Moisture Transport Properties of Silk Acrylic Knitted Fabrics

Abstract

In this study, moisture transfer properties of acrylic- silk blended fabrics have been examined. Moisture absorption and moisture transport, both are important properties of the fabric. Moisture absorption is inherent natural property of fibre. Moisture transport through clothing also plays a key role in comfort. It is necessary to transport moisture to the environment through the clothing quickly so as to provide comfort to the wearer. The clothing acts as a medium for transport of moisture so that an energy balance is maintained between wearer and environment. Three types of tests were performed in this study to evaluate moisture transfer properties – Wicking behaviour, water vapour transfer and total absorbency. It was observed that wicking height is maximum in case of 100% acrylic fabric. The rate of wicking is also fast in acrylic fabric in first 30 sec and 5 min. Among all the fabrics studied, wickability of the 100% acrylic fabric is maximum and reduces with increase in silk content in the blend. Wickability of 100% silk knitted fabric is slightly lesser than 100% cotton fabric. The results of spot test also indicate fastest transfer of moisture in 100% acrylic fabric among all the fabrics studied. Time taken by a drop of water to disappear in case of 100% cotton fabric is much greater than 100% silk fabric. This study indicates that water vapour transfer of acrylic-silk knits first decreases and then increases. This trend accords with yarn diameter and air- permeability of the fabrics.Total absorbency of the fabrics increase with increase in percentage of silk in the fabric. Although wicking properties of acrylic rich knitted fabrics are good but total absorbency of these fabrics is poorer in comparison to silk and cotton fabrics. This is due to hydrophobic nature of acrylic fibre.

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Introduction

Textile materials may broadly be divided into two categories : Fabrics coming in contact with the skin and fabrics not touching the skin. Moisture absorption and moisture transport are two different important aspects for fabrics which comes directly in contact with the skin. Moisture absorption is an important property for textile material as it is related to absorption of perspiration by cloth. Moisture absorption of a textile fibre can't be changed as it is an inherent natural property of fibre. A fibre may have low moisture regain but at the same time it may transport moisture quickly. Moisture absorption depends upon nature of fibre but moisture transport depends upon type of fibre, cross section of fibre, structure of fabric, capillary action, pore size and air space available in the fabric. Moisture transport and wicking properties are very important as they control transport of moisture from skin to outer surface and to the environment. Some fibres like cotton fibre have good moisture absorption properties but moisture transport is slow as cotton accumulates moisture whereas polyester fibre has low moisture absorption but moisture transport is faster. Moisture absorption and moisture transport properties depend upon type of fibre, blend ratio, woven or knitted fabric.

Different fibres have different moisture absorption and moisture transport property. A single fibre can't provide good moisture absorption as well as good moisture transport property, hence it is advisable to blend natural and manmade fibres so that resultant fabric has good moisture absorption as well as moisture transport properties. In case of blended fabric, it is necessary to study moisture transport for new kind of blends so as to study comfort aspect of fabrics for different end- uses like innerwear, outerwear, sportswear etc. For comfortable fabric, it is necessary to study moisture transport properties of a fabric. Wicking properties of the fabrics are related to transport of moisture from skin to the atmosphere through the fabric. It is related to comfort of the fabric for all types of fabrics like sportswear, activewear and innerwear. Water vapour transfer ensures rapid dissipation of sweat and perspiration. Different blends, yarn parameters, type of knitted structure, amount of open space available in the fabric affect moisture transport properties.

In case of blended fabrics, it is necessary to study the change in moisture transport properties with the change in the blend. In the present study, effect of blend on moisture transport and wicking properties of weft knitted acrylic silk blended knitted fabrics has been examined. Three types of tests are necessary to evaluate moisture transfer properties of a fabric – Wicking behaviour, water vapour transfer and total absorbency. For comparison purpose cotton fabric of same construction was also manufactured so that properties of different blends can be compared with very common and popular cotton knitted fabric.

Review of Literature

Researchers have realized the importance of moisture transport properties and these days lot of references are available in the field of moisture transport properties. Jhanji Y. et al[1] have studied moisture management and wicking properties of polyester cotton plated knits. Effect of yarn linear density on moisture management and wicking properties of polyester cotton plated knit structures was studied. Linear density of yarns used in inner and outer layer as well as the difference in the yarn linear density for the two layers have been found to affect the liquid transfer from inner to outer layer. Trans planer wicking is found higher for fabrics with greater difference in linear density between inner and outer layers as a result of selection of finer yarns in inner layer.In another study Jhanji Y. [2] has studied effect of fibre, yarn and fabric variables on heat and moisture transport of plated fabrics. It was found that thermal properties, air permeability as well as moisture vapour and liquid transport properties of fabrics are found to be affected by fibre types, yarn linear density and fabric loop length. Gorji M.[3] has studied moisture management behaviors of high wicking fabrics composed of profiled fibres. The effect of fibre cross- section, fibre content, yarn count, number of monofilaments and loop density on moisture management properties of some knitted fabrics composed of profiled fibres has been investigated. It was found that accumulative one way transport capacity of fabrics is mainly dependent on both yarn and fabric structures. Yu Z.C. et al [4] have studied wicking behavior and dynamic elastic recovery properties of multifunction elastic warp knitted fabrics. The purpose of the study was to evaluate the moisture transport and dynamic elastic recovery properties of the multifunction elastic warp knitted fabric used for personal protective clothing. GuptaD. [5] has studied heat and moisture transport in single jersey plated fabrics. Effect of yarn linear density in the inner and outer layer of single jersey plated knits on heat and moisture transport and air permeability of resultant fabrics was studied. Fabrics knitted with finer yarns and higher loop length are more permeable to air and water vapour and are found to have lower values of thermal absorptivity, making them more suitable for the use during hot and humid season. Das S. [6] has investigated moisture vapour transmission behavior of cotton fabrics. Moisture transmission properties of a series of cotton fabrics were studied. It was found that water vapour transport increases with wind velocity irrespective of the weft count and cover factor of the woven fabrics. Swelling phenomena of hygroscopic fibres are found to play significant role in determining the moisture vapour transmission characteristics of cotton fabrics. Yanilmaz M.[7] has investigated wicking, wetting and drying properties of acrylic knitted fabrics. In this study relationship between different knitted structures and some thermo-physiological comfort parameters were studied. Wetting, wicking and drying properties of single jersey rib and interlock knitted fabrics made out of acrylic yarns were studied. Sharabaty T. et al[8] have investigated moisture transport through polyester/ cotton fabrics. The wettability characteristics of different cotton, polyester and multi layered cotton/ polyester fabrics have been studied to manage human perspiration well. The vertical capillary action behavior of these fabrics has been compared by measuring the capillary height as a function of time. Zhou L.[9] has studied characterization of liquid moisture transport performance of wool knitted fabrics. In this study different kinds of fabrics knitted by wool yarn in plain structure, wool yarn matched with polyester yarn or cotton yarn as plating yarn are developed so as to have different liquid water transport properties. Daithankar A.V.[10] has studied moisturizing efficiency of silk protein hydrolysate. The composition and natural function of natural moisturizing factor with the amino acid content of silk fibroin was advantageously used to reconstruct the skin moisturizing system. Sreenivasan S.[11] has studied parameters related to clothing comfort and new approach for measuring moisture transport through fabrics. A new experimental set- up to measure water vapour transmission through fabrics under ambient temperature has been designed and fabricated. The moisture transfer through fabrics has been characterized in terms of time required to reach a certain RH in a dry chamber on passing moisture. The results of new test method are compared with that of previous method. It is observed that if the combined influence of fabric parameters on moisture transfer time can be kept constant, moisture transfer would be adversely affected by the polyester content in the blended fabrics.

Comfort is one of the most important aspect of clothing. Behera B.K. et al [12] have studied comfort properties of fabrics from ring, rotor and friction spun yarns. They have studied that clothing comfort can be divided into three groups : Psychological, Tactile and Thermal comfort. Moisture transport through clothing plays an important role in comfort. Phukon A. [13] has studied wicking behavior of knitted fabrics. They have also suggested methods for measurement of wicking behavior, water vapour transfer and total absorbency. In the previous study, Kumar R. [14], it was found that after steaming the increase in yarn diameter is maximum for acrylic- silk 50/50 blend. Lots of references are available for knitted fabrics but change in moisture transport with change in blend percentage on the properties of knitted fabrics are few.

Aim of the Study

The aim of the study is

1. To evaluate the moisture transfer properties of acrylic/silk blended single jersey weft knitted fabrics at different blend levels.
2. To study wicking behavior by strip test and spot test, of bulk silk weft knitted single jersey acrylic/silk blended knitted fabrics at different blend levels.
3. To study water vapour transfer of acrylic/silk blended weft knitted single jersey knitted fabrics at different blend levels.
4. To study total absorbency of acrylic/silk blended weft knitted single jersey knitted fabrics at different blend levels.

Material and Methods

Acrylic-silk yarns in different blend proportions such as 100% shrinkable acrylic A10, 80% shrinkable acrylic and 20% silk (A8S2), A6S4, A5S5, A4S6, A2S8 and 100% silk S10 were prepared. The process parameters were chosen in such a way that after steaming the hanks of blended yarns, the yarn should be of 30^s N_e and Twist multiplier 2.7 (T.p.i 14.8). For comparison of acrylic-silk blended yarns and fabrics with equivalent cotton yarn and fabric, 100% cotton yarn of 30^s N_e and Twist multiplier 2.7 (T.p.i 14.8) was also prepared. All acrylic silk blended fabrics, 100% silk and 100% cotton fabrics were knitted on single jersey, 24 feeder circular knitting machine having 12 inches diameter, total numbers of needles 886 and 24 gauge. All the fabric samples were knitted at the same time one by one with same cam setting.

Fabrics knitted in tubular form were laid free from constraints for 24 hours on a flat surface to facilitate recovery from the stresses imposed during knitting. Prior to testing all the fabric samples were conditioned to moisture equilibrium and the fabrics were tested in standard atmospheric condition of 65% $\pm$ 2% RH and 27^0C $\pm$ 2^0C temperature.

Evaluation of Moisture Transfer Properties

Moisture transport through clothing plays a key role in comfort. The clothing acts as a barrier or buffer to the free exchange of heat and moisture so that an energy balance is maintained between wearer and environment.

Three types of tests were performed to evaluate moisture transfer properties – Wicking behaviour, water vapour transfer and total absorbency.

Wicking behavior

When a porous material such as fabric is placed in contact with a liquid, spontaneous uptake of liquid may occur. Spontaneous uptake in the plane of a fabric is called wicking. The ability of a fabric to absorb water especially by wicking or capillary action may be observed by timing, the rate at which the water climbs up a narrow strip of fabric suspended vertically with its lower end dipping into water.

Two methods were used for assessment of wicking behavior i.e. strip test and spot test.

Strip Test

A strip of the test fabric 6 inches × 1 inch, preconditioned at 65% $\pm$ 2% RH and 27^0C $\pm$ 2^0C was suspended vertically with its lower end immersed in a reservoir of distilled water. The wicking behavior was studied by using a 0.2% soap solution. The soap solution was used because wicking with pure water was too slow and immeasurable. The height reached (at constant time of 30 sec, 5 minute and 15 minutes) by water in the fabric above the water level in the reservoir was measured. Wickability of the test fabrics was also measured from the wicking height by using the formula:

Wickeability = Average rise in height × Percentage of mass

$$\text{Percentage of mass} = \frac{(\text{Wet weight - Dry weight})}{\text{Dry weight}} \times 100$$

Spot Test

A drop of liquid (distilled water, drop volume 30 mm^3) was delivered from a height of approximately 6 mm onto horizontal specimen of test fabric (preconditioned at 65% $\pm$ 2% RH and 27^0C $\pm$ 2^0C) . The region of the test fabric on which the drop falls was illuminated by a beam of light to create a bright reflection from the liquid surface and the elapsed time between the drop reaching the fabric surface and the disappearance of the reflection from the liquid surface was measured. The time taken for complete absorption of the drop was noted.

Water vapour Transfer

The modified evaporation cup method was used to measure the water vapour transferred through the fabric. The fabric assembly was sealed over a cylindrical cup containing the water 1 cm below the brim. Evaporation takes place under standard atmospheric conditions of 65% RH and 27^0C temperature. Loss in the weight of cups was measured after 24 hours of starting the experiment for all the samples.

Total Absorbency

The water holding capacity of the fabrics was determined by using a 0.2% soap solution. A sample of size 20 cm × 20 cm was dipped in the solution for five minutes and then hung vertically to allow any extra water to drip down for a five minute period, it was then weighted. The percentage gain in the weight of the fabric sample was taken as the total absorbency of the fabric.

Results & Discussion

The results of moisture transfer properties acrylic- silk blended weft knitted single jersey fabrics are shown in Table 1.

Table 1 Moisture Transport Properties of Acrylic-Silk Blended Fabrics

	Acrylic	A8S2	A6S4	A5S5	A4S6	A2S8	Silk	Cotton
1. Wicking test								
(a)Wicking height (cm) 30 sec.	2.5	2.1	2.0	2.1	1.4	0.9	0.4	0.1
5 min	6.5	6.1	5.45	4.8	3.9	3.3	3.0	3.2
15 min	9.5	8.8	7.8	7.5	7.1	6.8	6.1	6.8
Wickability	14.28	11.85	8.16	6.24	6.15	5.86	5.56	8.86
(b) Spot Test (sec)	1.6	3.21	6.42	11.8	26.4	41.5	44.5	160
2.Water vapour transfer (gm)	7.43	7.32	7.21	7.12	7.53	8.14	8.34	7.72
3. Total absorbency %	2.68	2.85	2.94	3.01	3.21	3.11	3.13	4.21

(Figures in parenthesis represent CV %)

Rate of lifting of water in the fabric depends upon nature of the fabric. In the initial 30 seconds the height of water is more in case of 100% acrylic fabric. Same trend is observed after 5 and 15 minutes. Wicking is maximum in case of 100% acrylic fabric. As the percentage of silk increases the wicking height decreases. From Table 1 it is clear that wicking height is maximum in case of 100% acrylic fabric. The rate of wicking is also fast in acrylic fabric in first 30 sec and 5 min. This is due to the fact that although moisture regain of acrylic is lesser but moisture transport of acrylic fibre is good. The wicking height of 100% silk fabric after 15 minutes, is slightly lesser than 100% cotton fabric.

Wickability of the fabric depends upon rise in height of water as well as percentage of mass of water in the fabric. Among all the fabrics studied, wickability of the 100% acrylic fabric is maximum and reduces with increase in silk content in the blend. Wickability of 100% silk knitted fabric is slightly lesser than 100% cotton fabric.

The results of spot test also indicate fastest transfer of moisture in 100% acrylic fabric among all the fabrics studied. These results imply that wicking behaviour of acrylic majority blends in better than silk and cotton fabrics. This will ensure comfort to the skin of the wearer and wearing comfort to the consumer. During exercise the transfer of perspiration to the atmosphere is important. This transfer will be quicker in case of acrylic and silk acrylic blends. Time taken by a drop of water to disappear in case of 100% cotton fabric is much greater than 100% silk fabric.

Table 1 indicates that water vapour transfer of acrylic-silk knits first decreases and then increases. This trend accords with the results of yarn diameter and air permeability. In earlier publication it was found that yarn diameter is maximum for silk/ acrylic 50/50 level. Due to maximum value of yarn diameter air-permeability was found minimum at silk/ acrylic 50/50 blend level. The same trend is observed here also water vapour transfer is found minimum in case of silk/ acrylic 50/50 level. Lower water vapour transfer in case of A5S5 fabric is due to higher yarn diameter and lower air permeability of the fabric.

Total absorbency of the fabric depends upon the percentage of the hygroscopic fibre present in the blend. It is observed from Table 1 that total absorbency of the fabrics increase with increase in percentage of silk in the fabric. Total absorbency of the 100% silk fabric is slightly lesser than 100% cotton fabric. Although wicking properties of acrylic rich knitted fabrics are good but total absorbency of these fabrics is slightly lesser in comparison to silk and cotton fabrics. This is due to hydrophobic nature of acrylic fibre.

Conclusion

The results of the study are as follows

1. Wicking is maximum in case of 100% acrylic fabric. As the percentage of silk increases the wicking height decreases.
2. Wickability of 100% silk knitted fabric is slightly lesser than 100% cotton fabric. Wickability of the 100% acrylic fabric is maximum and reduces with increase in silk content in the blend.
3. The results of spot test also indicate fastest transfer of moisture in 100% acrylic fabric among all the fabrics studied.
4. Water vapour transfer of acrylic-silk knits first decreases and then increases. This trend accords with the results of yarn diameter and air permeability of the fabrics.
5. Total absorbency of the fabrics increase with increase in percentage of silk in the fabric.

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