THE EFFECT OF USED 3D PRINTING METHOD ON THE ABSORPTION COEFFICIENT OF ACOUSTIC METAMATERIAL

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ABSTRACT

Acoustic metamaterials are frequently manufactured using 3D printing techniques in the scientific development phase. Despite the notable differences between the most popular additive manufacturing methods, the state-of-the-art references usually cover minimal descriptions of the printing process and settings. The sensitivity of different printing settings or materials is usually omitted. The paper will present the research on the impedance tube measurements of absorbing metamaterial manufactured with different 3D printing methods. The differences between FDM, SLS, and DLP methods will be discussed. The practical aspects of additive manufacturing and sound absorption measurements in impedance tubes will be discussed, explaining the research quality improvement methods used.

Keywords: *electroacoustic absorption, standing waves attenuation, additive manufacturing postprocessing*

1. INTRODUCTION

Metamaterial absorbing structures are commonly used in multiple disciplines of acoustics. The state-of-art contains a vast design selection, but only a minor part of those papers covers the entire development process, including the description of modeling, validation, and construction [1–3]. Most of the novel designs are manufactured using 3D printing techniques, but almost none cover the details of sample manufacturing. There is a lack of materials explaining the postprocessing requirements or judgment on the additive manufacturing method selection. The current research provided the problems with replicating multiple structures found in references, and the proper measurement sample preparation was identified as the problem. This paper will describe the recent findings in 3D printed samples for impedance tube measurements and the approach for their postprocessing.

2. METAMATERIAL STRUCTURES CONSTRUCTION

The state-of-art references cover some fundamentals on the influence of 3D printing effects on the acoustic properties of structures. Previously, the surface roughness was investigated, explaining the changes in the absorption of materials with different FDM layer settings [4]. Also, the influence of porosity in additive manufacturing was investigated [5]. In this research, we have focused on the practical approach of sample preparation, covering not only the 3D printing settings and methods but also the forms of sample element assembly and sealing methods. The primary cell we have studied is the Helmholtz resonator form described in [6]. Figure 1 presents the primary form of the resonator in the reference paper and the modification prepared for the tests in an impedance tube, one of the most common methods for acoustic material testing [7][8].

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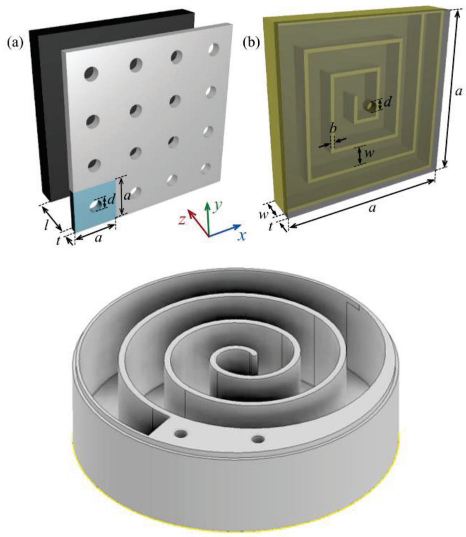

Figure 1. The reference metamaterial design [6] (top) and the representation of the sample preparation for a round impedance tube (bottom)

After preliminary tests, it occurred that simple printing does not provide satisfactory results and does not match the modeling output. We used the sealing method with elastic sealant (blue tack) to test initial modifications. The modified samples are shown in Figure 2.

Figure 2. Selected 3D prints in FDM (left) and SLS (right) with sealing

Regardless of the sealing, the most popular techniques in 3D printing were tested, including SLS, FDM, and DLP. In the other part of the research, we also tested the different types of joints between the parts of the sample, such as screws, glues, and sticky tape solutions.

3. IMPEDANCE TUBE MEASUREMENTS OF 3D PRINTED SAMPLES IN DIFFERENT TECHNIQUES

Differences in sound absorption between prepared samples were tested in impedance tube by Bruel&Kjaer type 4206. For all tested 3D printing methods, we have selected both sealed and non-sealed versions and compared them with FEM modeling in COMSOL Multiphysics. The results are shown in Figure 3.

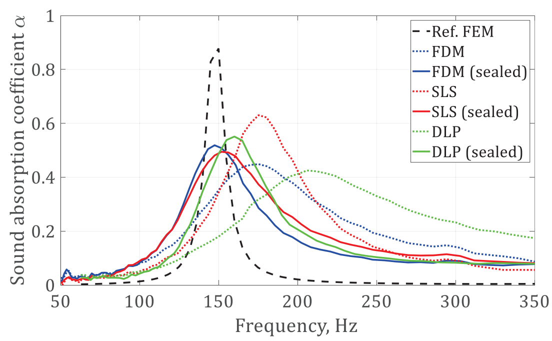

Figure 3. Measurements of the sound absorption coefficient for metamaterial cell samples manufactured in different 3D printing technologies

Before sealing, all samples showed a significant resonant frequency shift from the initial design. Sealing the sample allows to match the resonant frequency and decreases the quality factor of the resonant structure. It occurs that it is possible to prepare the proper samples in all tested technology. However, without further postprocessing, reaching a proper match with modeling results is impossible.

4. SUMMARY

The results of experimental verification sample metamaterial 3D printed models proved that postprocessing techniques are an essential part of sample preparation. The authors wanted to highlight the more detailed description in references of the sample preparation process as it leads to misconceptions and problems in research replication. It occurs that all the most common 3D printing methods can be used in sample preparation after postprocessing. However, more details on the postprocessing techniques and options should be derived in further research.

5. ACKNOWLEDGMENTS

The project was funded and supported by the Polish Government, National Centre of Research and Development, agreement no. LIDER/11/0065/L-12/20/NCBR/2021.

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