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MEASUREMENT VERIFIED BIOT–JCAL MODELLING OF WOOL FELT

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Abstract

Wool felt is a fibrous material composed of randomly oriented and mechanically entangled elastic fibres. Despite its widespread use in acoustic engineering, the sound absorption mechanisms of wool felt remain insufficiently understood. In this study, a Biot-Johnson-Champoux-Allard-Lafarge (Biot-JCAL) poroelastic modelling approach is employed, in which the felt is represented as an equivalent fluid with an elastic frame formed by the fibres. The model is calibrated using experimentally determined physical, non-acoustic, and geometrical parameters measured by the authors. Impedance tube measurements of sound absorption and transmission loss are further used to validate the proposed model. Both the measured and simulated absorption curves exhibit a pronounced low-frequency absorption peak that cannot be associated with any characteristic microstructural length scale of the material. This feature cannot be reproduced using rigid-frame equivalent-fluid models such as JCA or JCAL, demonstrating the importance of accounting for frame elasticity in wool felt. The presence of this resonance-like absorption behaviour suggests that wool felt may be regarded as a naturally derived acoustic metamaterial. Good agreement is observed between the experimental measurements and modelling results. The present study contributes to a deeper understanding of the acoustic behaviour of wool felt and related non-woven textiles. The reported measurements and validated model provide a basis for the tailored design and optimisation of sustainable sound-absorbing materials for engineering and noise-control applications with enhanced acoustic performance.

Keywords: *wool felt, fibrous media, poro-elasticity, Biot-JCAL model, acoustic metamaterials*

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