Tire Noise Modeling Using Actran

Actran Features and Examples of Application
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• Tire body sound radiation
  – Uncoupled simulation with road absorption
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  – Installation effect
Introduction

• Tire noise is an important contributor to entire vehicle noise

• Tire noise types
  – Impact noise
  – Release noise
  – Air pumping noise
  – Tire vibration sound

• Phenomena analyzed by Actran
  – Acoustic transfer function: horn effect of impact noise / release noise, air pumping resonance
  – Road absorption
  – Coupled vibro-acoustics: tire inner cavity resonance
  – Installation effect
Air Pumping: Influence of the Groove Pattern
Air pumping - mechanism

- The air trapped between the tread patterns is brutally compressed and ejected along the side of the tyre emitting a sound
- The sound is characterised by the acoustic resonance frequencies of the air channels under the contact patch (*organ pipe noise*) → air pumping
Mesh the acoustic volume

Geometry 1

Geometry 2
Model the sources and the microphones

Symmetric configuration

Asymmetric configuration
Actran Results with Different Grooves

Symmetric configuration

Asymmetric configuration
Actran Results with Different Grooves – Cont’
Impact & Release Noise
Impact & Release Noise

- Impact Noise: at the leading edge of the contact patch, the shock of the rubber blocks hitting the road surface

- Release noise: at the trailing edge, tread blocks compressed under the contact patch are suddenly released and vibrate

- Non-linear mechanical analysis of the rubber block on road can be studied using Marc
The transfer function (TF) between an individual source and a receiver can be calculated independently from the source strength.

Calculation of the amplification factor due to the horn effect made by the road and a car Tire of 31 cm radius. The road and the Tire are assumed to be rigid.
Horn effect Demo: Acoustic mesh and Actran model

Acoustic source at the contact point

Far acoustic field modeled by infinite element

Near acoustic field modeled by finite element
Horn Effect - Results

Figure 1 Geometry and insertion loss results for the 2D horn effect reference problem.. Results presented are for h=1 mm and d=80 mm. h is the vertical distance between the tyre and the road.
Tire Body Vibration Sound
Problem Description

- **Smooth HQ6784 Tire of dimensions:**
  - radius 0.314 m
  - width including sidewalls = 0.355 m

- **Tire deformation produced by Chalmers University:**
  - loaded Tire (3000 N)
  - rolling on a rigid or absorbing ground at a speed of 80 km/h
  - 256 frequencies (from 0 to 2800 Hz with a step of 11 Hz)
Uncoupled Model – Without Inner Air

Grid on which dynamic results are provided

Projection of dynamic results into the acoustic mesh

Exterior FEM Acoustic mesh
Effect of Absorbing Ground

- The road is either considered as rigid (perfectly reflecting) or absorbing. In the latter case the absorption is given, in third-octave band by:

Road absorption defined by:

- admittance on surface of mesh ground
- infinite admittance in infinite ground
Effect of Absorbing Ground – Cont’

Pass-by noise test position: rigid and absorbing road

Road absorption must be taken into account
Color Map Results

Map results at 124 Hz
Comparison with Measurements

SPL at the Trailing Edge

Results obtained in the frame of the RATIN project
Restart Capability for Acoustic Radiation

- Restart capability:
  - A database of acoustic propagation transfer function depending only on acoustic mesh, can be calculated and stored before imposing the structure excitation
  - For a new structure excitation, the propagation transfer function does not change and the acoustic response in far field can be calculated with little effort
Coupled Tire / Inner Air Model

- Inner cavity: FE
- Tire: FE
- Exterior: FE/IE
- Field mesh for far field map

- Allow to take into account the cavity modes and the basics modes of the Tire
- Non-congruent mesh support: the structure and acoustic fluid may be meshed completely independently
Coupled Tire / Inner Air Model – Color Maps

Map Frequency: 242 Hz

Figure 4 Left: Deformed shape and displacement amplitude contours on the tyre. Right: Sound field radiated by the tyre (near field). Frequency : 242 Hz.

Deformed shape and displacement amplitude on the Tire

Sound field radiated by the Tire (near field)
Coupled Tire / Inner Air Model – Influence of Cavity

First cavity mode at 200 Hz
Pass-by Noise

- Tire Noise is an important contributor to pass-by noise

- Installation effect should be studied
NCT5 Tire radiation including car body: model

*Surrounding surface*

*Volume mesh*
NCT5 Tire radiation including car body: Results

500 Hz

1000 Hz
NCT5 Tire radiation including car body: Results

500 Hz

1000 Hz
Flow Effects

• A flow velocity field can be defined in order to support the solution of the convected Helmholtz wave equation

• Treatment of flow effects:
  – Finite elements: non uniform flow
  – Infinite elements: uniform flow