การศึกษาการซึมผ่านอากาศของการใช้เส้นใยไผ่ทอร่วมกับเส้นใยไหมและฝ้ายเพื่อการพัฒนาผ้าทอไทย

The Study on Air Flow or transfusion Permeability of Bamboo Fibres with Silk Fibres and Cotton Silk for Thai Textile Development

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บทคัดย่อ

จุดมุ่งหมายของงานวิจัยนี้คือการศึกษาเพื่อพัฒนาสิ่งทอไทย โดยศึกษาเปรียบเทียบการซึมผ่านอากาศในการทอผ้าของชุมชนในการใช้เส้นใยไผ่ทอร่วมกับไหม (50:50) เส้นใยไผ่ (100 เปอร์เซ็นต์) และเส้นใยไผ่ทอร่วมกับฝ้าย (50:50) ทำการทดสอบด้วยเครื่องทดสอบการซึมผ่านอากาศ M012A ที่มีความแตกต่างของความดันระหว่างพื้นผิวด้านบนและด้านล่างของตัวอย่าง (12.7 มิลลิเมตรของน้ำ) ซึ่งเป็นไปตามมาตรฐานของสหรัฐอเมริกา (ASTM) D737: 2004 ผลการศึกษาพบว่า การซึมผ่านอากาศของเส้นใยไผ่พุ่งด้วยไหม 50:50มีค่าสูงสุด (98.20 ลูกบาศก์เซนติเมตรต่อวินาทีต่อตารางเซนติเมตร) เปรียบเทียบกับการใช้เส้นใยไผ่ 100 เปอร์เซ็นต์ มีค่า 89.12 ลูกบาศก์เซนติเมตรต่อวินาทีต่อตารางเซนติเมตร และเส้นใยไผ่ทอร่วมกับฝ้าย 50:50 มีค่า 87.06 ลูกบาศก์เซนติเมตรต่อวินาทีต่อตารางเซนติเมตร ดังนั้น ผ้าทอที่ผลิตด้วยเส้นใยไผ่พุ่งด้วยไหม 50:50 เหมาะที่จะนำไปใช้เป็นเสื้อผ้าหรือเครื่องนุ่งห่มที่ผู้ใช้ต้องการความสบายในการสวมใส่ แต่ราคาต้นทุนวัสดุของเส้นใยไผ่พุ่งด้วยไหม 50:50 (ประมาณ 80 บาทต่อตารางเมตร) มีราคาสูงกว่าเส้นใยไผ่ 100 เปอร์เซ็นต์ และเส้นใยไผ่พุ่งด้วยฝ้าย 50:50 (ประมาณ 50 บาทต่อตารางเมตร)

คำสำคัญ: การซึมผ่านของอากาศ เส้นใยผสม เส้นใยไผ่

Abstract

The aims of this research were to develop Thai textile products by comparing air flow or transfusion permeability of local textile made by warp bamboo fibres with weft silk fibres 50:50, warp 100% bamboo fibres and warp bamboo fibres with weft cotton fibres 50:50. By considering the air permeability of these process, M012A air permeability tester with different pressure between top and bottom surface of sample (12.7 mm of water) was applied as follow as American Society for Testing and Material (ASTM) D737: 2004. The results showed the air permeability of warp bamboo fibres with weft silk fibres 50:50 is the highest (98.20 $cm^3/sec/cm^2$) comparing with warp 100% bamboo fibres (89.12 $cm^3/sec/cm^2$) and warp bamboo fibres with weft cotton fibres 50:50 (87.06 $cm^3/sec/cm^2$). So, the warp bamboo fibres with weft silk fibres 50:50 is suitable to apply to be any clothing and garment with the demand for more comfortable of air permeability but its cost (80 $Baht/m^2$) is higher than the other (50 $Baht/m^2$).

Keywords: Air permeability, Blended fibres, Bamboo fibres

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Introduction

Air permeability is an important factor in the performance of such textile materials as gas filters, fabrics for air bags, clothing, mosquito netting, parachutes, sails, tent, sport wear, underwear and vacuum cleaners (Bivainytė & Mikučionienė, 2011). Air permeability, being a biophysical feature of textiles, determines the ability of a fabric to carry out gaseous substances, significantly influences the thermal comfort of the human body and secures the support of proper body temperature (Frydrych et al., 2003). In filtration, for example, efficiency is directly related to air permeability. The air permeability is mainly dependent upon the fabric's weight and construction (thickness and porosity). Air permeability also can be used to provide an indication of the breathability of weather-resistant and rainproof fabrics, or of coated fabrics in general, and to detect changes during the manufacturing process. Performance specifications, both industrial and military, have been prepared on the basis of air permeability and are used in the purchase of fabrics where permeability is of interest. The air permeability of a fabric is influenced by several factors including the type of fabric structure, the design of a woven, the number of warp and weft yarn per centimeter (or inch), the amount of twist in yarns, the size of the yarns and the type of yarn structure (Joseph, 1986). The variation of the air permeability with the porosity rate for the different number of the warp yarns per centimeter is shown in figure 1 (Ogulata, 2006; Benltoufa & Fayala, 2007). It is seen that the air permeability of the woven increases with the porosity rate. On the other hand, the increase in the number of warp yarns per centimeter leads to a decrease the air permeability of the woven. Woven fabrics are produced by interlacing wrap and weft yarns. The wrap lies along the length of the fabric whereas the weft (or filling) lies across the width. Every warp yarn is separated from all the others. Thus, the warp consists of multitude of separate yarns fed to the weaving apparatus. On the other hand, the weft yarn is usually laid into the fabric, one length at a time (Lord & Mohamed, 1973). There are voids between weft and warp yarns in the fabric. The void volume within a textile fabric plays a major role in a variety of consumer and industrial applications including apparel comfort, flammability, thermal insulation efficiency, barrier fabric performance and the precision of filter media (Epps & Leonas, 1997). The air permeability of a textile fabric is determined by the rate of air flow through a material under a differential pressure between the two fabric surfaces (Epps, 1986). The prescribed differential pressure is 10 mm of water (Saville, 2003). For improving and developing Thai textile, researcher also studied the air permeability of bamboo fibres for northeast community for optimizing development and application of bamboo fibre including warp bamboo fibres with weft silk fibres 50:50, warp 100% bamboo fibres and warp bamboo fibres with weft cotton fibres 50:50 using M012A air permeability tester with different pressure between top and bottom surface of sample (12.7 mm of water) following American Society for Testing and Material (ASTM) D737: 2004 a textile testing center/Thailand textile institute, ministry of industry.

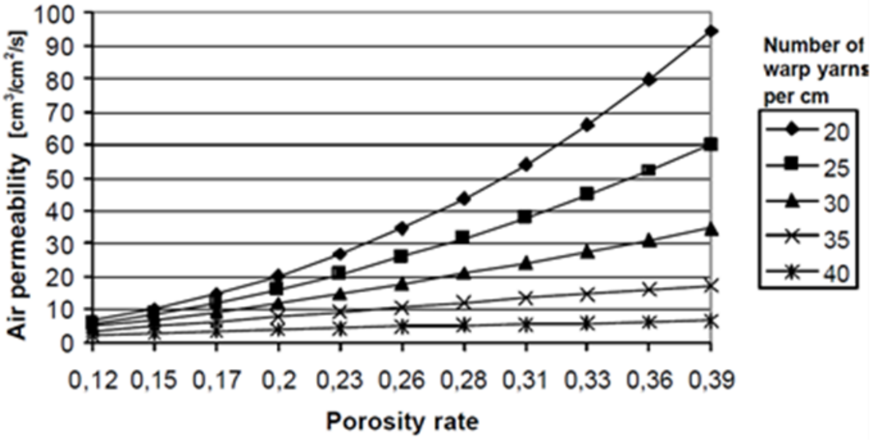

Figure 1: The variation of the air permeability of the woven with the porosity rate for different the number of the warp yarns per centimeter (Warp no: 20 Nm, Weft no: 20 Nm) (Ogulata, 2006).

Scope and Limtation

- M012A air permeability tester with different pressure between top and bottom surface of sample (12.7 mm of water) was applied for testing these samples following American Society for Testing and Material (ASTM) D737: 2004. Table 1 showed the ID number's report of each sample tested by textile testing center/Thailand textile institute, ministry of industry. Calculate the water absorption of individual specimens using values read directly from the test instrument in SI units.

- The samples were prepared as ISO 7211/2: 1984, Method C for determination of warp and weft threads used in fabrics per unit length at textile testing center/Thailand textile institute, ministry of industry and analyzed from northeast community is presented in table 2.

- The costs of each fabric were collected from northeast community including Ban Lhong Pra Du, Moo 1, Sub-District Huay Talhang, Nakhon Ratchasima, Ban Ta Ma, Moo 1, Chum Saeng Sub-district, Satuek District, Buriram, Ban Somphon Rat, Moo 10, Nong Sano Sub-District, Buntharik District, Ubon Ratchathani, Ban Kokjan, Moo 2, Kokjan Sub-district, Uhumporn Phisai District, Sisaket and Ban Khaen Koet, Moo 14 and Ban Khok Sung, Moo 8, Chumphonburi Sub-district, Chumphonburi District, Surin, Thailand.

Table 1: ID number's report of each sample tested by textile testing center/Thailand textile institute

Type	Wrap bamboo fibres with weft silk fibres 50:50	Wrap 100% bamboo fibres	Warp bamboo fibres with weft cotton fibres 50:50
ID number	R 00027/54	R 00007/54	R 00026/54

Table 2: Characteristics of each sample for testing air permeability following ISO 7211/2: 1984

Type	Wrap bamboo fibres with weft silk fibres 50:50	Wrap 100% bamboo fibres	Warp bamboo fibres with weft cotton fibres 50:50
Warp fibres @in^2	57	57	58
Weft fibres @in^2	71	61	27
Total of fibres @in^2	128	118	85

Table 3: The costs of each fabric studied

Type	Wrap bamboo fibres with weft silk fibres 50:50	Wrap 100% bamboo fibres	Warp bamboo fibres with weft cotton fibres 50:50
Cost @Baht/m^2	80	50	50

Testing procedure and experiment

American Society for Testing and Material (ASTM) D737 is standard test method for air permeability of textile fabrics. This standard is widely used worldwide for air permeability testing of diverse types of materials from parachutes, filters, foam, paper, films, rubber, ceiling tiles and powders to granola bars. There are 3 versions of ASTM D737 including 1996, 2004, 2008. Its testing procedure is measuring the rate of air flow passing perpendicularly through a known area of fabric is adjusted to obtain a prescribed air pressure differential between the two fabric surfaces. From this rate of air flow, the air permeability of the fabric is determined. So, M012A air permeability tester was applied to test the samples following ASTM D737: 2004 at textile testing center/Thailand textile institute, ministry of industry. Calculate the air permeability of individual specimens using values read directly from the test instrument in SI units. The conditioned specimen in the standard atmosphere for testing textiles is 21±1°C (70±2°F) and 65±2 % relative humidity, unless otherwise specified in a material specification or contract order. This test method covers the measurement of the air permeability of textile fabrics and applies to most fabrics including woven fabrics, nonwoven fabrics, air bag fabrics, blankets, napped fabrics, knitted fabrics, layered fabrics, and pile fabrics. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated. A woven fabric structure (plain woven) is shown in figure 2 and the cross sectional fabric structure is shown in figure 3. During the transport of the air through the porous of woven fabrics part of the energy of the air is used to overcome the friction of the fluid on the fabric and the rest to surmount the inertia forces. When the size of the pores decreases, the fluid friction of the fabric also increases (Kulichenko & Langenhova, 1992).

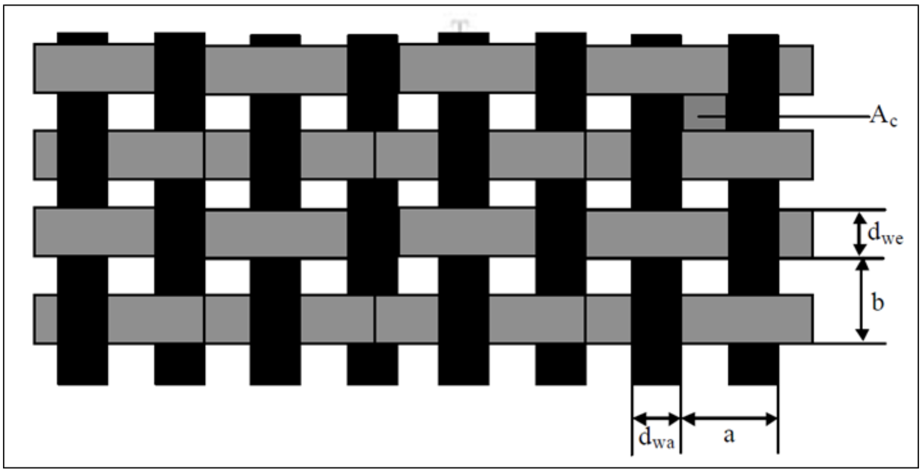

Figure 2: Plain woven fabric structure (Kulichenko & Langenhova, 1992)

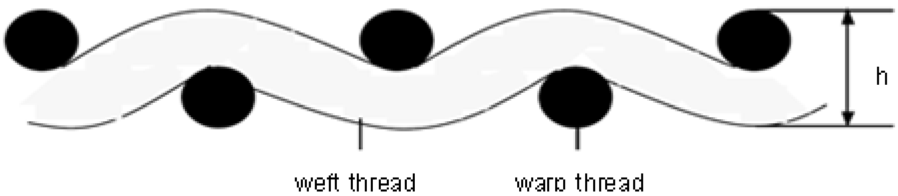

Figure 3: Cross sectional fabric structure (Kulichenko & Langenhova, 1992)

Nomenclature

A_c	cross sectional area of a pore (m^2) = a × b
d_{wa}	diameter of warp thread (m)
d_{we}	diameter of weft thread (m)
h	thickness of fabric (m)

Conclusion and Discussion of experiment

After applying the M012A air permeability tester with different pressure between top and bottom surface of sample (12.7 mm of water) following American Society for Testing and Material (ASTM) D737: 2004, the results was also satisfactorily and showed at table 4.

Table 4: Air permeability of each sample

Type	Air permeability ($cm^3/sec/cm^2$)
Warp bamboo fibres with weft silk fibres 50:50	98.20
Warp 100% bamboo fibres	89.12
Warp bamboo fibres with weft cotton fibres 50:50	87.06

Remark: Means for drawing a steady flow of air perpendicularly through the test area and for adjusting the airflow rate that preferably provides pressure differentials of between 100 and 2500 Pa (10 and 250 mm or 0.4 and 10 in. of water) between the two surfaces of the fabric being tested. At a minimum, the test apparatus must provide a pressure drop of 125 Pa (12.7 mm or 0.5 in of water) across the specimen.

1. The air permeability of warp bamboo fibres with weft silk fibres 50:50 is the highest (98.20 $cm^3/sec/cm^2$) comparing with warp 100% bamboo fibres (89.12 $cm^3/sec/cm^2$) and warp bamboo fibres with weft cotton fibres 50:50 (87.06 $cm^3/sec/cm^2$). So, the warp bamboo fibres with weft silk fibres 50:50 is suitable to apply to be any clothing and garment with the demand for more comfortable but its cost (80 Baht/m^2) is higher than other (50 Baht/m^2) as follow as table 2. We also should consider these features and compare the price and service that we get from the manufacturer before order to get the best of our limited budget.

2. Not only the air permeability but also the cost between of warp 100% bamboo fibres (89.12 $cm^3/sec/cm^2$ and 50 Baht/m^2 respectively) and warp bamboo fibres with weft cotton fibres 50:50 (87.06 $cm^3/sec/cm^2$ and 50 Baht/m^2 respectively) were slightly different. These results were similar to previous research that investigated the air permeability of socks knitted from bamboo and cotton yarns (Čiukas & Abramavičiūtė, 2010) according to EN ISO 9237: 1997. So, they can be applied instead of each other.

3. Testing air permeability is the rate of air flow passing perpendicularly through a known area of fabric is adjusted to obtain a prescribed air pressure differential between the two fabric surfaces. From this rate of air flow, the air permeability of the fabric is determined.

4. The permeability and porosity are strongly related to each other. If a fabric has very high porosity, it can be assumed that it is permeable. A fabric with zero porosity can be assumed to have zero permeability in theory (Dunn, 2005).

5. The applying new technology, such as bamboo fiber, is the one way to improve and develop products not only making more comfortable to customers but also supporting community and creating jobs for them based on plenty of local textile products (Wannajun & Vatchrakup, 2012). Figure 4-5 present some products made by bamboo fibres of northeast community including Ban Lhong Pra Du, Moo 1, Sub-District Huay Talhang, Nakhon Ratchasima, Ban Ta Ma, Moo 1, Chum Saeng Sub-district, Satuek District, Buriram, Ban Somphon Rat, Moo 10, Nong Sano Sub-District, Buntharik District, Ubon Ratchathani, Ban Kokjan, Moo 2, Kokjan Sub-district, Uhumporn Phisai District, Sisaket and Ban Khaen Koet, Moo 14 and Ban Khok Sung, Moo 8, Chumphonburi Sub-district, Chumphonburi District, Surin, Thailand. All of products showed the unique characteristics and should be developed to standard models of Thai fabrics for commercial level (Wannajun & Srihanam, 2012).

6. Bamboo fabric is a natural textile made from the pulp of the bamboo grass. Bamboo fabric has been growing in popularity because it has many unique properties and is more sustainable than most textile fibers. Bamboo fabric is light and strong, has excellent wicking properties, and is to some extent antibacterial (Wannajun et al., 2011; Erdumlu & Ozipek, 2008; Karahan et al., 2006) as follow as figure 6. So, it should be promoted and developed in order to support the marketing of textiles both of community and national.

7. Bamboo fabric is favored by companies trying to use sustainable textiles (Amanda & Untao, 2001) because the bamboo plant is very quick growing and does not usually require the use of pesticides and herbicides to thrive. As a result, plantations can easily be kept organic and replanted yearly to replenish stocks. The process of making unbleached bamboo fiber is very light on chemicals that could potentially harm the environment.

Figure 4: Blanket made by 100% bamboo fibres

Figure 5: Bed case made by bamboo fibres with weft cotton fibres 50:50

Figure 6: Bamboo textile's properties

Acknowledgment

We are grateful to the Thailand Research Fund (TRF), Office of the Higher Education Commission and Mahasarakham University of Technology for granting the budget for this research, and thank the staff of textile testing. Textile Institute, ministry of industry, Bangkok for testing textiles. Finally, we thank northeast communities for supporting information and samples.

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