Inverse estimation of static flow resistivity in porous materials - discussion of the method and results for two tested porous materials

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Abstract

Porous materials are widely used in applications which focus on noise and vibration control. Their thermal, mechanical and acoustical properties are beneficial for the use of these materials in aeronautical and vehicle industries. Standard measurements for the characterization of porous materials exist and are carried out in many laboratories worldwide. However, these measurements do not always consider the possible anisotropy, present in porous materials. The production process of porous materials introduces an inherent geometric anisotropy in the material at micro scale, which influences the material properties at macro scale. It has been shown by Khurana et al. [3] that the anisotropy can have a significant influence on the acoustical behaviour of the material, especially if the angle of incidence is increased. One of the macroscopic parameters, which is important for the performance of these material in acoustical applications, is the static flow resistivity. The methodology to measure the flow resistivity in porous materials is described in ISO 9053 [2], giving the flow resistivity of a porous material along one direction. These unidirectional measurements do not allow for a full characterization of the flow resistivity tensor, and hence a proper characterization of the porous material. The identification method developed by Göransson et al. [1] provides a non-destructive measurement method to determine the static flow resistivity tensor. The method is based on an inverse estimation of the measured pressure

drops over a cubic material sample.

The method as described in the work of Göransson et al. [1] has been improved in several ways. The Globally Convergent Method of Moving Asymptotes (GCMMA) [5] , which assures convergence, has replaced the Method of Moving Asymptotes (MMA) [4]. Secondly, the approach of inverse estimation has been verified for a wide range of anisotropy, by setting artificial and a priori known anisotropic flow resistivity tensors as a target in the estimation. Furthermore, another approach towards the problem has been tested, in which the focus is on the eigenvalues and eigenvectors of the tensor, in stead of the independent components. In addition, a more precise description of the errors will be presented as well as an error estimation.

This method for identification of the anisotropic flow resistivity tensor has been applied to two different porous materials, a fibrous glass wool and a Melamine foam. The two materials are expected to show different degrees of anisotropy with respect to flow resistivity. Glass wool is assumed to be transversely isotropic while the level of anisotropy of Melamine is not as obvious. The full anisotropic flow resistivity tensors of the tested glass wool and Melamine samples are presented, together with their principal values and directions. The eigenvalue decomposition provides an insight into the connection between the directionality of the flow resistivity in each material, and its production process. The overall approach of the method is validated by comparing the estimated flow resistivity tensors to the flow resistivity measured in cylindrical samples extracted from the cubic samples tested. Furthermore, a study of the homogeneity in density and flow resistivity for the two materials shows that these properties vary within the block of material.

References

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