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Acoustic Properties of Aluminium Foams – Measurements and Modelling

Introduction

Open-pore aluminium foam, a corrosion-resistant, self-supporting light-weight material free from possibly dangerous fibres, has attracted increasing attention in materials science and technology. In line with this development the acoustic properties of a certain foam variety have been examined. Measurements are accompanied by a theoretical description, which serves as a basis for further improvement of the sound absorption potential.

Sample Production

The cylindrical aluminium-foam samples **(Figure 1)** investigated are the result of a high-pressure die-casting process around a sintered polymer-granulate compact [1]. The polymer (polystyrene) is finally removed by thermal treatment. The samples possess a practically completely open porosity around 60% and specific flow resistances between 3 and 10 kPas/m². Average pore size is about 2.5 mm.

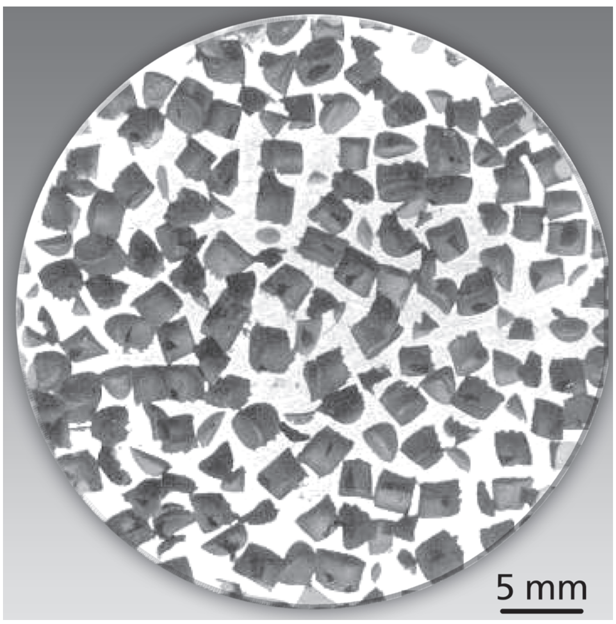

Figure 1: Aluminium-foam sample.

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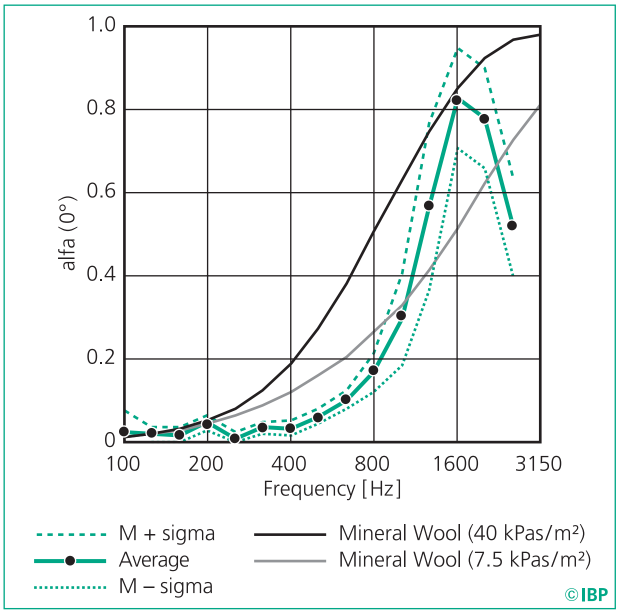

Figure 2: Measured sound absorption of nine 25 mm thick aluminium-foam samples: Average and average ± standard deviation (M ± sigma). For comparison: Two calculated fibre-absorber curves.

Absorption

The measured normal-incidence sound absorption **(Figure 2)** has a pronounced maximum around 1.6 kHz. In this region it is superior to mineral wool with the same specific flow resistance (7.5 kPas/m²). However, this is easily surpassed by mineral wool with 40 kPas/m².

Two theoretical models – a corrected and extended version of the model of Lu, Chen and He [2] (4 parameters) and the

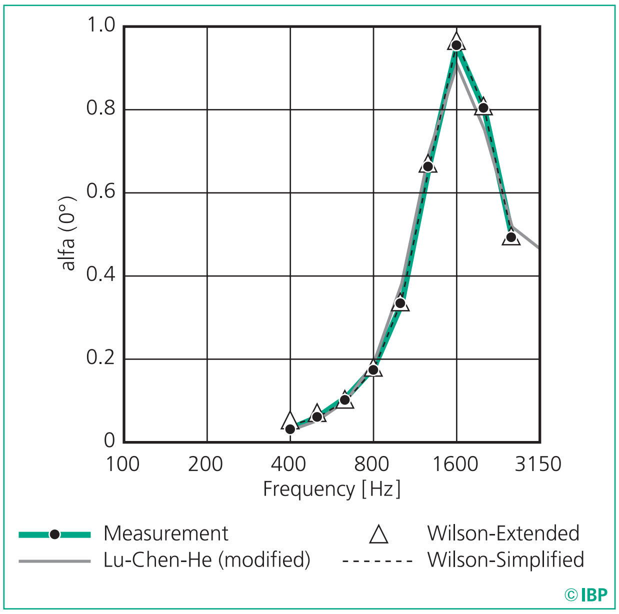

Figure 3: Absorption of sample o073 (25 mm thick, 7.6 kPas/m²): Measurement and three model calculations.

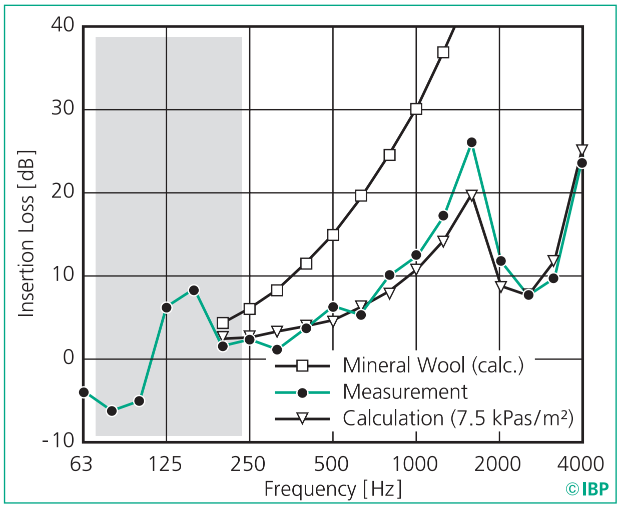

Figure 4: Insertion loss of the test silencer: Measurement and calculation with MAPS [4] using Wilson's absorber model. Shaded area: Insufficient anechoic duct terminations. For comparison: Calculated curve for silencer filled with mineral wool (40 kPas/m²).

variants 'Simplified' (4 parameters) and 'Extended' (6 parameters) of Wilson's model [3] – have been used for fitting and analysing the experimental data **(Figure 3)**. The agreement with absorption measurements is quite satisfactory with both models. However, Wilson's model, which has some advantages in general and also in particular with respect to porosity and flow resistance, is preferred. It helped to explain the orientation dependence of the absorption as an effect of a slight inhomogeneity of the samples. Its validity has been further checked against absorption measurements with an empty cavity behind the sample. Approximate empirical relationships between the fitted model parameters (4 out of 6) of Wilson's ‚Extended Model' and the measured properties porosity and flow resistance are provided as a (preliminary) prediction tool. The ‚Extended Model' is superior to the ‚Simplified Model' especially for transmission loss calculations because of the simultaneous reproduction of flow resistance (low frequencies) and absorption peak (high frequencies).

Insertion Loss

A test silencer (hollow cylinder with diameters 60 mm and 140 mm and length 275 mm) has been assembled from numerous aluminium-foam pieces with the above described absorption properties. The measured insertion loss **(Figure 4)** shows a maximum at 1.6 kHz corresponding to the absorption peak in **Figure 2**. The calculated values correspond well with the measured ones. They have been obtained with a MAPS routine (Book III Chapter 29.2 / Least att, lat abs & Zs.nb) [4], in which the implemented absorber model has been replaced by Wilson's ‚Extended Model'. As expected the performance of the aluminium-foam test silencer is well below a fibre-absorber ‚reference' (here: mineral wool with 40 kPas/m²).

Conclusions

The absorption properties of the investigated aluminium-foam material are satisfactorily described by Wilson's relaxation model, in particular by the ‚Extended Model'. For higher absorption the flow resistance has to be increased. This can be accomplished with finer polystyrene granulates.

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