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STRUCTURAL ACOUSTICS WITH INTERFACE DAMPING: VARIOUS CONSIDERATIONS ABOUT STATIC TERMS FOR EFFICIENT DYNAMIC BEHAVIOR DESCRIPTION

M. Ouisse and E. Sadoulet-Reboul

FEMTO-ST Applied Mechanics, University of Franche-Comté
24 rue de l'épitaphe, 25000 Besançon, France
morvan.ouisse@univ-fcomte.fr, emeline.sadoulet-reboul@univ-fcomte.fr
http://www.femto-st.fr

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In this paper, we propose an insight into structural acoustics with interface damping problems. A particular attention is paid to the links between static and dynamic at several levels: on the formulation itself, on the impact on physical variables, and on the efficiency of the Reduced Order Models that can be derived from the formulations. Special acknowledgements are due to Prof. Roger Ohayon who inspired a large part of this work through its articles, book and passionate discussions.

1 Displacement formulation for structural acoustics with interface damping

A generic formulation is first developed, using structural and acoustic displacements as physical variables. A special attention is paid to the static behavior of the formulation, and implications on physical variables are derived: the irrotational character of the fluid displacement is discussed, and mathematical properties of the operator used for the description of the interface damping. A pneumatic stiffness operator is exhibited and uniqueness of the solution is discussed. The whole set of equations is given to obtain a well-posed problem which is valid for null frequency. In a practical point of view, in particular for solving the problem using the finite elements method, the irrotational constraint for the static case should be discretized, which is not trivial. In the following, alternative formulations will be derived to avoid the discretization of the constraint while keeping the validity of the formulation for static case.

2 Structural acoustics formulations

The three most popular formulations for fluid-structure problems are considered, which can be distinguished one to another by the choice of the variable used for the description of the behavior of the acoustic fluid: pressure, displacement potential and velocity potential. Their static behavior is analyzed and commented. Wherever necessary, an uniqueness contraint is presented and included in the formulation. Comments are given about the formulations used in finite elements popular codes.

3 Structural Acoustics Reduced Order Models with Interface Damping

Reduced-Order Models are finally derived from modal considerations. A particular focus is proposed on techniques based on the use of decoupled modes. Comments are given on the proper use of zero-th order mode, in close link with the formulations presented in the previous sections. A numerical convergence analysis is performed on a reference test-case, using the various formulations. It is finally shown that the use of static residuals in the ROM basis can improve the convergence rate.

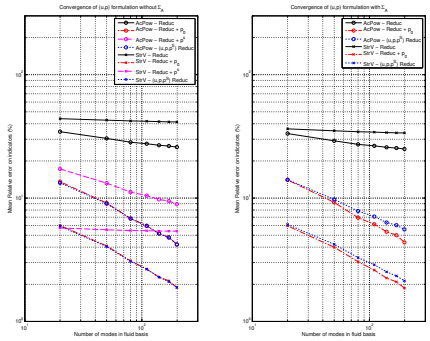

Figure 1: Convergence analysis on acoustic power and quadratic structural velocity

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