Unsteady Flow Calculation on a Moving Grid

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Objective

Develop a computational method for flutter analysis of a composite wing designed for B-777X

- Develop three computer programs by three graduate students
  1. CFD code for moving grid (Hayashi)
  2. Grid deformation code for deformed wing (Takayama)
  3. Modal analysis code for composite wing structure (Matsuoka)

- Combine into one flutter analysis code and conduct preliminary computations

  Preliminary flutter analysis of a composite wing designed for B-777
Numerical Methods

CFD code
• Conventional FVM for 3D Euler Equations
• Two-step explicit time integration
• Exact integration of 4D (space-time) conservation law on moving grid

Grid deformation
• Interpolating a coarse structured grid based on inverse distance weight

Structural analysis
• Modal analysis using up to 10th mode
• Two-step explicit time integration
• Damping is ignored
Computational Model for Composite Wing Designed for B-777

Computational grid
- Grid type: CO type
- Number of computational grid: $52 \times 22 \times 30$

Structural model
- Shell and bar elements
Computational Conditions for Composite Wing Designed for B-777

A steady flowfield over a semi-span wing is obtained
• Flutter analysis is performed using the steady flowfield as an initial condition

Flow conditions
• Mach number : 0.9
• Angle of attack : 4.0 [deg.]
• Flight altitude : 11,000 [m]
Temporal variation of the pressure distribution

- Large bending deflection occurs in the wing
- First bending mode is dominant
Compared Results for Composite Wing Designed for B-777

Modal analysis

Bending mode
- 1st mode
- 2nd mode
- 5th mode
- 7th mode
- 10th mode

Torsion mode
- 3rd mode
- 4th mode
- 6th mode
- 8th mode
- 9th mode
Summary

• Three programs are combined to study wing flutter problem

• Preliminary study of flutter analysis for a composite wing designed for B-777 is attempted
  - Large bending deflection occurs in the wing
  - First bending mode is found dominant

• Further studies are needed to examine the possible flutter of a composite wing in more details