# Zukunft Bau

## STRUKTUR / GLIEDERUNG KURZBERICHT

### Titel

Development of multi-phase porous sound absorbing materials by microstructure synthesis

### Anlass/ Ausgangslage

kurze Beschreibung des Problems und des Lösungsansatzes
max. 450 Zeichen (mit Leerzeichen)

The demand for slim sound absorbers for room acoustical applications increased in recent times. With porous materials as fibre absorbers or soft foams a noteworthy sound absorption at lower frequencies can only be realized by bigger layer thicknesses. Therefore, the material properties should be improved by multi-phase pore morphologies.

### Gegenstand des Forschungsvorhabens

Beschreibung der Arbeitsschritte und des Lösungswegs
max. 4.300 Zeichen (mit Leerzeichen)

The sound propagation in multi-phase porous materials shows some specifics. The pore volume consists out of two or more interconnected pore networks with distinctly different pore diameters. The principle should be realized exemplarily on basis of expanded glass granules. The goal was to shift the first absorption maximum by one octave to lower frequencies compared to an equaly thick fibre absorber.
The concept of the investigation was designed in a way that a separate analysis of the different pore phases could be carried out. Here model substances had a special importance. These were build up in a way that the relevant parameters of each porous phase could be determined by measurement where possible. In a next step models of the geometries of these phases were generated and evaluated by simulation. The concludung parameter varations delivered optimal ranges of the acoustically relevant parameters. The correlation to some parameters of the pore geometry like grain sizes and pore diameters are known thereby.
For the analytical desription of the sound propagation a classic absorber model (Johnson-Champoux-Allard) is used for the several porous phases. The input parameters of the model were determined indirectly by measurement. For synthesized geometries frequency undependent simulations with the software GeoDict were used (Figure 1). The models were constructed out of computer tomographies (Figure 2) and particle analyses. The needed coupling function was determined in the case of simple geometries by GeoDict simulation as well. Solutions by finite element calculations were used for random packings of granules.
The analytical description was verified by measurement of model substances at normal sound incidence in an impedance tube. The survey included perforated plates made out of porous materials and loose packings of massive and porous granules. The agreement between measurement and calculation is sufficient for the purpose of development (Figure 3). Suitable ranges of the geometrical parameters could be delimited by measurement. Compositions of filtration media revealed the limits of effective pore diameters of the microporous phase. This yields the fact that more than two porous phases have no advantages with the required layer thicknesses of a few centimeters.
Acoustically optimal ranges were identified by parameter variations for double porous materials made of roughly spherical granules. For this purpose the open celled porosity, flow resistivity and tortuosity of both phases were varied. Suitable values for the pore volume between the granuales can be reached with grain sizes around 2 mm. A high flow resistivity (Figure 4) and a tortuosity as high as possible should be chosen for the microporous phase inside the granules. However, the percentage of the open celled pore volume is critical. The resulting absorption spectra are no more practical with values below 50 percent.
The way of binding of the granules to panels is important for the acustical properties. Binders can close the the pores inside the granules in a way that they are ineffective. Two systems of binding-agents on basis of cement and epoxy were investigated. Furthermore the sintering procedure of the project partner Liaver GmbH was examined. Computer tomographies show the obvious encapsulation of the granules by the binder systems (Figure 5). In contrast the sintering keeps the open porosity intact for the most part (Figure 6).
The results obtained can be transferred to a range of different material systems such as textiles or mineral and plastic foams. For this reason they are interesting for different industrial sectors as vehicle construction, where only small layer thicknesses are possible.

### Fazit

Beschreibung der geplanten Ziele und der erreichten Ergebnisse
max. 700 Zeichen (mit Leerzeichen)

The target shift of the absorption maximum by one octave band has been achieved with the model substances. The theoretical modeling of the sound propagation is available for systems of roughly spherical granules. Optimal geometries of granular systems have been determined by the separate simulation of the several pore networks.
A realisation with expanded glass granules is generally possible. The sintering method is a possibility to consolidate the granules to plates without any impairment of the acoustic properties. But within the term of the project the needed granules with very narrow pore diameters were not available.

## Eckdaten

Kurztitel: Multi-phase porous sound absorbing materials

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Gesamtkosten: € 135.700,—

Anteil Bundeszuschuss: € 95.000,—

Projektlaufzeit: 24 months

## BILDER/ ABBILDUNGEN:

Figure 1: Bild 1 links Tomografie Granulat.tif
Bild 1 rechts Tomografie Granulat.tif
Tomography of a random packing of expanded glass granules (left) and single granules after particle separation (right).

Figure 2: Bild 2 Simulation Granulat.tif
Magnitude of the simulated steady flow velocity in a random packing of cubic granules.

Figure 3: Bild 3 Spektra Perforated Plate.tif
Measured and calculated sound absorption coefficients at normal sound incidence of a 45 mm thick layer of mineral wool unpunched and with perforation (cylindrical, diameter 16 mm).

Figure 4: Bild 4 Parameter Variation.tif
Calculated sound absorption coefficients at normal incidence of a 30 mm thick random packing of granules with 1.5 mm grainsize compared to an equally thick fibre absorber. The flow resistivity in kPa s/m² of the pore volume in the granules is varied.

Figure 5: Bild 5 Epoxidbindung.bmp
Slice of a computer tomography of expanded glass granules bound by epoxy. Edge length of the cutout 7.2 mm.

Figure 6: Bild 6 Sinterung.bmp
Slice of a computer tomography of expanded glass granules bound by sintering. Edge length of the cutout 7.2 mm.