Short Communication

REAPOR® – Sintered open-pore glass foam as a high-strength sound absorber

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The market for sound insulation products and services, accounting for some 6 000 mill. DM per annum in Germany alone, is covered to the extent of more than 90 % by developments which are over 40 years old. Experts at the Fraunhofer Institute for Building Physics (IBP) (Director: Prof. Dr. Dr. h. c. mult. Dr. E. h. mult. K. Gertis) have, together with an increasing number of small to medium-sized licensees, concentrated on the development of alternative, fibre-free absorbers (ALFA). The aim is to thus reduce noise pollution with more efficient sound-proofing technologies even in cases where traditional sound insulation materials are at a disadvantage as regards fitting and durability.

REAPOR® – ein druckfester Schallabsorber aus porösem Glas

Der Markt für Schallschutz-Produkte und Dienstleistungen mit ca. 6 Mrd. DM/a allein in Deutschland lebt zu über 90 % von Entwicklungen, die älter als 40 Jahre sind. Experten des Fraunhofer-Instituts für Bauphysik (IBP) (Direktor: Prof. Dr. Dr. h. c. mult. Dr. E. h. mult. K. Gertis) haben, zusammen mit einer wachsenden Zahl von mittelständischen Lizenznehmern, auf die Entwicklung neuer alternativer, faserfreier Absorber (ALFA) gesetzt. Mit effizienteren Schallschutz-Technologien möchte man so die Lärmbelastungen auch dort abbauen, wo herkömmliche Akustik-Materialien hinsichtlich Montage und Dauerhaltbarkeit Nachteile aufweisen.

1. Introduction

The overall cost to the economy of noise pollution in Germany alone can be put at over 30 000 mill. DM per year [1]. This total, comparable to the entire electricity costs of all private households, takes not only the costs of noise-generated hardness of hearing (approx. 1 %) and cardiac and circulatory ailments (5 to 8 %) into account, but also the public's "readiness to pay" for peace and quiet. These few figures clearly show that sound insulation is not a luxury that an affluent society can afford in times of plenty but also dispense with in times when money is short, but that it is an economic and environmental factor of the first order. To the obvious costs of noise pollution must be added further damage to health and losses in productivity caused by the noise-induced reduction in working efficieny as well as a number of hidden noise protection costs. These are balanced by investments in noise abatement amounting to approx. 300 mill. DM/a in the public sector, to approx. 600 mill. DM/a in the manufacturing sector and approx. 2 800 mill. DM/a in private households. Annual investments in combatting noise pollution, including planning and supervision costs, thus amount at present to a mere 4 000 mill. DM. There is thus considerable ground to be made up in noise reduction as regards machines, plant, and on the roads.

The environmental sector, flourishing on the world market at 20 %, could expand its technological lead even further (e.g. in the case of air purification plant) if it showed more confidence in innovative, environmentally compatible materials for acoustic building elements and in building methods that are installation- and maintenance-friendly. Particularly in their treatment of low frequencies and under tough operating conditions, conventional sound absorbers exclusively employing synthetic mineral fibres and high-resilient foams as absorption materials have several disadvantages [2].

The wide demand for non-fibrous absorber materials for noise control in many branches of industry prompted the Fraunhofer Institute for Building Physics (IBP), Stuttgart (Germany), to develop new materials as passive absorbers. Back in the 80s, a mineral-organic gypsum foam based on FGD gypsum produced as a secondary material in flue gas desulphurization, as well as on water and a prepolymer MDI (methylene di-(phenylisocyonate)) was formulated and is used successfully today in mobile wall-divider systems [3 and 4]. For years the IBP has been concerned with the use of porous bulk materials in technical acoustics. Here expanded glass granulates have demonstrated their particular suitability by virtue of their high sound absorption capacity. But in view of the form taken by the product, such loosely-packed materials have limited applications. In order to supply the demand for completely inorganic absorber materials with good shaping properties, a manufacturing process has been developed over the past few years with the help of which siliceous granules can be turned into open-pore, inorganic foams. It is thus, for example, possible to produce, from thermally expanded, vulcanized glass (Perlite), absorbing components with a low specific gravity (150 to 300 kg/m^3) which are suitable, for instance, as nonflammable baffles. Within the framework of these projects, a new pressure-resistant absorber material based on recycled glass (REAPOR®) was formulated [5].

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2. REAPOR® property profile

For over 7000 years, man has known and used glass, constantly attempting to improve its properties. The concept "glass" is often associated with the idea of transparency, and of water and gas proofness. REAPOR® is, by contrast, an opaque glass made of recycled glass with individually-adjustable micro- and macropores[1]. Figure 1 shows the microscopic structure. Both the pore spaces within the sintered granulates and in the intermediate spaces are clearly visible. By modifying the pore structure, the most important building physics properties such as sound absorption, caloric conductivity and compressive strength can be changed as required. Table 1 shows the REAPOR® property profile realized so far. Important features, alongside the high degree of sound absorption, are the compressive strength which can be achieved as well as the resistance to temperature and chemicals. The graph in figure 2 shows the results of measuring the degree of sound absorption in dependence on frequency for a REAPOR® panel 75 mm thick (raw density 400 kg/m^3). An absorption degree of >0.6 is already achieved at a frequency of 250 Hz, remaining at about this level until 2000 Hz are exceeded. The good recyclability of the soda-lime glass used permits material cycles in the sense of true recycling which have so far only been achievable for building materials in individual cases, e.g. in the case of structural steel.

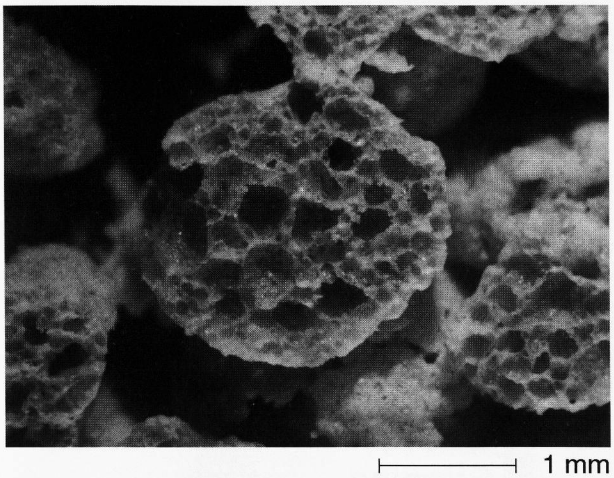

Figure 1. Microphotograph of a REAPOR®.

Table 1. Overview of the most important properties of REAPOR®

tested property	values determined for REAPOR®	testing method
pressure resistance	0.7 to 9.0 N/mm^2	DIN 1164 [6]
water proofness	0.0 wt%	refractory guideline
raw density	300 to 500 kg/m^3	DIN 51 065 [7]
caloric conductivity	0.078 W/(m · K)	DIN 52 612 [8]
water vapour permeability	25	DIN 52 615 [9]
degree of sound absorption	>0.6	analogous to DIN 52 215 [10]
softening temperature	540 °C	DIN 51 045 [11]

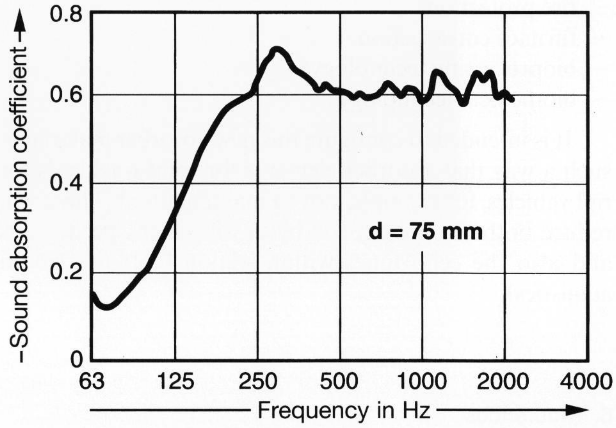

Figure 2. Sound absorption coefficient in dependence on frequency for a REAPOR® panel 75 mm thick (raw density 400 kg/m^3).

3. REAPOR® production

Starting with shards of recycled, a preliminary processing step is followed, as schematically shown in figure 3, by a grinding and mixing process during which an expanding agent is added. Subsequently, the granules are thermally expanded and finally fractionated. These products are already commercially available and are used in many cases as light aggregates for mortars. In the production of REAPOR®, these expanded glass granules are coated with a sintering assistance agent. With the aid of a moulding procedure (e.g. axial compression), the resultant mass is shaped into a moulded body which is subsequently dried. The green product thus produced and which can already be mechanically processed is subjected to a final thermal treatment during which it is fired like a brick. During this firing process, a kind of liquid-phase sintering takes place which "glues" the expanded glass granules to one another at certain points. In the course of this sintering process, there is an exchange between the liquid phase and the granules, which results in a bonding of the materials themselves. The resulting fibre-free absorber material can subsequently be machine-cut, e.g. by drilling, sawing or milling on commercially available machines, permitting simple application.

4. Applications

The property profile of this new material enables it to be used in a wide range of applications. By varying the pore structure, the material can also be tailored to individual fields of application. Its acoustic properties, for instance, can be optimized by adapting the flow resistance. In combination with the chemical resistance of the systems, these structure parameters are, however, also of the greatest importance to bioprocessing and biomedical technologies.

[1] REAPOR®: *Re*cycliertes *A*ltglas mit gezielt einstellbaren Mikro- und Makro-*POR*en.

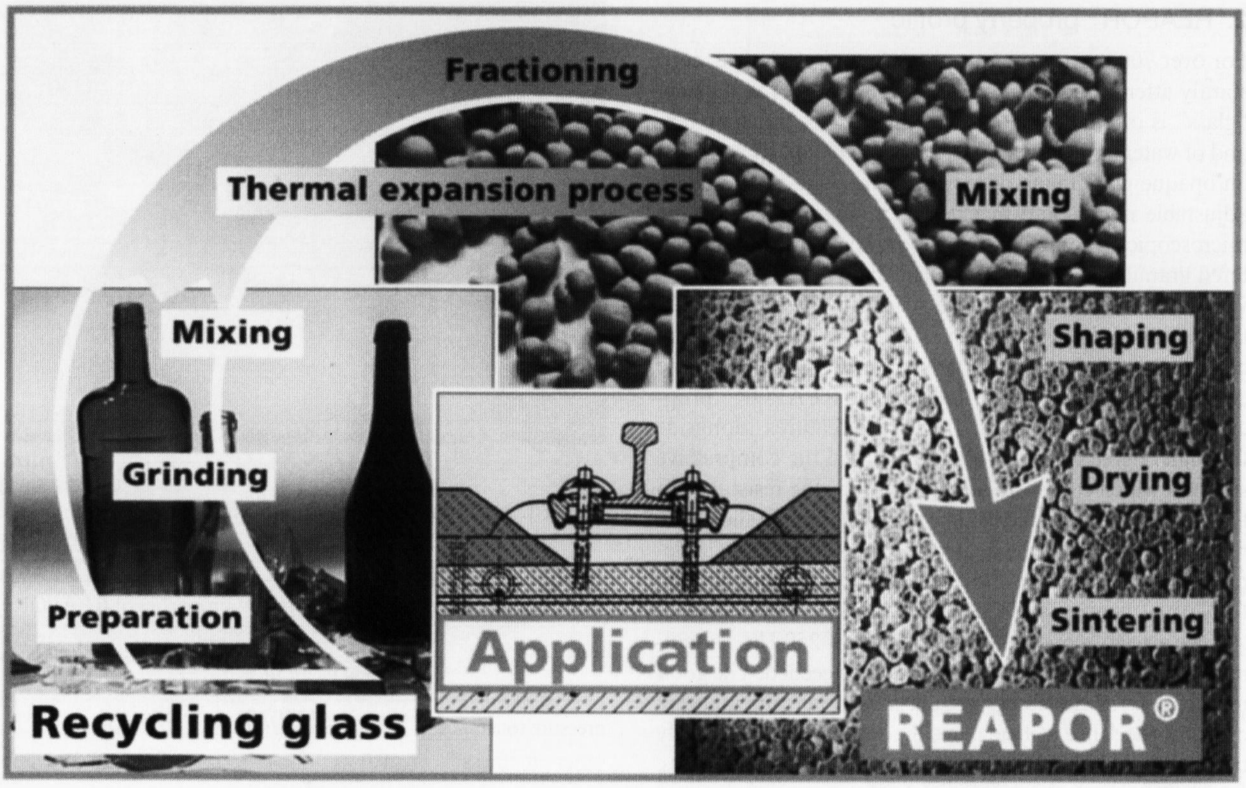

Figure 3. Schematic presentation of the REAPOR® manufacturing process.

The most important fields of application will be found wherever porous materials of high mechanical strength and chemical or thermal resistance are needed. The principal fields of application are:

- sound-proofing;
- thermal insulation;
- fire protection;
- furnace construction;
- bioprocessing technology;
- biomedical technology.

It is intended to configure this new absorber material in such a way that absorber elements for solid trackbeds for rail vehicles, for example, can be manufactured. These will reduce both the noise made by passing high-speed trains and also the echo times within station buildings (room acoustics).

6. References

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