iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** II **Month of publication:** February 2020

DOI: http://doi.org/10.22214/ijraset.2020.2118

Effect of Inlay Yarn in Moisture and Thermal Transmission Properties of Plaited Double Knit Fabric Structures

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Abstract: The present study aims to investigate the effect of in-lay material and number of tuck points in wales on the physical, moisture management and thermal comfort properties with plaited double knit fabrics. For this purpose, two types double knit plaited fabric structures such as fabric layer connected with inlay-yarn in all wales line as well as once in every sixth wales line have been developed with same cotton yarn in outer and inner layer. The inlay yarn of cotton and polyester with two different polyester yarns (4.6 dpf&0.54 dpf) was used. The result shows that knit structures with different inlay tuck pints, are highly influences the physical, moisture management and thermal transmission properties as distinct from inlay materials.
Keywords: Plaited knit fabric, Inlay yarn, Physical, Moisture, Thermal

I. INTRODUCTION

With the increased market demand for better performance active and sportswear garments, necessary importance has to be given in selection of better comfort yielding fabrics. Fabric act as an intermediate between human body and environment and to provide better comfort, it should not impede air, heat besides provide better liquid and vapour moisture transfer. Moisture transmission ability of the fabric under transient humidity conditions is significantly influences the dynamic comfort of the wearer on the practical usage (D Uttam.2013 & Higgins 2003). Many research works have been carried out in thermo-physiological comfort properties of layered knitted fabrics for sports and active wear. T Suganthi *et al.2017* studied the comfort properties of bilayer knitted fabrics with bi-layer knitted structures using tencel yarn on outer layer and Micro polyester/ acrylic yarn on inner layer and reported that the fabrics with micro polyester has low thermal resistance when comparing with other fabrics. A Bivainytė *et al.* (2012), investigated the influence of knitted fabric structural parameter such as the knitting structure, materials on heat transfer process through double–layered fabrics and researchers concluded that the knit structure has highly influences on the heat transfer process. Supuren *et al.* (2011) investigated bi-layered knitted fabrics with polypropylene in inner yarn and cotton in outer layer was providing better comfort for sportswear applications.

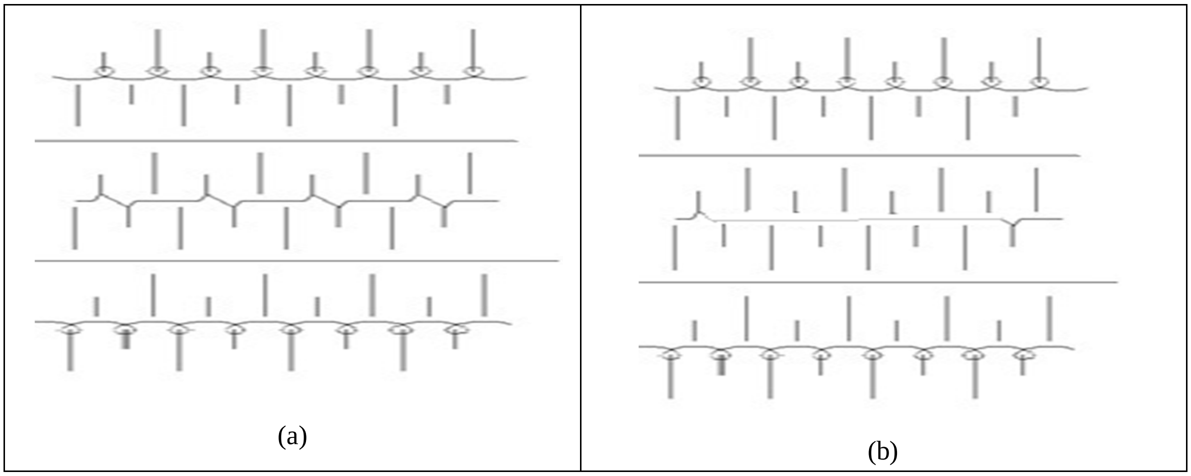
Previous published literature shows that the different combinations of hydrophilic and hydrophobic yarns were used in inner and layers of double knit fabrics to improve moisture and thermal transmission characteristics. But, no detailed study was conducted regarding the effect of in-lay yarn on thermo-physiological properties such as moisture management, and heat transmission properties. The basic aim of this study was to investigate the effect of in-lay material and number of tuck points with cotton plaited knit fabrics. For this purpose, double knit plaited fabrics of same tightness factor with same yarn count in outer and inner layer were used for production of knitted fabrics. The two different inlay yarn of hydrophilic yarn (100% cotton) and hydrophobic yarn (polyester with 2 different dpf) were used.

II. MATERIAL AND METHODS

A. Production Of Knitted Fabric

The plaited double knit fabrics were produced in knitting with the machine following machine specifications: Double jersey knitting machine with positive Feeder, Gauge-18GG, Diameter-20 inches, Speed- 25rpm, Feeders 50 and number of needles 2240. The knitting room atmosphere temperature around of 30^{o}C and humidity of 60% RH was maintained during sample development. All the samples were produced with uniform tightness factor of 13.70. To study the influence of number tuck stitches fabrics knitted with the following structural type, the face and back layers of knitted fabrics a) connected with inlay-yarn in all wales line (With space between layers) b) connected with lay-yarn in every Sixth wales line (Without space between layers).

Fig.1 Structural representation of plaited double knit fabric structures



In structure (1a), cylinder and dial needles produces separate face and base layers by knitting of cylinder needles and floating of dial needles and vice versa on Feeder nos. of 1 and 3 as shown in Figue1(a). The linking yarn in Feeder No 2, is tucked/connected the two surface of fabric by tucking of all dial and cylinder needles. Due to all tuck stitches, no space is created between layers. These tuck stitches forms middle layer, will assist for capillary transmission of fluid. In structure (1b), the alternate dial and cylinder needles produces knit stitches separately, forms the face and back layers of fabric using cotton yarn. A linking yarn produces tuck stitch on cylinder and dial needles for every six alternate wales line, as per the design shown in fig 1 b, through which an air space is created between layers.

In order to evaluate the influence of connecting yarn on moisture and thermal transmission characteristics, cotton spun yarn and polyester filament of different fineness of 4.6dpf (Normal) & 0.54dpf (Micro) were used. The table 1 shows material specifications used for this study.

Sample Code	Structure of knit	Yarn Specifications		
		Inner layer	Connecting in-lay yarn	Outerlayer
A_1	Knitted sample with inlay-yarn in all wales line	30^sNe Cotton	30^sNe Cotton	30^sNe Cotton
A_2		30^sNe Cotton	155D Normal Polyester (4.6 dpf)	30^sNe Cotton
A_3		30^sNe Cotton	155D Micro Polyester (0.54 dpf)	30^sNe Cotton
B_1	Knitted sample with inlay-yarn in every Sixth wales line	30^sNe Cotton	30^sNe Cotton/	30^sNe Cotton
B_2		30^sNe Cotton	155D Normal Polyester(4.6 dpf)	30^sNe Cotton
B_3		30^sNe Cotton	155D Micro Polyester(0.54 dpf)	30^sNe Cotton

Table 1 Material specification of plaited double knit fabric structures

B. Fabric Evaluation

The fabric physical fabric properties were evaluated according to following standards; aerial density (ASTM D 3776), thickness (ASTM D 1777), wales and courses per unit length (ASTM D 3887: 1996) and loop length (ASTM D 3887) . The air permeability tests were conducted according to the ASTM D737-04(2008) by using the Tex-test FX 3300 Air Permeability Tester at a test pressure drop of 100 Pa and a test rea of 20 cm^2 test area. Multi directional moisture management properties have been evaluated with Moisture management Tester (MMT) as per AATCC test method 195-2009. With the instrument critical moisture management parameters such as Accumulative one-way transport capacity index (AOTI) and Overall moisture management capability (OMMC) of samples were determined. TF 130 Flat plate thermal conductivity tester was used to determine the thermal insulation properties of various fabrics. The testing was carried out according to the ASTM D1518 standard.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

III. RESULTS AND DISCUSSION

The effect of in-lay yarn type and number tuck pints on the fabric physical, moisture management and thermal comfort properties have been studied.

A. Fabric Physical Properties

Table 2 Fabric physical properties of plaited double knit fabrics

Fabric Sample Code	Wale density (wales/cm)	Course density (courses/cm)	Areal density (GSM)	Thickness (mm)	Air Permeability ($ft^3/ft^2/min$)
A_1	24	52	356	0.70	158.97
A_2	25	53	344	0.54	173.09
A_3	25	52	362	0.60	148.14
B_1	19	43	264	0.48	238.5
B_2	20	46	275	0.45	260.6
B_3	21	43	277	0.49	237.6

Table 2 shows the physical properties of the developed fabric samples. From the table, it observed that the fabric areal density and thickness of plaited double knit derivatives is significantly influenced by the number of tuck loops in the fabric structure. With the more number of tuck stitches formed between the layers leads to more consolidation fabric loops in course direction, results increased course density in plaited Type-A fabric than plaited Type-B fabrics. This causes increase in fabric thickness and areal density for Type-A fabrics. The influence of yarn type on fabric areal density is minimal, whereas fabrics knitted with inlay micro polyester yarn (A_3 & B_3) has 6% higher thickness value than normal polyester (A_2 & B_2) fabrics, respectively. This is due to increase in number of filaments, increases the bulkiness and thereby higher fabric thickness yields. Table 2 results also show that the air permeability values of Type A fabrics are lower than Type B fabrics; this might be influenced by fabric thickness. Since air permeability is increases as the thickness is decreases irrespective of yarn type. It is also interesting to note that the rate of air transmission is reduced 15-20 % with the micro polyester fabrics. This is due to increased bulkiness of micro polyester inlay fabrics, which entraps more air and decreases the air flow through the fabric.

B. Moisture Management Properties

Figure 2 and 3 shows the AOTI and OMMC values of plaited double knit fabrics respectively. AOTI and OMMC are observed higher for Type-A fabrics with inlay-yarn in all wales line than Type-B fabrics with inlay-yarn in every Sixth wales line. This is due to more tuck points, which act as a capillary channel for moisture transmission from inner to outer surface. From the results, Type-A fabric can be classified as moisture management fabric due to excellent AOTI and OMMC grade. This fabric gives dry feel to the wearer' skin due to low absorption at inner layer and better transmission of sweat to outer layer because of higher AOTI and spreading speed.

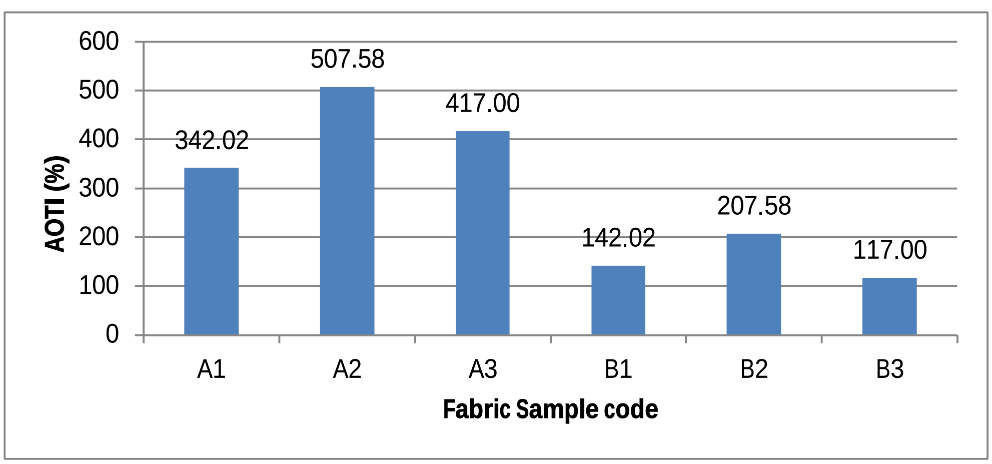


Figure 2 Accumulative one-way transport capacity index of plaited double knit fabrics

It is also interesting to note that the yarn inlay yarn type has significant influence on the moisture management properties. Fabrics made up of hydrophilic cotton inlay yarn of have 15% lower AOTI value than the fabric made up of hydrophobic polyester yarn. Similarly, Normal-polyester yarn as an in-lay yarn provides better moisture management properties than micro-polyester, due to reduced fabric bulkiness, which supports for faster transmission.

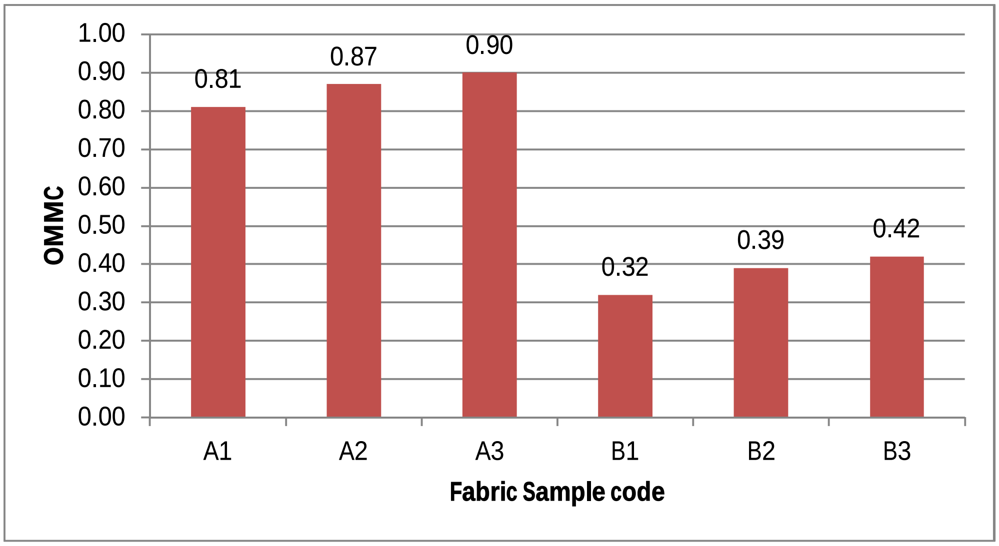


Figure 3 Overall moisture management capacity of plaited double knit fabrics

Inspite of lower the stitch density, fabric areal density and thickness with Type- b fabrics structures, OMMC value of plaited double knit fabric does not increase significantly. This might be due to higher volume of dead air within a fabric structure, which spreads the liquid moisture with the fabric structures.

C. Thermal Conductivity properties

Figures 4 show that the Type-B fabric has lower Clo value than other Type-A fabrics.

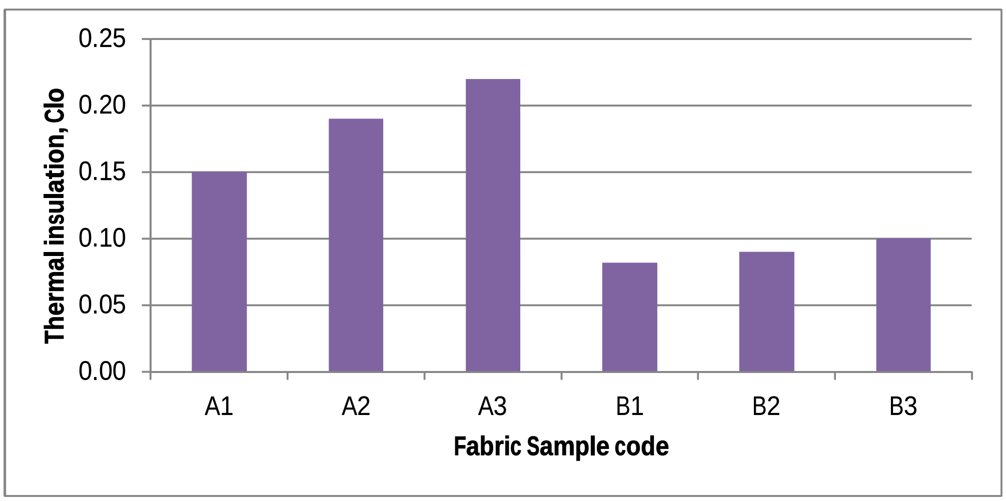


Figure 4 Thermal insulation values (clo) of plaited double knit fabrics

The volume of entrapped air present in the fabric structure has significantly influences the thermal insulation, thereby thermal conduction properties. The reason is, presence of tuck stitch in all wales lines leads to closer consolidation of double knit fabrics and increases the fabric thickness and stitch density of the fabric. Greater air space arises between the layers due to tuck stitch in the wale leads to lower the thermal conductivity of fabric.

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