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The sound absorption evaluation of rattan cane

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ABSTRACT

The objective of this paper is to investigate the rattan materials and test the sound absorption coefficients of rattan cane with standing wave tube. We discuss the relationship between the sound absorption performance and sample thickness, and analyze the influence of epidermis and nodes as factors on the sound coefficients. The results show that rattan cane material has good absorption properties, the sound coefficients increase with the increasing frequency; the coefficients increase with the adding thickness; epidermis and nodes improve the absorption properties. As a whole, rattan cane material has good absorption properties, and can be provided as a basis for future usage.

KEYWORDS

Rattan cane; Standing wave tube; Sound Absorption Coefficient.

Noise pollution has become a worldwide problem, and along with water and air pollution are listed as the top three global pollutions[1]. With the rapid development of industry and agriculture, noise pollution is becoming worse, and it becomes a hot issue in the environmental governance process now. Currently, the main solutions are controlling sound source and using sound-absorbing materials[2], the latter being the most effective and practical way to control noise. Absorption coefficient is an important measure in the sound absorption properties, which can be expressed as the energy absorbed by a material or has not been reflected out of the total incident energy: the greater the absorption coefficient is, the better the sound absorption properties is[3]. Good absorption properties of a material have some general characteristics, such as lightweight, loose and porous. Porous materials have a great sound absorption coefficient in high-frequency, but small in low-frequency. With the successful development of the new types of porous materials, the sound absorption performance has been significantly improved under low-frequency. Therefore, porous material has become the most widely used in modern sound-absorbing material[4-5].

The research about the materials absorption properties is mainly focused on wood, metal, ceramic, etc. For example, wood-based panels, particleboard and wood composite materials have been discussed[6-10]; metal fiber materials for sound absorption characteristics have been studied[11-12], and the results show that the metal fibers have excellent sound absorbing properties and great abilities to work in inferior conditions; there are also some comparative studies on sound-absorbing materials[13], from which ceramic as a sound-absorbing material has advantages to meet some special working conditions. There is also some research on the absorption properties of materials[14-15]. As a natural porous material, rattan cane has desired properties of the absorbing material, such as lightweight and loose structure, but research on the absorption properties of rattan cane materials has not been reported yet. Since the available information on such properties is lacking and many rattan cane species remain unutilized, research is needed to determine the properties of those species and develop their appropriate utilization technology. In this paper, we take rattan cane material for the study of absorption coefficient measurements and evaluate its absorption properties, which can provide a theoretical basis for the use of rattan cane material.

MATERIALS AND METHODS

The materials were taken from rattan cane *(Calamus manna)* grown in Ruili, Yunnan Province, China. Their length and diameter are 20cm and 3.2cm in average, respectively. The rattan was cut into segments (1cm, 5cm, 10cm longitudinally and about 4cm^2 in cross-section). According to the length and diameter of the standing wave tube, we selected some samples with a diameter of 2.9cm and took the knot samples with a diameter of 10cm, in order to reduce the impact on the absorption properties of the samples with knots. Then the samples were kept in a Humidity Chamber (20℃, 65% h) preparing them for the experiment (Figure 1).

Figure 1 : Experimental materials

According to GBJ88-85 "*Standing wave tube sound absorption coefficient and acoustic impedance measurement norms*" and GB3240-82 "*Commonly used frequency in Acoustical measurement*", we took the standing wave tube to measure the sound absorption coefficient of the rattan cane material, and took six frequency doublings to measuring the absorption coefficient of materials, such as 125, 250, 500, 1000, 2000, 4000 Hz. We selected multiple samples and several points to measure, and then took the arithmetic average to evaluate the material sound absorption performance. Results on the material sound absorption performance showed that when the absorption coefficient is greater than 0.2, it is sound-absorbing material, and if the coefficient is greater than 0.56, it is called efficient sound-absorbing material[16]. The experiment is conducted at the Institute of Acoustics. The equipment is shown in Figure 2.

Figure 2 : The experimental equipment

RESULTS AND DISCUSSION

The affection of sample thickness on absorption characteristics

The sound absorption characteristic of the sample curve in different thickness is showed in Figure 3. The results show an upward trend in the absorption coefficient while the thickness increases. That's because the air flow resistance affects the sound absorbing properties, which represent the size of resistance when air goes through the material per unit thickness. When the thickness of the material is small, the air flow resistance is large, and only a smaller amount of air can penetrate, the absorption properties exhibited a downward trend; increasing the material thickness, the acoustic performance will be improved. It also addresses that there is a sound absorption peak when the frequency is maintained at 1000Hz, and in the low-frequency phase, the absorption coefficient increases while the frequency increases; when the frequency is higher than 1000Hz, the sound absorption curve is showing a certain degree of volatility, but the sound absorption coefficient is larger than that in low-frequency. It indicates that the material had a better sound absorption performance at high frequency, but in the initial phase of the experiment, there was almost no sound-absorbing effect.

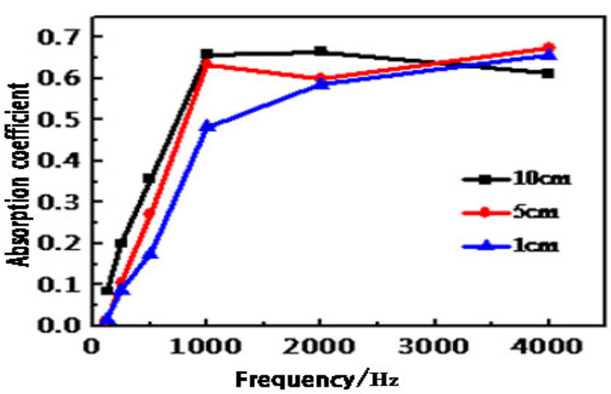

Figure 3 : The affection of sample thickness on absorption characteristics

The affection of knot on absorption characteristics

To indicate whether the knot will impact the sound absorption characteristics, we select samples with and without knots to test at different frequencies, and then get the corresponding characteristic curve (Figure 4). The results show that knots improves the sound absorption performance significantly. That's because the material with a knot changes the frequency of the incident sound wave, increases the energy component of the vibration signal and consumes more energy. And because of the viscous and friction of the material, a large part of the sound energy turns into heat, so the sound energy attenuates. In addition, the epidermis near the knot is dense, it prevents a part of sound energy from penetrating outside and weakens the feedback of the sound energy, and thus it improves the sound absorption coefficient of the material.

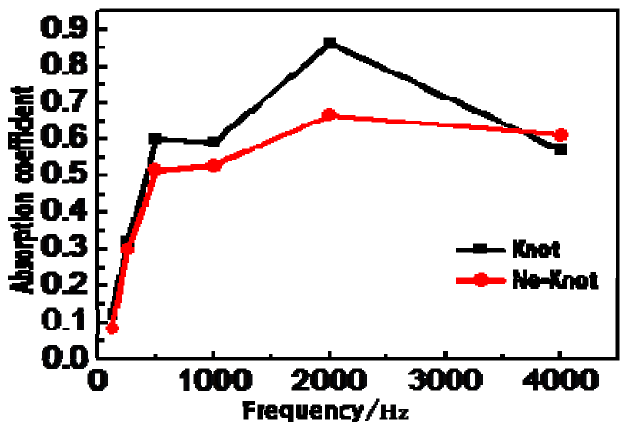

Figure 4 : The affection of knot on absorption characteristics

The affection of epidermis on absorption characteristics

Rattan cane as a monocot plant, without lateral tissue, has a big difference of the vascular density distribution in transverse section. The part of the tissue near the epidermis is denser than the inner, and it also has high mechanical properties. The study shows that epidermis could promote the sound absorption properties of the material (Figure 5). This is because the part of structure near the epidermis is dense and when the acoustic wave spreads in the material, only a small part of the sound waves are transmitted into the air after reflection on the inner wall with most of the waves reflected back. Together with internal friction, viscous and heat conduction, most of the sound energy turns into heat energy and can then be absorbed. All the aforementioned improve the sound absorbing properties of the material. There is a sound absorption peak when the frequency is maintained at 1000Hz; it has a higher sound absorption coefficient in this phrase. The absorption coefficient also increases slowly while the frequency increases, which shows that the material has good sound absorption properties in high-frequency.

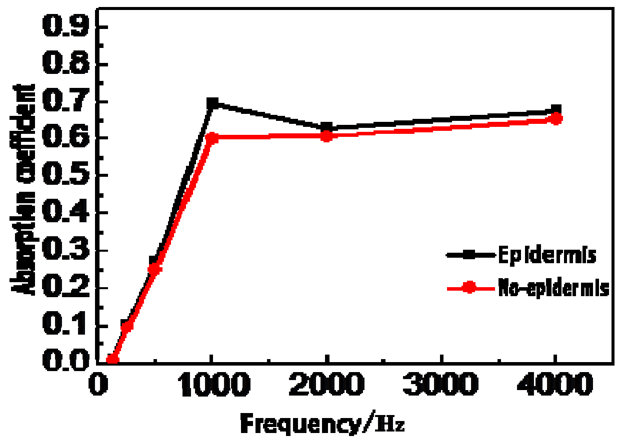

Figure 5 : The affection of epidermis on absorption characteristics

RESULTS

Rattan cane has good absorption properties, and in the current study the main factors are epidermis, thickness, knots and frequency phrase. Material thickness has a significant impact on absorption characteristics. In the same frequency phrase, the larger the material thickness is, the greater the absorption coefficient is, and the better the sound absorption properties of the material are. The sound absorption performance of the rattan cane is not distinct under low-frequency, and there are almost no absorption properties during the initial phase of the experiment, but there is lager sound absorption coefficient in middle and high frequencies.

Knots have a certain impact on absorption properties of the material. It changes the incident sound energy and the frequency of the sound wave, because of its friction and viscous force, which make most of the sound energy turn into heat, increases the acoustic energy absorbing, thus improves the absorption properties of the material.

Epidermis also has a distinct impact on absorption properties of the material. The epidermis reduces the amount of the sound energy projection, and increases the absorption coefficient and the consumption of the acoustic energy, thus improves the absorption properties of the material.

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