Available online at www.elixirpublishers.com (Elixir International Journal)

Mechanical Engineering

Elixir Mech. Engg. 53 (2012) 11690-11694

ISSN: 2229-712X

Moisture management properties of polyester with bamboo biply knitted fabrics

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ARTICLE INFO

Article history:

Received: 4 January 2012;

Received in revised form:

19 November 2012;

Accepted: 28 November 2012;

Keywords

Bamboo,

Moisture management,

Knitted fabrics,

Areal density and

Vapour permeability.

ABSTRACT

A Study on moisture management properties for Polyester with Bamboo Biply knitted fabrics has been reported. The polyester (80 D), Bamboo yarn (30^s and 40^s Ne) were selected to produce the Biply rib knitted fabrics with various areal density, thickness and tightness factors to analyze the moisture management properties of fabrics. It was observed that polyester with bamboo Biply knitted fabrics have higher air permeability than the polyester with cotton Biply knitted fabric. It is also observed that there is a significant difference between water vapour permeability of polyester with bamboo and polyester with cotton Biply knitted fabrics. It is also found that the polyester with bamboo knitted fabric has better wicking rate than the polyester with cotton Biply knitted fabrics. This Polyester with Bamboo Biply knitted fabrics materials can be used to prepare the composite materials.

Introduction

"Thermo physiological wear comfort" concerns with the heat and moisture transport properties of clothing and the way it helps the clothing to maintain the heat balance of the body during various levels of activity. The body temperature is the most important factor in deciding comfort to the human body. Clothing influences are not only the metabolic heat periodical, but also the conductive, convective, evaporative and radioactive components of the balance equation including interactions between and among these. Exposure to a hot and humid environment combined with physical work may lead to an elevated body temperature which may impair cognitive and / or physical performance (1). During physical exertion, the primary way for a human body to dissipate heat is by the evaporation of sweat. The human body has a high heat capacity and 2.43 KJ of heat energy can be removed from the body for every gram of sweat evaporated (2). The extent to which evaporation occurs depends on the relevant vapour pressure gradients (of the skin, air, clothing and ambient environment) and decreases as the relative humidity increases. If the humidity of the air is such that evaporation cannot occur, the body continuous to store heat and the body core temperature rises. Clark (3) concentrates his attention on the physical conditions existing next to the skin surface and uses infra-red thermography to demonstrate temperature variations over the body in the presence and absence of clothing. In case of a nude body, an envelope of warm air moves by convection or evaporation, with the surrounding environment. The presence of clothing interferes with the freedom of this process and thus modifies the amount and rate of heat loss in a complex manner. Mecheeles (4) suggests that the ambient air temperature is the dominant influence in differencing the skin temperature and when the temperature is low, clothing is essential for the regulatory process because the body does not have the ability to continue compensating for heat loss under these conditions. He also suggests that in addition to preventing undue heat loss, winter clothing must also allow the escape of surplus heat or moisture when this is necessary. Harris (5) gives a way of estimating the heat stress experienced by the workers under light moderate or heavy conditions of work and recommends suitable exposure limits for each case. The microclimate within the garment can vary and the resultant effect on comfort (6, 7, 8, and 9), estimates of the changes in thermal or moisture conditions being attempted in some way in each case. Attempt to clothing construction factors to modify the microclimate are made by many workers. Forced heat exchange by using air or water cooled suits flexible tubing in the linings, solid-carbon-dioxide heat skins or pre-frozen jackets is credited with varying degrees of success (10). These are some of the attempts made for modifying microclimate. The resistance that a fabric offers to the movement of heat through it is obviously of critical importance to its thermal effects. Weiner and Shah (11) attempt to isolate the factors of thickness and weight and found that for a fixed weight, thermal insulation increases with thickness (i.e. with increased enclosed air) where as the property decreases with increased weight. (i.e. with decrease in enclosed air)On the other hand, many authors argue that entrapped air is the most significant factor in determining thermal factor insulation. Forseca (12) claims that the thermal characteristics of clothing assemblies are governed decisively by the properties of the outer layer and interior layers occupying a part of the still air layer presence therefore merely serves to prevent a decrease in size of the still air layer by collapse of the outer garment onto the body. Kawabata (13) find a close correlation between the feeling of the warmth on first touching a fabric and the maximum absorption rate of heat flow as measured physically. Gagge (14) studied the sensory comfort and thermal sensation of resting sitting unclothed subjects and compared them with the associated physiological responses under steady state and transient conditions of 12-48^{0}C. When exposed to steady cold and warm

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environments thermal comfort and neutral temperature sensation lay between 28-30^{0}C when no physiological temperature regulatory effect was needed. Discomfort perception was related to lowering average skin temperature toward cold environments and increased sweating towards hot environments. In this present research work, Bamboo yarn and polyester yarn are selected to produce the Biply Rib knitted fabrics in order to analyse moisture management properties of knitted fabrics.

Materials And Methods

Materials Used

The Polyester yarn (80 Denier), Bamboo yarn (30^s Ne & 40^s Ne) are selected to produce the Biply Rib knitted fabrics with various areal density, various thickness and various tightness factor. The circular knitting machine was used to produce the Biply rib knitted fabrics. The bamboo yarn and polyester yarn were feed in 27 feeders each used to produce the Biply Rib knitted fabrics (as in Table 5.1) with Terrot Rib knitting machine (German) specifications of gauge - 18 inches, needle – 3840, Feeder – 54, Cylinder Diameter – 34 inches, rpm – 12.

Testing Methods

Areal Density

The method of obtaining this value is implicit in the title: one has merely to weigh a known area and divide the weight by the area. The actual determination is not to straight forward since sampling, making out, cutting, accuracy of weighing, and moisture content must all be considered.Area measurement and cutting should be to accuracy of 1% and for an area loss than 100 sq.inch a cutting die or template is recommended. Weighing should be accurate to 1 part in 500. The effect of moisture content can accounted for either by conditioning the specimen in the standard (B.S. 2471, 1974) atmosphere or by taking the specimen to oven dry weight and adding the official regain.A piece of fabric with 100 sq.cms area was cut from the fabrics and weighed. The weight has been multiplied by 100 to arrive at the data of GSM of fabrics.

Fabric Thickness

The determination of the thickness (ASTM D1777 – 96 Standard Test method for Thickness of Textile materials) of a textile fabric consist of the precise measurement of the distance between two plan parallel plates when they are separated by the cloth, a known arbitrary pressure between the plates being applied and maintained. It is convenient to regard one of the plates as the presser tool and the other as the anvil.No special specimen preparation is necessary except that the edges and creased area are avoided. At least 10 determines are made and the mean value is obtained for all the samples.

Air Permeability

Air permeability (standard method ASTM D737 – 96) of the fabric samples were measured on KES-F8 API Air Permeability Tester under a pressure of 98pa and for an area of 5 sq.cm. The air permeability of fabric samples are measured with the "KES air permeability tester" With the load 8 kg and, the pressure head of water is 10mm. In which the test area is 5.07 sq.cm, since a 1 inch diameter circle is exposed when the specimen is clamped in the holder. From the readings on the Rota meter either the air permeability or the resistance can be computed. The average rate of flow from five specimens is calculated and by dividing by 5.07 we obtain the air permeability of the fabric in cubic centimeters per second at 1 cm head of water. Alternatively, 5.07 may be divided by the mean flow; this gives the air resistance of fabric in seconds per cubic centimeter per square centimeter under a pressure of 1 cm of water.

Measurement of Water Vapour Permeability

Cup Method

In the British Standard version of this method the specimen under is sealed over the open mouth of a dish containing water and placed in the standard testing atmosphere. After a period of time to establish equilibrium, successive weights of the dish are made and the rate of water vapour transfer through the specimen is calculated. The water vapour permeability index is calculated by expressing the water vapour permeability (WVP) of the fabric as a percentage of the WVP of a reference fabric which is tested alongside the test specimen. Each dish is filled with sufficient distilled water to give a 10 mm air gap between the water surface and the fabric. A wire sample support is placed on each dish to keep the fabric level. Contact adhesive is applied to the rim of the dish and the specimen, which is 96 mm in diameter, is carefully placed on top with its outside surface uppermost. The cover ring is then placed over the dish and the gap between cover ring and dish sealed with PVC tape. A dish which is covered with the reference fabric is also set up in the same way. All the dishes are then placed in the standard atmosphere and allowed to stand for at least 1 hour to establish equilibrium. Each dish is then weighed to the nearest 0.001g and the time noted. After a suitable time for example overnight the dishes are reweighed and the time noted again.

$$WVP = \frac{24M}{At} g / m^2 / day$$

Where: M-loss in mass (g),

t- time between weights (h),

A – Internal area of dish (m^2).

Wickability

The wicking properties of fabric were measured by the technique of vertical wicking by Strip Test Methods. In which the results are measured in terms of wicking height in cm. In this test a strip of fabric is suspended vertically with its lower edge in a reservoir of distilled water. The rate of rise of the leading edge of the water is then monitored. To detect the position of the waterline a dye can be added to the water. The measured height of rise in a given time is taken as a direct indication of the wickability of the test fabric. The simple form of the test does not take into account the mass of the water that is taken up. This will depend on the height the water has raised to, the thickness of the fabric and the water holding power of the fabric structure. One way of allowing for this is to weight the fabric at the end of the test and hence obtain the mass of the water taken up by the fabric. The mass can then be expressed as s percentage of the mass of the length of dry fabric which is equivalent to the measured height of water rise.

Thermal Insulation Value

The term thermal insulation (ASTM F1291 standard test Method for measuring Thermal Insulation of clothing) can refer to materials used to reduce the rate of heat transfer, or the methods and processes used to reduce heat transfer. Thermal insulation is the method of preventing heat from escaping a container or from entering the container. In other words, thermal insulation can keep an enclosed area such as a building warm, or it can keep the inside of a container cold. Heat is transferred from one material to another by conduction, convection and/or radiation. Insulators are used to minimize that transfer of heat energy. In home insulation, the R-value is an indication of how well a material insulates. To offset high ambient heat, clothing must enable sweat to evaporate (cooling by evaporation). When we anticipate high temperatures and physical exertion, the billowing of fabric during movement creates air currents that increase evaporation and cooling. A layer of fabric insulates slightly and keeps skin temperatures cooler than otherwise. To combat cold, evacuating skin humidity is still essential while several layers may be necessary to simultaneously achieve this goal while matching one's internal heat production to heat losses due to wind, ambient temperature, and radiation of heat into space. Also, crucial for footwear, is insulation against conduction of heat into solid materials.

Results and discussion

Air Permeability

The parameters of the Biply Rib Knitted fabric are tabulated in Table 1. The knitted fabrics were produced using the circular knitting machine. It can be observed from the Figure 1 that the sample No 2 (Polyester 80 D/Bamboo 40^s Ne) has higher Air permeability than sample No 3 (Polyester 80 D/Cotton 30^s Ne) and sample No 1 (Polyester 80 D/Bamboo 30^s Ne) it may be due to the cross section of the Bamboo fibres filled with various micro – gaps and micro – holes and also due to the low tightness factor of fabrics since, these properties largely governed by the porosity of the fabric or more exactly by the size and length of the pores in the knitted fabrics structures.

Table 1. Fabric Details

S.No	Parameters	Sample - 1	Sample - 2	Sample – 3
1	Face Loop	Polyester – 80 denier	Polyester– 80 denier	Polyester – 80 denier
2	Back loop	Bamboo - 30 ^{s} Ne	Bamboo - 40 ^{s} Ne	Cotton - 30 ^{s} Ne
3	GSM	194.6 g/m^2	122.2 g/ m^2	200.96 g/ m^2
4	Thickness	1.78 mm	1.65 mm	1.78 mm
5	Bursting strength	115 lbs/inch^2	99 lbs/ inch^2	120 lbs/ inch^2
6	Tightness factor	20.56	18.95	22.47

Therefore construction variables like twist level, yarn count, fabric density etc. may all have an effort upon Air permeability by causing a change in length and air flow paths through a fabric.

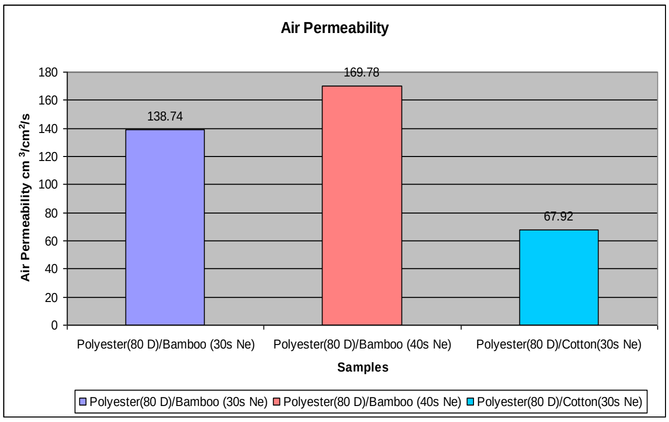

Figure 1 Air Permeability Values of The Samples

Moreover concerning the effect of constructional variables on air permeability, this is a general recognition that the function of tightness factor is most profound. However it was reported that even at constant tightness factor and same yarn count still can result in varies air permeability value. It is evident from Figure 1 that Sample No 1 has higher air permeability than Sample No 3 it is due to the Bamboo fibre micro – gaps and micro – holes which leads to have more air permeability of the fabrics.The t test was carried out to find out the significant difference between two samples. It was found that there is a significant difference between Sample No 1 with Sample No 3 and Sample No 2 with Sample No 3.

Water Vapour Permeability

It can be understood from Figure 2 the sample No 1 has better water vapour permeability than Sample No 2 and 3. It is due to the unique micro structures of bamboo fibres which enable to permit the water vapour through the various micro gaps and micro holes in the bamboo fibre. In general bamboo fibre have excellent water absorbent, able to take up three times its weight in water. In a humid transient condition, moisture transported through textiles both in liquid and vapour form. The transmission of moisture in humid transient conditions happens in different three stages. The first stage is dominated by two fast processes - water vapour diffusion and liquid water diffusion in the air filling the inter fibre voids, which can reach a new steady state condition in a fraction of a second. During this period, water vapour diffuses into the fabric due to the concentration gradient across the two surfaces. Meanwhile, the liquid water starts to flow out of the regions of higher liquid content to the drier regions, driven by surface tension. During the second stage, the moisture sorption of the fibres is much slower than during the first stage, and takes a few minutes to a few hours to complete, depending on the heat transfer processes.

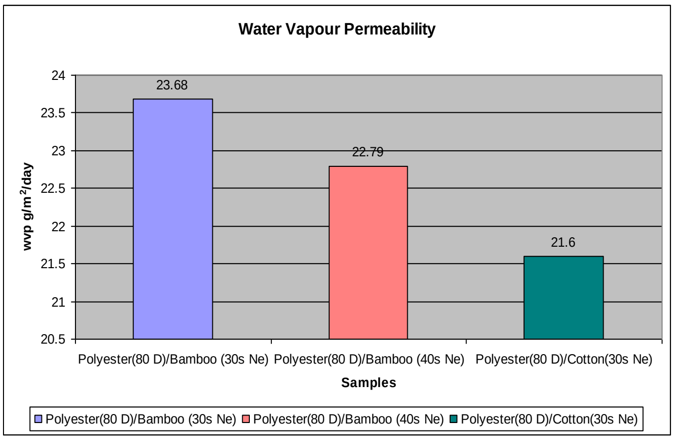

Figure 2 Water Vapour Permeability Of Samples

In this period, sorption of water into the fibres takes place as the water vapour diffuses into the fabric, which increases the relative humidity at the fibre surfaces. After liquid water diffuses into the fabric, the surfaces of the fibres are saturated due to the film of water on them, which enhances the sorption process. Finally, the third stage is reached as a steady state, in which all forms of moisture transport and heat transfer become steady and the coupling effect between them becomes less significant. In this condition, distributions of temperature, water vapour concentration, fibre water content, liquid fraction volume and evaporation rate become independent of time. With liquid water evaporation, liquid water is drawn from the capillaries to the upper surface. Combined liquid water and water vapor transmission along the fabric is very important in the case of sweat. The liquid transport (i.e. liquid diffusion or capillary wicking) is very small compared with the vapour diffusion at low moisture content, whereas at saturation, capillary wicking is the major mechanism of moisture transport.

Wickability

It can be absorbed from Figure 3 the Sample 1 and 2 have higher wicking rate than the sample No 3, the reason might be related to the moisture absorption characteristics of bamboo material and the yarn structures of the fabric. The Bamboo fibre content plays an important role in influencing the wickability, because water vapour absorbed by fibres, transported through fibres and then desorbed to the environment in this process inherent absorbency of the fibres are the affinity for water determines the process of wickability. Bamboo fibre is Hydrophilic (water loving) which can be absorbing significant amount of moisture. The wicking capacity of bamboo fabric would increase due to the micro – gaps and micro – holes of Bamboo fibres. Bamboo is a highly water absorbent, able to takeup three times its weight in water. These lead to the increase in wickability of bamboo fabric.

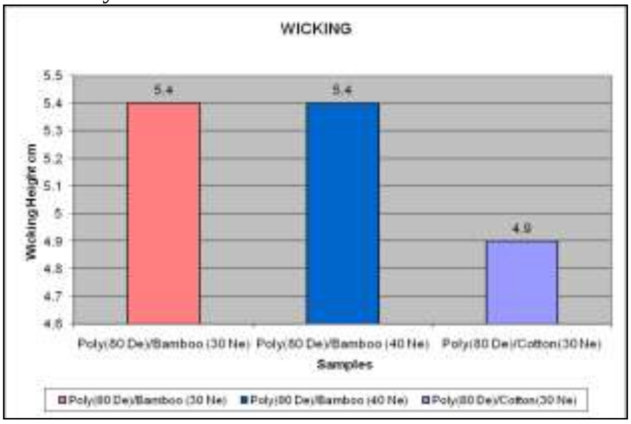

Figure 3. Wickability of Samples

The convection method is important in transferring perspiration from the skin to atmosphere in windy condition. With an increase an air velocity, moisture transfer by convection increases. Wicking plays an important role in moisture transmission when the moisture content of the clothing is very high and body is producing large quantity of liquid perspiration. The fabric to be worn as a work wear tropical climates or as a sportswear, should posses very high wicking properties. The bamboo with polyester biply fabric has higher wicking properties than polyester with cotton fabric. Hence the biply Bamboo fabric can be used for Active sportswear. The biply(polyester/Bamboo) material can easily absorb the sweating liquid by bamboo materials from body, transmitted to the polyester materials. In general polyester fibre has good capillary properties so large amount of moisture can passes very quickly through them to the atmosphere. Thus providing a dry and comfortable feeling to the wearer.

Thermal Insulation Value

Heat is transferred to one material to another material by conduction, convection and/or radiations. Insulators are used to minimize that transfer of heat energy. The term thermal insulation can refer to materials used to reduce the rate of heat transfer, or the methods and process used to reduce the heat transfer. It can be understood from Figure 4 that the samples No 3 have higher thermal insulation value than sample No 2 and sample No 1. This may be related to the increase in fabric thickness. The changes in fabric thickness affect the resistance to heat of the fabrics. As the fabric thickness increases, the resistance of the fabric to heat flow decreases. The Bamboo fibres having the higher absorption of moisture due to the micro - gaps, which are the reason for the higher moisture regain value. The Bamboo will helps to higher rapid heat transfer from body. The transfer of the liquid from body to atmosphere the polyester and Bamboo plays a significant role. During the sports activities the human body having the various movements which will generate the heat on the human body. The transferring of this generated heat to the atmosphere is very essential one. In order to carry out this process the sportswear should posses the required heat transfer in order to make the human body at normal temperature. So the bamboo having the ability of absorbing the heat along with the liquid from the body and transfer to the polyester fibres. Since the bamboo has low thermal insulation value than the cotton. So it can easily transfer the heat and moisture very quickly. Generally polyester having the higher capillary action and quick transfer of heat to the atmosphere, which will helps to maintain the temperature in the human body.

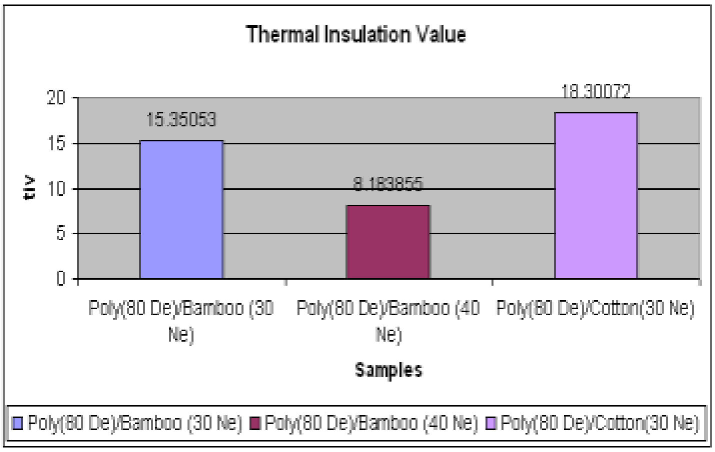

Figure 4. Thermal Insulation Value

Conclusion

The fundamental functions of clothing is to keep the human body in an appropriate thermal environment in which it can maintain it's thermal balance and thermal comfort. During the course of biological development the human body has lost much of its ability to control heat loss and maintain thermal balance. Therefore clothing is needed to protect the body against climate influence and to against its own thermal functions under various combinations of environmental conditions and physical activities. In this work polyester with bamboo and polyester with cotton Biply knitted fabrics moisture management properties have been studied. The following are the conclusion drawn.

- Polyester with bamboo Biply knitted fabrics have better moisture management properties than the polyester with cotton Biply rib knitted fabrics.
- Polyester with bamboo Biply knitted fabrics have better air permeability, water vapour permeability and wickability than other fabrics.
- The Bamboo fibre having the ability of absorbing the heat along with liquid from the body and the transfer to the polyester fibre. So that polyester fibres can easily transfer the heat and liquid to the atmosphere by capillary actions.
- Polyester with bamboo Biply knitted fabrics can be used for sportswear due to the low thermal insulation value and better moisture management properties.

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