TEXTILE NOISE REDUCTION – REQUIREMENTS; OPTIONS AND RESTRICTIONS FOR INTERIOR DESIGN

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ABSTRACT

Noise conditions in large office rooms have a negative impact on the people in the workplace, which results in stress, tension and decreased work performance. Also other large rooms like trade shows, hotel lobbies, conference centres or theatres have to deal with noise and the influence of sound on comfort and performance of human beings.

The aim of this work is to:
- examine how textile noise absorbers are working, that are already available on the market.
- inspect the fields of application within large rooms regarding restrictions and requirements
- demonstrate the possibilities of enhancing the efficiency of noise absorption within textiles

Key Words: acoustic textiles, sound absorbers, indoor textiles, functional fabrics

1. INTRODUCTION

In common indoor rooms like offices, conference centers or hotel lobbies a wide range of textiles is used for different purposes. Each textile surface has a certain influence on the behaviour of sound waves within the room, intentionally or unintentionally. Some textile elements such as ceiling panels, wall panels or partition walls (red marks in **Figure 1**) are implemented intentionally to improve the acoustic quality within the rooms.

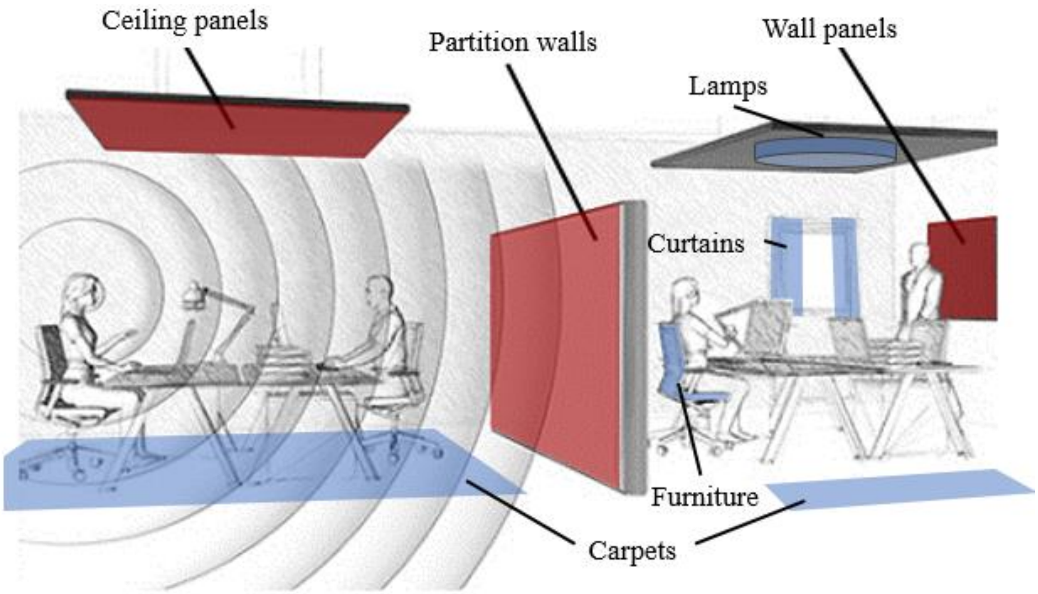

Figure 1: Possible room furnishings for improved room acoustics [1]

The aim of this work at Institut für Textiltechnik der RWTH Aachen University (ITA), Aachen, Germany is to further enhance the noise reduction within such rooms by changing the properties of the textile surfaces which are necessary in an office, a lobby or theatre (blue marks in

Figure 1). In this case the existing textiles are replaced by a sound absorbing version e.g. curtains, sun shades, lamps, chairs and carpets. Therefore, no additional elements are necessary which results in more space and less cost in total.

2. ACOUSTICS IN ROOMS

Sound absorption is a decisive criterion for room acoustics and is based on the loss of energy of the sound waves. The energy of the sound waves is converted into heat due to different processes when getting in contact with an object. A sound wave that hits a surface can be reflected, absorbed and/or transmitted (see **Figure 2**). This behaviour is depending on the intensity of the sound wave as well as on material and structure of the surface.

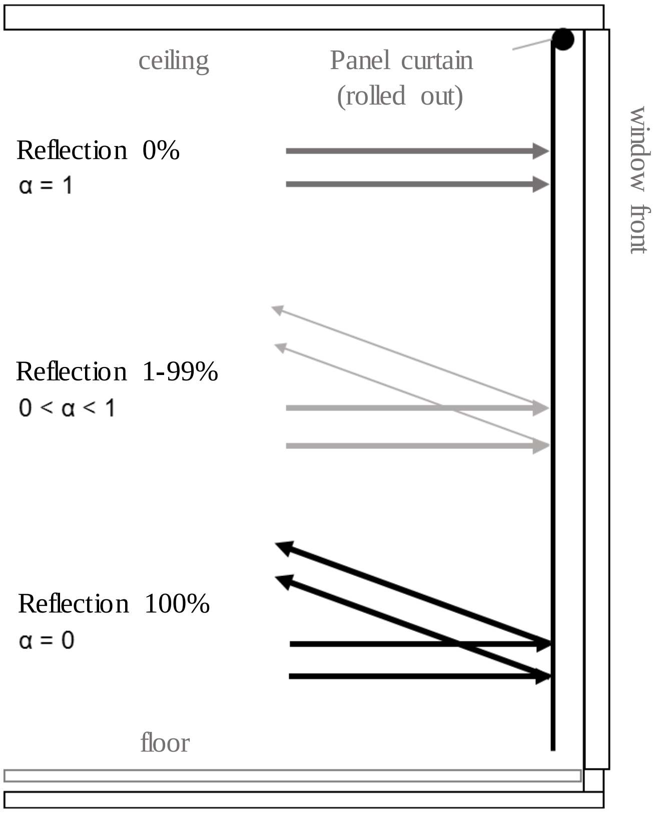

Figure 2: Principle of reflection and sound absorption coefficient [3]

The sound absorption coefficient indicates the absorption capacity of a material, measured in percent. It is the quotient of the absorbed intensity and the intensity of the impacting sound wave. In case of a dense, soundproof wall the sound absorption coefficient is therefore 0 %. The value is α = o and stands for a complete reflection. A complete absorption with a coefficient of $\alpha = 100$ would be the effect occurring with an open window. [4]

Objects that a sound wave hit can have a different sound absorption behaviour depending on material and structure of the surface. A high pile carpet, for example, has a high sound absorption behaviour. Used in a room, this type of carped induces, that noise cannot spread far and fades away quickly. Heavy, voluminous curtains have a similar effect.

3. SOUND ABSORBERS

In general a basic distinction is made between two different types of sound absorbers: porous sound absorbers and resonance absorbers.

3.1. Porous sound absorbers

Porous sound absorbers usually have a structured, voluminous or bulky surface. This surface forms a larger impact area for the sound waves than a smooth surface of the same size would. Porous sound absorbers primarily absorb high frequencies. This type of sound absorber can be a surface especially designed for noise reduction. On the other hand, every garment, carpet and even person can act as a porous sound absorber and contribute to changing room acoustics.

When considering porous sound absorbers like curtains or ceiling panels, the distance from the sound-reflecting wall is decisive for their absorption maxima. The ideal distance to the wall can be calculated using the wavelength of the respective sound source. The so called rapid maximum of a sound wave is at one fourth of its wave length. Therefore, the distance of the absorber to the wall must be increased if an absorption maximum is needed at lower frequencies. [5]

A typical curve for the sound absorption coefficient of different frequencies is shown in **Figure 3**, comparing porous sound absorbers and resonance absorbers. It is noticeable that porous absorbers are more efficient for higher frequencies.

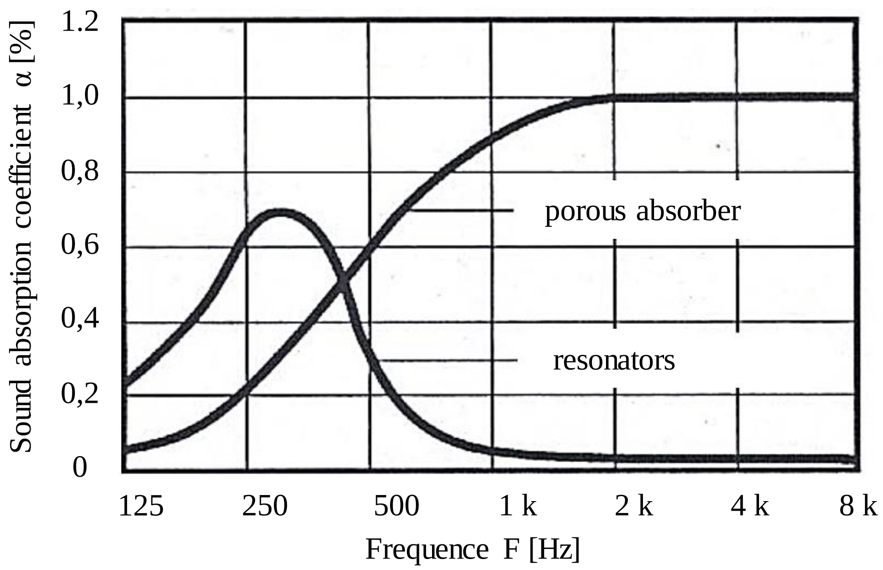

Figure 3: Principle frequency curve of sound absorption coefficient α of porous absorbers and resonators [2]

3.2. Resonance absorbers

Resonance absorbers are also called resonators. They are structures that vibrate as a result of the incoming sound. The sound is damped and its further dissemination reduced. [6] An example from everyday life is the cover of a loudspeaker. At high bass, i.e. low frequencies with high sound pressure levels, clearly visible vibrations of the loudspeaker cover occur. A special type of resonance absorber frequently used in room acoustics is the Helmholtz resonator. The principle is shown in **Figure 4**.

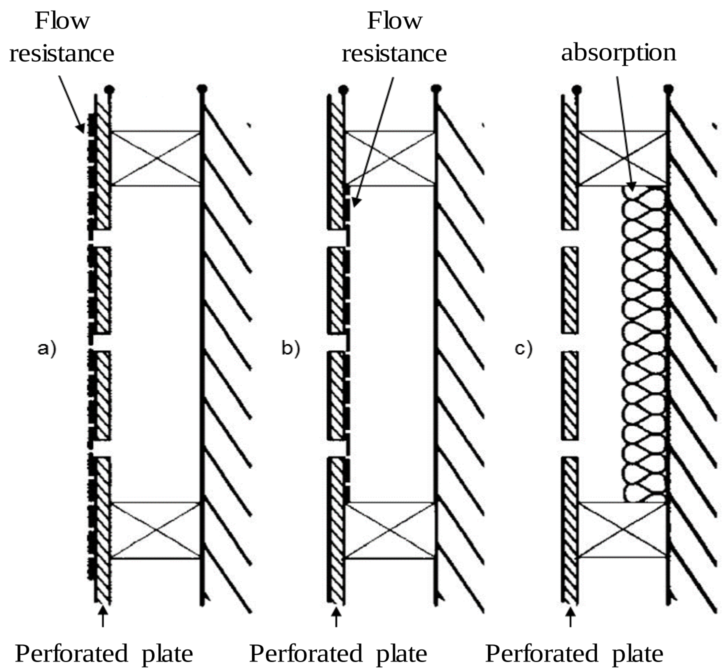

Figure 4: Helmholtz resonators of classical design with damping (c) in the cavity or flow resistance (a) in front or (b) behind the perforated plate [7]

There are three classical types of Helmholtz resonators, which are equipped with a flow resistance in front of the perforated plate, behind the perforated plate or with a damping in the cavity. Helmholtz resonators usually consist of a perforated or slotted plate combined with damping or a flow resistance material. In order to absorb vibrations, the resonators are mounted at a distance from the wall. The resonance frequency decreases as the distance between the shells increases and as the mass of the cover surface increases. Both the shell distance and the wall distance are of great relevance for the effectiveness of a resonator.

4. TEST METHODS

Sound absorption measurement in the impedance tube is a common test procedure for determining the sound absorption of textiles. In this test, only vertically arriving sound is measured. The test setup is shown schematically in **Figure 5**.

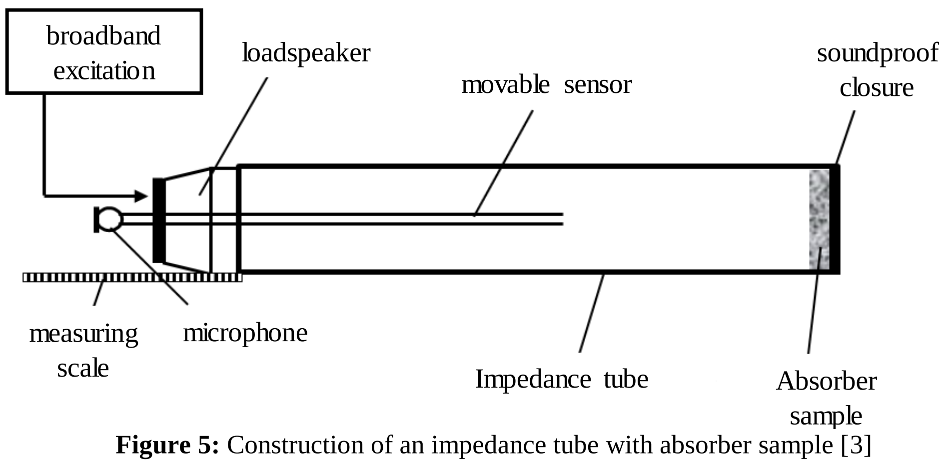

Figure 5: Construction of an impedance tube with absorber sample [3]

A loudspeaker generates a sound wave in a round, closed impedance tube. The superposition of the output wave and the reflected wave produces a standing wave, which forms between the loudspeaker membrane and the absorber sample or pipe end. A sensor with microphone is mounted in the impedance tube so that the pressure minima and maxima can be measured. This is used to determine the reflection factor and thus also the degree of absorption of the absorber sample or soundproof tube closure. [8]

5. REQUIREMENTS AND RESTRICTIONS

For each application of acoustic textiles shown in **Figure 1** different restrictions and requirements apply. This is even more important if the acoustic properties of a textile, that is already following a certain purpose, should be increased. Sun shades, for example, should be foldable or rollable, whereas a porous absorber requires a voluminous, open structure. The approach of a new development should therefore be to increase the acoustic properties without the reduction of already existing functionalities. The following table gives a brief insight into the requirements for some exemplary applications.

Table 1. Requirements of textiles related to different applications

x = relevant	Curtain	Carpet	Lamp	Chair/ furniture	Wall panel	Sun shade
Transparency	x		x			x
UV resistance	x	x	( )	( )	( )	x
Flame retardancy	x	x	x	x	x	x
Flexibility/drapability	x			( )		x
Low thickness	x					x
Abrasion resistance		x		x		( )

6. DEVELOPMENT APPROACHES

Many textiles with acoustic properties are specially developed for the use in acoustic products like wall and ceiling panels as well as partition walls. These products therefore represent an additional purchase for the company, the hotel or theatre. By improving the acoustic properties of already existing textile surfaces there can be two effects: either cost reduction or increasing the absorption effects in a room in total. Consequently, innovative solutions for room design and textile material are required. As an example, the Nimbus Group, Stuttgart, has created an innovative textile solution with the Rossoacoustic Lighting Pad, which serves both as sound absorber and light source. It has a nonwoven surface with integrated LED lights. Light sources are part of the basic equipment of every room, therefore the idea to equip them at the same time as sound absorbers and to integrate the lighting technology into the acoustic panel is an innovative solution.

The Institut für Textiltechnik of RWTH Aachen University (ITA) in Aachen is representing the whole process chain of a textile production, starting with a polymer granulate and ending with a finished fabric or even a structural element. Therefore, the approach of this work on acoustic textiles is to analyse and enhance the acoustic properties on all different production levels:

- Fibre material: e.g. polymer structure
- Fibre dimension and shape
- Yarn structure

- Fabric construction
- Finishing and Coating

7. CONCLUSION AND OUTLOOK

The approach of the ITA for the development of innovative acoustic textiles is to work interdisciplinaryly to maximize the noise reduction within rooms. Different projects are addressing all levels of the textile process chain without losing the focus on the final application with its restrictions and requirements.

Furthermore, this knowledge can be transferred to further application fields. Within the automotive or aircraft industry noise is a very important factor when looking at comfort and security of the passengers. Within this sector it is essential to address not only high frequencies, but to improve also the noise reduction at low frequencies. Consequently, both principles, the porous noise absorber as well as the resonance absorbers will be considered for textile applications.

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