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Aeroelastic Analysis Using Unstructured CFD Method for Realistic Aircraft Design

***Takayasu Kumano[1], Hiroyuki Morino[2], Shinkyu Jeong[1] and Shigeru Obayashi[3]**

[1] Institute of Fluid Science, Tohoku University Sendai, Japan {kumano, jeong}@edge.ifs.tohoku.ac.jp

[2] Mitsubishi Heavy Industries, Ltd., Nagoya, Japan hiroyuki_morino@mhi.co.jp

[3] Institute of Fluid Science, Tohoku University Sendai, Japan obayashi@ifs.tohoku.ac.jp

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ABSTRACT

In Japan, a 5-year R&D project has been in progress toward the development of environmentally friendly high performance regional jet aircraft subsidized by New Energy Development Organization of Japan(NEDO) since 2003. The conceptual image of a regional jet is shown in Fig.1. For the success of the project, authors have developed a Multidisciplinary Design Optimization (MDO) system based on the integration of Computational Fluid Dynamics(CFD) codes and the NASTRAN-based aeroelastic-structural interface codes. The MDO system was applied successfully to an engine-airframe design problem [1], which is one of the most important issues in the aircraft design. However, the MDO system still remains a concern about the prediction of the aeroelastic characteristics at transonic speed since NASTRAN uses the doublet lattice method, which is based on the liner theory, to compute the unsteady aerodynamic forces. The objective of this study is to develop a high-fidelity aeroelastic analysis code based on the nonliner aerodymamics in order to predict the aeroelastic characteristics of the aircraft at transonic speed accurately.

The developed aeroelastic analysis code is a fully implicit, unstructured-mesh Euler/Navier-Stokes solver coupled to a linear, second order structural solver. The subiteration algorithm of the fluid equations based on the LU-SGS with three points Euler backward difference is directly applied to the structural equations of motion. In the grid modification, the unstructured dynamic mesh method developed by Murayama, et al. [2] is used because it is able to maintain the grid quality in a complicated geometry.

To verify the code, flutter analysis for the AGARD 445.6 standard aeroelastic wing configuration [3] at M=0.60-1.14 has been performed (Fig.2). The computed results predict well the transonic dip of the flutter boundary found in the experiment. Moreover, the present code has been applied to the wind tunnel model of the wing-pylon-nacelle configuration (Fig.3). The predicted flutter boundary shows good agreement with the experimatal results. This paper will discuss the details of these two applications.

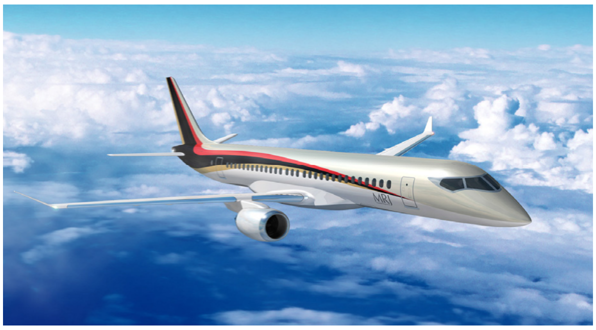

Figure 1. Environmentally friendly high performance regional jet.

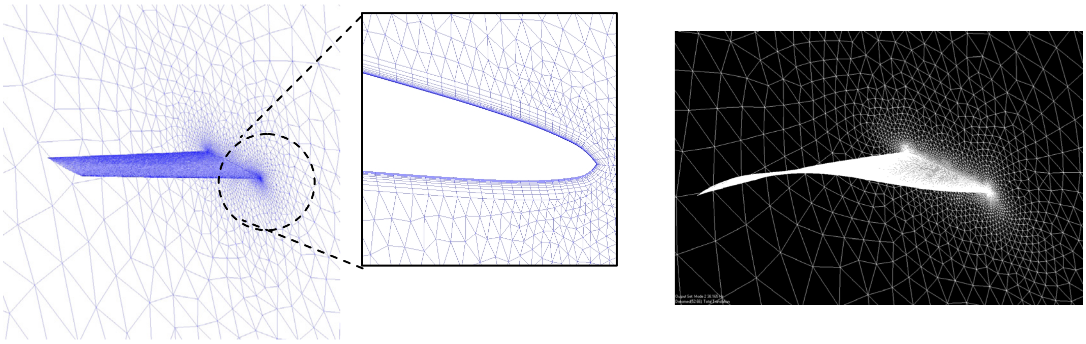

Figure 2. Unstructured hybrid mesh of the AGARD 445.6 (left),
and the mesh motion of the twisting mode (right).

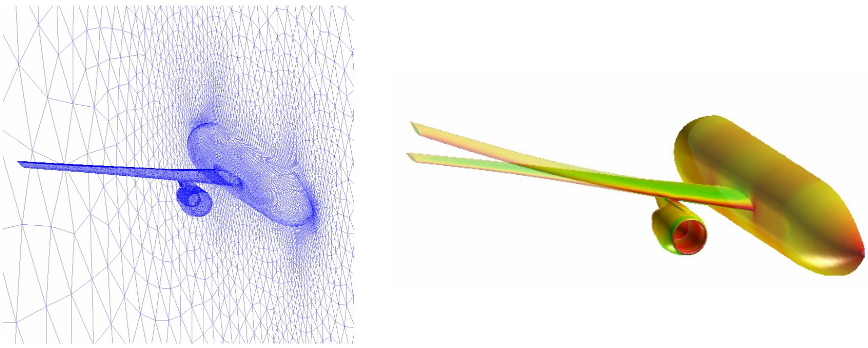

Figure 3. CFD mesh of the wind tunnel model of the wing-pylon-nacelle configuration (left),
and the unsteady pressure distribution at Mach=0.7 (right).

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