INSA - LABORATOIRE VIBRATIONS ACOUSTIQUE

Mid Frequency Vibroacoustic Modeling of an Innovative Lightweight Cab – Floor/Cavity Interaction

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VIbrations, SHocks and NOise



Outline

- Context
- Statistical modal Energy distribution Analysis SmEdA
- Vibroacoustic Floor Cavity interaction
- Viscoelastic modeling
- Multilayers modeling
- Modal analysis and distribution
- Conclusion







CONTEXT - CLIC Project

- City Lightweight & Innovative Cab
- MidFrequency VibroAcoustic modeling of a cab

COMPUTATION TOOL

SmEdA : method linking FEM and energetic model

Validation on RT cab

ISSUES



Application on CLIC cab



- FEM with 6 million structural dofs and 1 million acoustical dofs
- Very high computer resources for a complete analysis

Substructuring technique side by side with impedance rupture hypothesis

SmEdA - Review

Statistical modal Energy distribution Analysis

 $\begin{array}{c} \mathsf{SS1} \\ (\omega_p, \eta_p, \phi_p) \end{array}$ $\begin{array}{c} \mathsf{SS2} \\ \left(\omega_q, \eta_q, \phi_q\right) \end{array}$ β_{pq}

Input: Injected power π_{inj}

Output: Energy level E

$$\begin{bmatrix} \pi_{inj}^{p} \\ \pi_{inj}^{q} \end{bmatrix} = \begin{bmatrix} \omega_{p}\eta_{p} + \sum_{q=1}^{N_{2}}\omega_{c}\beta_{pq} & -\sum_{q=1}^{N_{2}}\omega_{c}\beta_{pq} \\ -\sum_{p=1}^{N_{1}}\omega_{c}\beta_{pq} & \omega_{q}\eta_{q} + \sum_{p=1}^{N_{1}}\omega_{c}\beta_{pq} \end{bmatrix} \begin{bmatrix} E_{p} \\ E_{q} \end{bmatrix}$$

Coupling loss factor = Spatial coupling * Spectral coupling

$$\beta_{pq} = \beta_{\omega} * \beta_{W}$$





SmEdA - Review

Fluid structure interaction



$$\beta_{pq} = \beta_{\omega} * \beta_{W}$$

$$\beta_{\omega} = \frac{\eta_p \omega_p^2 + \eta_q \omega_q^2}{\left(\omega_p^2 - \omega_q^2\right)^2 + \left(\eta_p + \eta_q\right)\left(\eta_p \omega_q^2 + \eta_q \omega_p^2\right)} \quad \text{Spectral coupling}$$

$$\beta_W = \left(\frac{\int \phi_p \phi_q dS}{M_p M_q}\right)^2$$

Spatial coupling

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Floor Cavity Interaction



Floor Cavity Interaction



Floor Cavity Interaction

Contaur Flat Displazamenta

Anatra o syste

-3.354E+33

-2 8001+33 -1 867=432 -1 116E+32 -3.703E+31 -3.75501+0 -1 1267E+03 -1.867E+02 - 2.819E+03

-(11950) +(0) Normani Max = 31954 ±+11 Node 2102787 M1 = -5.3555 ±+05 Node 210935

Exact acoustic mode shape

Acoustic mode shape interpolated on the floor nodes

Model Fift: 000se-Siggerges/Decuments/CUCMEde et/Restrati/Analysis models extensives models conty.op2 Result: 000se-Siggerges/Decuments/CUCMEde et/Restrati/Analysis models extensives models_conty.op2

SUBCASE I = MUDES - WideW21 requirey= EX80240.1Hz

Frances

N 8

Viscoelastic modeling

WLF law measured by ACOEM



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Multi-layers modeling*



Equivalent homogenous shell

Hypotheses

- Constant thickness
- Continuous normal and tangent displacements
- Continuous normal and shear • stress



 $\eta_{eq}, E_{eq}, \nu_{eq}, \rho_{eq}$

*Guyader, Cacciolati 2007











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Work in Progress

- Experimenta validation of SmEdA computing
- Backboard- Cavity interaction
- Rain on the roof excitation



- Filling modeling
- Extension to CLIC cabin







