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Study on Sound Absorption Performance and Transmission Behavior of Perpendicular-laid Nonwovens ⋆

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Abstract

This work deals with the study of acoustic performance of perpendicular-laid nonwovens and their relation to fabric air permeability and thermal properties. Seven perpendicular-laid nonwoven fabrics were selected to examine sound absorption like average values of sound absorption coefficients ($\overline{\alpha}$) and noise reduction coefficient (NRC) as well as air permeability and thermal insulation properties. The Brüel and Kjær impedance tube instrument, Alambeta and FX3300 Air Permeability Tester were used for evaluation of acoustic, thermal and air permeability properties, respectively. It was observed that sound absorption had insignificant correlation with thermal conductivity while it was strongly correlated with thermal resistance. And the correlation coefficient of NRC and thermal resistance was 0.9835, indicating that NRC was directly proportional to thermal resistance of perpendicular-laid nonwovens. It also was observed that $\overline{\alpha}$ was inversely proportional to air permeability, with correlation coefficient 0.95. It was concluded that a higher thermal resistance and lower air permeability suggested a better sound absorption performance for a perpendicular-laid nonwoven fabric.

Keywords: Perpendicular-laid nonwoven; sound absorption; thermal conductivity; thermal resistance; air permeability

1 Introduction

Nonwovens have very high porosity, high specific surface area, economical price, light weight, good elasticity and a great flexibility in air permeability, they can be presented in a large number of kinds of fiber assemblies, above characteristics decide that nonwovens have been widely applied in thermal insulation and sound absorption field [1].

Thermal properties of nonwoven fabrics are extensively studied by researchers. Generally, the thermal insulation properties of nonwoven fabric have a strong correlation with its fabric

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dimensional and structural parameters [2]. Arambakam numerically investigated the thermal performance of fibrous insulation materials and concluded that heat conduction through fibrous structures increases by increasing the solid volume fraction, fiber diameter, and fibers' through-plane orientations [3]. Researchers summarized that for a fixed weight, thermal insulation increases with thickness [4]. Vallabh confirmed that fabric density is a significant factor influencing the radiation component of effective thermal conductivity and the radiative thermal conductivity decreased with increase in the fabric density [5]. Soltani and Zarrebini reported that the acoustic characteristics of woven fabrics are related to fabric structural parameters such as weave type, yarn linear density, yarn twist, and fabric thickness of woven fabric [6]. Moreover, they stated that air permeability of woven fabrics, which is strongly dependent on fabric cover factor, can be used as a criterion of sound absorption behavior. Yang and Yu conducted experimental study and found that nonwoven fabrics with highest value of air permeability exhibit inferior acoustic absorbency [7]. Kucuk M and Korkmaz Y measured sound absorption properties of eight different nonwoven composites including different fiber types mixed with different ratios, they stated that the increase in thickness and the decrease in air permeability results in an increase in sound absorption properties of the material [8]. Perpendicular-laid nonwovens exhibit excellent compression recovery, softness and very good sound absorption performance since perpendicular-laid nonwovens have highloft structure where all the fibers are orientated in the vertical plane [9, 10, 11]. Tascan and Vaughn investigated the acoustical insulation of perpendicular-laid nonwoven fabrics made from different polyester fibers, and stated that fabrics made from 3 denier fibers have better sound insulation than those made from 15 denier fibers. It was also found that perpendicular-laid nonwoven fabrics made from 4DG and trilobal fibers showed better sound insulation than those made from round fibers [12, 13]. Klara Kalinova reported that perpendicular-laid nonwovens (perpendicularly laid fiber web) have better sound absorption performance than longitudinally laid fiber web [14].

Since the transmission behavior and acoustic property of nonwoven both strongly depend on its structure parameters, for a specified nonwoven fabric there should be some relation between these performances. However, there is very limited research devoted to understanding this relationship. In this paper, seven perpendicular-laid nonwovens were selected to measure sound absorption properties, air permeability and thermal performance. The relationship between sound absorption and thermal properties were studied as well.

2 Methodology

2.1 Materials

Seven perpendicular-laid nonwoven fabrics made by Technical University of Liberec were selected to measure transmission and acoustic properties. The vibrating perpendicular lapper used to fabricate perpendicular-laid nonwovens is illustrated in Fig. 1. The vibrating perpendicular lapper consists of a carding machine, a perpendicular-laid vertical lapper and a through-air thermobonding chamber [13]. The carded web is fed onto conveyor belt and a reciprocating forming comb pulls the carded web towards the hold back roller to form a fold. The fold is pulled off the comb by a system of needles placed on a reciprocating compressing bar and pushed to the fiber layer which is created and moved between the conveyor belt and a wire grid. The fiber layer is bonded by melting bonding fibers present in the fiber blend when it passes through thermo-bonding cham-