Fluid Structure Interaction Simulation of Hood Flutter
FSI Simulation of Hood Flutter

Outline

• Aeroelastic Phenomena
  • Extraneously Induced Excitation
  • Instability Induced Excitation
  • Movement Induced Excitation
• Hood Flutter Study
• Hood Flutter FSI Analysis – Outline
  • Pressure profile on DrivAer model
  • Time-varying loads from wake of preceding vehicle
  • FSI of spoiler
  • 2D FSI of flexible hood
• Conclusions
Aeroelastic Phenomena

3 groupings for aeroelastic phenomena from Naudascher & Rockwell:

1. **Extraneously Induced Excitation**
   ![Diagram](image1)

2. **Instability Induced Excitation**
   ![Diagram](image2)

3. **Movement Induced Excitation**
   ![Diagram](image3)
Aeroelastic Phenomena

1. Extraneously Induced Excitation

Excitation caused by fluctuations in the oncoming flow conditions.

Examples:
- Buffeting
- Vortex shedding from upstream body
Aeroelastic Phenomena

2. Instability Induced Excitation

Excitation caused by flow instability about the structure.

Examples:
• Vortex shedding
• Separation
Aeroelastic Phenomena

3. Movement Induced Excitation

Excitation caused by fluid forces arising from movements of structure.

Examples:
- Classical flutter
- Gallop
If we want to minimise the risk of hood flutter during design, what tools are there to analyse this problem?

One way coupled CFD and FEA – Apply pressure time histories from CFD to FEA model

Fully coupled FSI simulations

Aeroelastic wind tunnel tests

Track testing

Requirements: What do we need from FSI simulations to make them useful for bonnet flutter analysis?

• Accurate representation of Physics
  • Strong, two way Coupling
  • High fidelity CFD
  • Bonnet gap opening
  • Engine bay flows
  • Opening mechanism

• Scalability
Hood Flutter FSI Analysis - Outline

1. Validation of ICFD solver using DrivAer generic car model
2. Simulation of unsteady loads from the wake of a preceding car
3. FSI simulations of a spoiler on the DrivAer car
4. 2D FSI simulations of separated flow over a flexible hood
FSI Simulation of Hood Flutter

Pressure profile on DrivAer model

- Comparison is made to experimental pressure profile from TUM.

- Two ICFD simulations:
  - Steady state k-ω
  - Transient LES

- Steady state OpenFOAM k-ω simulation for comparison.

- Flow is sensitive to turbulence model.
Time-varying loads from wake of preceding vehicle
FSI Simulation of Hood Flutter

FSI of spoiler

- Structural model of plastic spoiler added.
- Some difference in vertical loads, but load fluctuates due to eddies from rear window.
- Endplate of the spoiler visibly deflects.
FSI Simulation of Hood Flutter

FSI of spoiler
2D FSI of flexible hood

- Hood leading edge raised to promote separation.
- Thin gap under hood can open up.
- Non-linear spring on front edge to act as contact.
2D FSI of flexible hood
Conclusions

Conclusions:

- Validation of pressure profile around generic car geometry.
- Reproduction of structure excitations generated by the wake of a preceding vehicle.
- Model instability induced vibrations using the FSI tools.

Challenges:

- Complex models, long run times.
- Instability issues associated with remeshing.
- Validation required with results from aero-elastic wind tunnel testing.
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