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GRADUATE SEMINAR

Adaptive Harmonic Balance Method for Nonlinear, Unsteady, One-Dimensional Periodic Flows

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***Date*:** May 16, 2003
***Time*:** 3:00 - 4:00 p.m.
***Place*:** 755 Baldwin Hall

Refreshments: 2:45 – 3:00 p.m.

ABSTRACT

A new adaptive split-domain harmonic balance computational fluid dynamics (CFD) method is developed to solve highly nonlinear time-periodic flows such as those found in transonic turbomachinery. The basic harmonic balance CFD method transforms an unsteady time-periodic problem into a steady-state problem by assuming a solution in the form of a Fourier series in time. Convergence acceleration techniques, such as FAS Multigrid, can then be applied to reduce compute time. The new method employs a unique multi-domain split-operator solution technique to remove a large-series stability restriction present in previous harmonic balance CFD approaches. The new method also minimizes the computational work required to obtain a harmonic balance solution by adapting the frequency content to the flow, starting with a small number of Fourier frequencies and augmenting the frequency content in each cell as necessary to capture local flow physics. The method reduces compute times by allowing larger integration time steps, reducing Fourier transform calculations, and reducing overall problem size. The adaptive split-domain approach is applied to the 1-D and quasi-1-D Euler equations. Supersonic and subsonic Euler calculations show that the adapted and non-adapted harmonic balance solutions are equivalent. Accurate adapted quasi-1-D Euler solutions for a supersonic/subsonic diverging nozzle with periodic unsteady outflow conditions are generated in 86% less time than an equivalent non-adapted split-domain solution, demonstrating the benefit of adapting frequency content to the local flow. Approaches for improving the effectiveness of multigrid with the harmonic balance method will also be discussed.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Maple received his Bachelor's Degree in Mechanical Engineering from Cornell University in 1985. He received his Masters and Doctorate in Aerospace Engineering from the Air Force Institute of Technology (AFIT) in 1989 and 2002, respectively. He is currently serving on the faculty of AFIT as an assistant professor of Aerospace Engineering. His research interests include all aspects of Computational Fluid Dynamics, including grid generation and overset grid methods, algorithm development, high performance parallel computing, and visualization.

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