Acoustic Properties of Weave Structure Depending on Their Internal Geometry

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SUMMARY

The rapid growth of civilization, especially in urban areas, has led to increased noise pollution, which can have a negative impact on our acoustic well-being. Excessive noise levels can cause stress, sleep disturbances, hearing damage, and other health problems.

Sound insulation materials are designed to reduce the amount of noise that passes through walls, floors, and ceilings, thereby reducing the level of sound that is transmitted from one space to another. This can include materials such as acoustic panels, acoustic ceiling tiles, and soundproofing curtains. On the other hand, sound-absorbing materials are designed to absorb sound energy and prevent it from reflecting into space, reducing the overall noise level. These materials include acoustic porous or foam materials, acoustic wall panels, sound-absorbing tiles, etc.

The sound absorption effectiveness of the porous acoustic material is limited at higher frequencies. To overcome this limitation and to maximize the absorption performance of porous materials, it was necessary to investigate woven fabrics' different weave structures and yarn properties. Therefore, this thesis aims to investigate the acoustic characteristics of woven fabric related to its weave structure and yarn properties. As a result, using woven fabric increases the level of sound absorption at low frequencies in the porous material is the main hypothesis of the study.

To understand the impact of the yarn characteristics on the fabric structure, the samples were prepared using only polyester fiber as textured (dtex 167 f 32 × 2), twisted (dtex 334 f 32 × 2, (S95), and staple yarns (dtex 200 × 2). In addition, four basic weave structures, such as plain, rib, sateen, and twill, were selected based on the assumption of differences in their porosity. The study started with the preparation of fabric samples using the Sample Dobby Loom SL 8900S. Overall, 12 woven fabrics were prepared. Yarn physical characteristics such as yarn twist/m, yarn hairiness, and yarn evenness were investigated. Furthermore, fabric properties such as warp and weft density, fabric thickness, mass per unit area (g/m^2), crimp %, cover factor, porosity, roughness, and air permeability were studied.

The acoustic properties of woven fabrics were measured using two methods. Firstly, acoustic anechoic chambers were utilized to understand fabrics sound absorption phenomena from different

incidence angles. The measurements were performed in the range of low to medium acoustic frequencies. As a result, the materials measured at 0° from the sound source demonstrated higher sound absorption than the fabrics measured at 45° of incidence angle. This result is beneficial when applying such material to obtain satisfactory absorption results. The fabric's sound absorption results are also different based on the yarn they were formed from and the type of weave structure. As a result, the plain weave structure showed higher sound absorption over the rib, sateen, and twill weave structures. Generally, the fabric formed from textured yarn demonstrates higher sound absorption than the other yarn types.

The second acoustic examination was conducted in an impedance tube with a frequency range of 80–5,000 Hz. Fabrics with similar weave structures were measured as single, double, and triple layers, with a combination of nonwoven and air gaps. Acoustic test for only woven fabric with different layers reveals low absorption. In addition, the sample, which consists of a woven fabric with an air gap, exhibits a higher sound reduction coefficient. As a result, except for the sateen and rib weave structures formed from staple yarn, the fabrics can be categorized as useful acoustic materials. The outcomes of combining woven and nonwoven fabrics can be categorized as high-performance absorber materials. The Noise Reduction Coefficient of the nonwoven fabric cannot be classified as an acoustic material because the result is below 0.2. In contrast, single-layer plain fabric with nonwoven fabric and single-layer plain fabric with an air gap indicates a higher sound absorption coefficient at lower frequencies than other results.

Based on additional testing, the most effective soundproofing package consisted of three layers of sateen fabric, nonwoven fabric, three layers of plain fabric, and an air gap (3TS+N+3TP+A) prepared. As described in the preceding section, plain fabrics have a particularly high absorption at low frequencies. In order to maximize acoustic performance, plain fabrics are employed as a base material. In addition to nonwoven fabric and airgap, combining different weave structures sateen with plain fabric with proper layout design and a number of layers can improve the sound absorption performance of multilayered porous materials below 500 Hz. Furthermore, between 400 - 5000 Hz, with increasing and consistent sound absorption obtained between 0.8 – 1(α). Generally, these combined samples (3TS+N+3TP+A) can be acoustic in environments at low to high frequency bands.