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ADVANCED METHODOLOGIES FOR TOPOLOGY AND GEOMETRY OPTIMIZATION OF NOISE CONTROL DEVICES

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Abstract: Regarding acoustic attenuation, reactive silencers show a good behaviour at low to mid frequencies, whereas dissipative silencers, i.e., those containing absorbent material, are used in exhaust system applications due to their good performance in wide frequency bands, essentially at high frequencies. The combination of both types of configurations results in the hybrid silencer concept, which shows considerable attenuation in almost all the frequency range of interest. As an initial approach, plane wave models with low computation cost can be employed for acoustic attenuation prediction mainly at low frequencies. However, for more general problems with complex geometries and heterogeneous absorbent material it is necessary the use of multidimensional numerical analysis methods, such as the Finite Element Method (FEM). In the present work, an axisymmetric acoustic model based on a FEM pressure formulation [1] is used in order to predict sound attenuation in dissipative and hybrid silencers in terms of transmission loss (TL). Next, a Topology Optimization (TO) gradient-based algorithm is implemented in order to get the maximum attenuation in a certain target frequency range, assigning a different filling density to each element of the central chamber, while keeping constant the total mass of absorbent material. The adjoint method is used during the TO process in order to speed up the computation of the objective function sensitivities with respect to the design variables (bulk density of each element or group of elements). This TO method is combined with the geometry optimization of the dissipative and reactive chambers. Thus, the implemented algorithm is capable of obtaining not only the optimal absorbent material layout but also the optimal geometry of both chambers (radius and length) which maximizes the silencer transmission loss. In order to combine both techniques, the Method of the Moving Asymptotes (MMA) described in reference [2] is implemented. The FEM solver algorithm is validated with experimental results available in the bibliography. Finally, it is demonstrated that the optimization process results in substantial improvement of the silencer sound attenuation at the target frequency range.

References

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