculations to investigate stability to an initial disturbance ¹ and calculating Hopf bifurcation points through the use of an augmented system². The second method is more direct but has not yet been developed to the point where it can be applied in the design environment. The time marching method is more computationally expensive because of the search over multiple parameters to identify stability characteristics. For each parameter an unsteady flow calculation is required. It is therefore important that the time marching method is as efficient as possible.

A number of choices for a time marching simulation present themselves. For unsteady flow simulations a rational approach to minimising the calculation cost is to first ensure that the time step can be chosen from accuracy considerations alone and secondly to then minimise the cost of each time step. This can be achieved using Jameson's pseudo time method ¹², where the solution at the next time step is obtained by solving a modified steady state problem using an efficient steady state solver such as multigrid. The updated solution is second order accurate in time and there is no stability limitation on the size of the real time step.

The solution of the structural model for