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Research Paper

Effect of Fabric Structural Parameters on Various Comfort Properties of Automobile Seat Cover Fabrics

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Abstract

In this study, the effects of the structural parameters forming automobile seat cover fabrics on the comfort properties (such as water vapor permeability, air permeability, and thermal resistance properties of fabrics) that may affect the user's usage performance were examined. A special finishing process did not apply to the fabrics. It was aimed to evaluate the direct (without any special treatment) effect of the basic structural parameters that make up the fabric. Thus, it was considered that the fabrics used in the seat covers during the usage or after the treatments such as seat cleaning would create an important design input in terms of the breathability of the seat cover fabric and its sustainability throughout the lifetime of the car. As a result of this research, it was observed that thickness, weight per unit area, and weave structure of seat cover woven fabrics have an essential effect on the water vapor permeability, air permeability, and thermal resistivity properties.

Keywords: Automobile seat cover woven fabric, water vapor permeability, air permeability, thermal resistivity, comfort properties

1. INTRODUCTION

Besides the aesthetic and abrasion performance of the fabrics used in automobile seat cover, comfort features are also important. The breathability, permeability (air and water vapor permeability, etc.), and the fabric's thermal comfort properties to be used as seat cover are important for the sustainability of the face fabric's comfort properties used in the seat covers during use and after cleaning.

In determining the thermal comfort of seat cover fabrics used in the automotive industry, various parameters such as heat and moisture transfer, air permeability, thermal resistance, static electrical tendency, water vapor permeability, water absorbency should be taken into consideration in the design of seat cover fabrics. It is expected to have a fabric structure that minimizes sweating, especially in long-distance travel.

Automobile seat cover fabric structures are generally produced polyester, wool and wool/polyester mixture, polyamide, acrylic, leather structures [1]. Comfort in cars is closely related to the seat cover fabric structural properties and components of the seat that the user touches in the car [2]. High moisture transfer and air permeability increase comfort and decrease user fatigue [3]. For this reason, materials suitable for air, water vapor, and heat permeability are preferred in seat cover fabric [4].

Factors affecting the thermal properties of textiles could be listed as follows [5,6]:

- thermal conductivity of fiber and air held in the fabric
- special heat of the fiber
- fabric thickness and number of layers
- volume density of the fabric (number, size, and distribution of air gaps in the fabric)
- fabric surface (type of fiber, structure of fabric, finishing processes in fabric)
- contact area between fabric and surface
- atmospheric conditions: temperature, relative humidity, movement of the surrounding air.

The thermal conductivity of the fabric structure depends on the number of air gaps in the fabric. The thermal conductivity of stagnant air is lower than that of all fibers. The ideal insulating material is stagnant air. Bulky materials are capable of holding excess air in them due to their structure. A high amount of air should be present in a textile material's inner structure with high thermal insulation. Fabric thickness is one of the most important factors determining the thermal and vapor conductivity of the structure. As the thickness of the material and therefore the amount of air it contains increases, the material's thermal and vapor resistance increa-

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ses, and its permeability decreases [7,8].

The permeability of the fabrics depends on the raw material (such as fiber type, fineness, and cross-section, etc.), yarn properties (such as linear density, twist level, yarn hairiness, etc.), and fabric structural properties (such as geometrical properties, weave type, fabric thickness, porosity, etc.) as well as the finishing processes applied to those fabrics [9,10]. When the effect of fabric weave structure (considering the same density values and yarn type) on comfort properties was examined, it was observed that twill fabrics had higher air permeability, water vapor permeability, and heat resistance values compared to plain fabrics [11]. In fabrics with a knitted upper surface, it was found that the thickness value directly affects the water vapor permeability value, and the permeability decreases as the thickness increases [4].

Fabrics used as seat cover could be exposed to water and moisture effects (such as sweat, moisture, and cleaning, etc.) during usage. In this case, it was expected that the fabrics used as seat covers in terms of user comfort features had properties such as good water vapor and air permeability. These features are not only important in terms of user comfort but also affect automobile usage performance. It was expected that the seat cover fabric would dry out in a short time to prevent unwanted conditions such as smell, staining, and mold after cleaning or contact of the seat surfaces with liquid during usage. This situation was considered to be taken into account in terms of easy drying of seat cover fabrics with good air and water vapor permeability. For this purpose, it was aimed to evaluate the water vapor permeability, air permeability and thermal resistivity properties of automotive seat cover woven fabrics having with different structural parameters.

2. MATERIALS AND METHODS

2.1. Materials

In this study, 100 % polyester face woven fabrics were used. A special finishing (coating etc.) process did not apply to the fabrics. The structural parameters of automotive seat cover fabrics were given in Table 1. Seat cover fabric samples and weave structures were presented in Figures 1 and 2, respectively.

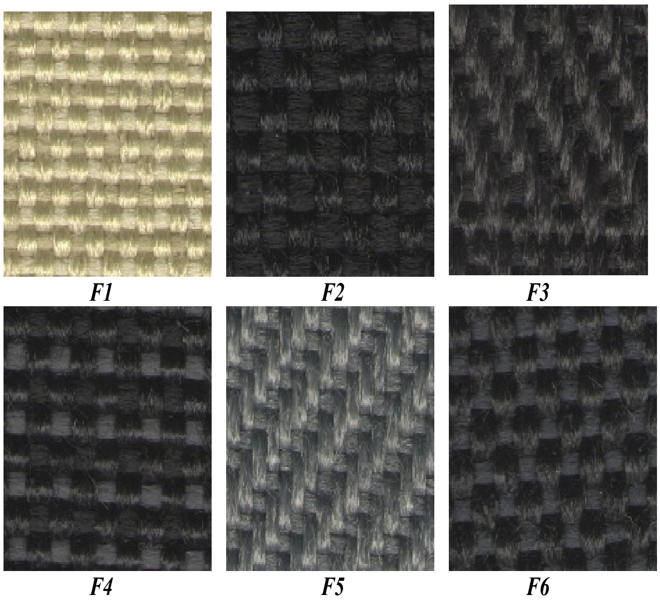

Figure 1. Images of seat cover fabric samples

F3 fabric had a dobby fabric pattern structure where twill 3/1 weave was dominant and basket 2/2 connections were formed in between.

2.2. Method

This study aimed to investigate the effect of fabric structural parameters on some comfort properties of the automotive seat cover woven fabrics. Fabric samples were conditioned at 65±2% relative humidity and 20±2°C for 24 hours by the ASTM D 1776-08 [12] standards before all mentioned tests.

Relative Water Vapor Permeability

Relative water vapor permeability is the ability of the fabric to transfer water vapor on a percentage scale. Among this

Table 1. Structural parameters of seat cover fabrics

Fabric No	Yarn Count (Nm)		Yarn Density (thread/cm)		Fabric Thickness (mm)	Fabric Weight per Unit Area (g/m²)	Weave
	Warp	Weft	Warp	Weft			
F1	28	16	16	14	0.53	228.1	Weft Rib 2/2
F2	16	16	10	10	0.83	303.2	Basket 3/2
F3	12	12	16	14	0.94	310.1	Dobby
F4	8	8	12	12	0.76	307.5	Plain
F5	18	18	18	16	0.56	233.9	Twill 3/1
F6	12	12	12	10	0.78	324.4	Weft Rib 2/2

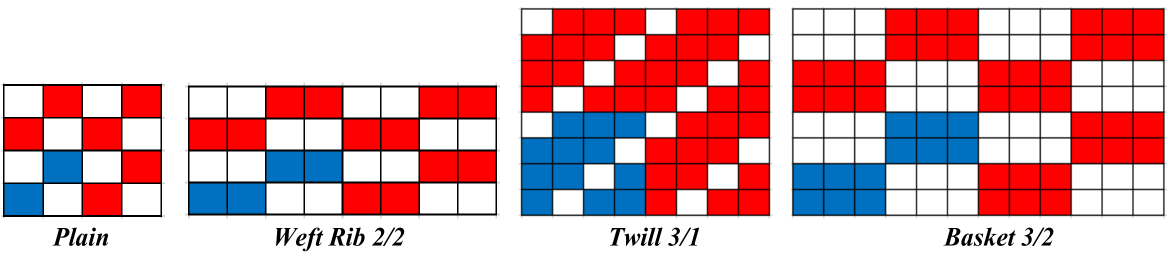

Figure 2. Weave structure of fabric samples

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study, relative water vapor permeability was measured on 'Permetest' instrument according to EN ISO 11092 standard [13].

Air permeability

Air permeability of the fabrics was measured based on EN ISO 9237 [14] standard using SDL Atlas Digital Air Permeability Tester Model M 021A. Measurements were performed by application under 100 Pa air pressure per 25 cm^2 fabric surface.

Thermal Resistivity (r)

It is defined as the resistance of the structure against heat flow. Thermal resistance was measured by using Alambeta instrument. Thermal resistance is connected with fabric thickness and thermal conductivity coefficient by the Equation (1) [15].

$$r = \frac{h}{\lambda} \quad \left(m^2 K / W\right) \tag{1}$$

where,
r: thermal resistance,
h: fabric thickness (m),
λ: thermal conductivity coefficient (W/mK)

3. RESULTS AND DISCUSSION

3.1. Analysis of the Water Vapor Permeability

Water vapor permeability values of the fabrics were given in Figure 3. In Fig.3, it was observed that the fabrics with low thickness and weight per unit area showed high water vapor permeability values. It was seen that the fabric thickness and weight values on the water vapor permeability of the fabrics were determinant according to the weave structure. Although F1 and F6 fabrics have the same weave structure, it was seen that the F1 fabric, which had a low thickness and weight, had a higher water vapor permeability value.

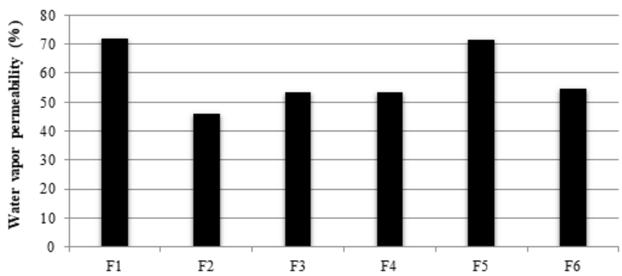

Figure 3. Water vapor permeability values of fabrics

3.2. 3.2 Analysis of the Air Permeability

In Fig. 4, air permeability values of the fabrics were given. When Figure 4 was examined, it was observed that the weave structure was a determining factor in the air permeability values of the fabrics. It was observed that plain and rib weave structures gave low air permeability values.

Higher air permeability values were obtained in weave structures (F2, F3, and F5) where the yarns made long floats. This was due to the increase in the air permeability between the yarns in the structures where the yarns have long floats. When the weave structures of the fabrics were examined, it could be seen that the twill weave structure, such as F5, increased the air permeability value (Fig. 4). Similarly, it was seen that the regions with twill weave structure in the dobby pattern structure that forms the F3 fabric also increased the air permeability value. Besides, it was observed that high air permeability values were also obtained in the basket weave structure in which F2 fabric intersects by making long floats.

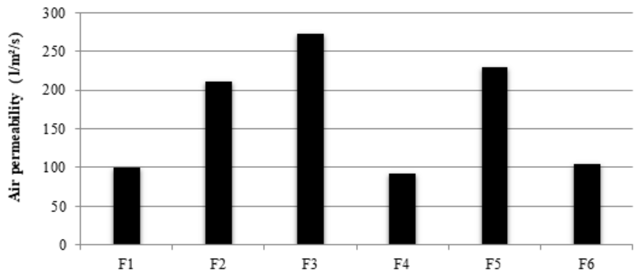

Figure 4. Air permeability values of fabrics

3.3. Analysis of the Thermal Resistivity

In Fig. 5, thermal resistivity values of the fabrics were given. In Fig. 5, it was observed that F1 and F5 fabric structures had lower thermal resistance values compared to other fabrics. It was observed that fabrics with low fabric thickness and weight per unit area values had lower thermal resistance values.

This result showed that the fabric thickness and weight values were more determinants of the fabrics' thermal resistance than the weave structure.

In the literature, it was stated that the parameters affecting fabric porosity affect the thermal transmittance of the fabric. It was stated that the parameter that most affects the thermal behavior of the fabric is the thickness of the fabric. An increase in fabric thickness affects fabric porosity by increasing fabric volume [16,17]. The high amount of stagnant air present in the structure in fabrics with high thickness values caused these structures to show high thermal resistance. Experimental results showed that the low amount of stagnant air present in the fabric structures with low thickness and weight per unit area values caused these structures to show low thermal resistance values.

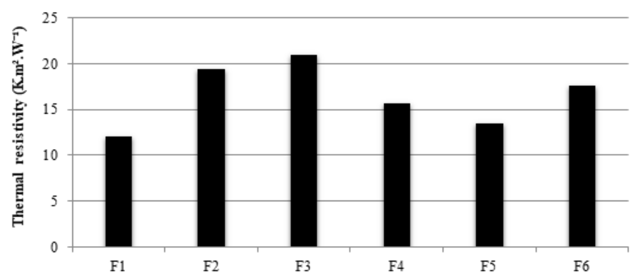

Figure 5. Thermal resistivity values of fabrics

4. CONCLUSION

In this study, the permeability and thermal resistance values of woven fabrics used in automobile seat cover woven fabrics were evaluated in terms of providing user and usage comfort. The effects of structural parameters forming the fabric on water vapor permeability, air permeability and thermal resistance values were investigated. A special finishing process did not apply to the fabrics and it was aimed to evaluate the natural effect of structural parameters in terms of high sustainable usage performance.

When the fabric structures used in automobile seat cover were evaluated in terms of user comfort, the breathability and hence permeability properties of the fabrics were expected to be high in terms of reducing user sweating. Similar expectations are important in terms of easy drying of seat cover fabrics wetted due to conditions such as cleaning or liquid spillage during use. Considering such usage expectations, fabric structures with high water vapor and air permeability should be preferred. In the experimental study, it was observed that fabrics with low thickness and weight per unit area values gave high water vapor permeability values. Experimental results showed that the weave structure was a determining factor in the air permeability values of fabrics. Higher air permeability values were obtained in weave structures where the yarns made long floats.

When the thermal resistance values of the fabrics used in the seat cover fabrics were evaluated, it was considered that it might be appropriate to prefer fabric structures that did not show high resistance to heat flow in terms of user comfort or usage comfort. Since the thermal conductivity of the materials with low thermal resistance was higher, it could easily transmit the user's body temperature, thus preventing sweating and providing comfort. Besides, since the car's interior temperature could easily balance the heat of the fabrics with low thermal resistance values, it would be ensured that the seat covers that get wet due to seat cleaning or external factors could be easily dried. In this case, the formations such as odor, stain, and moisture due to wetting would be prevented. It should be ensured that the heat did not keep within the fabric structure but that it could be transferred more easily, and thus it could be kept in balance with the surrounding temperature in a continuous manner. Therefore, automobile seat cover structures with low fabric thickness and weight values might be preferred in terms of showing low thermal resistance values.

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