Moisture Management Study on Inner and Outer Layer Blended Fleece Fabric

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ABSTRACT

Comfort properties of textiles are extremely important. It is sometimes more important than the aesthetic properties when the garments are wearing next to skin. Among all the comfort properties, good absorption and easy drying is one of the major requirements. When we do some physical work, we sweat; garments should absorb this sweat quickly and transport it to the outer surface of the garment. From the outer surface, sweat (or water to be precise) should be evaporated quickly to keep the body dry and cool. All these desired phenomena come under one technical term, called *"moisture management"*.

Moisture flow through blended material (fleece knitted fabric inner and outer layer blended) is a complex phenomenon. Clothing should possess good liquid moisture transmission property, for providing the thermo physiological clothing comfort. The clothing should take up the moisture from the skin as well as transmit it to the atmosphere. Higher hydrophilicity and micro denier of a material is known for good absorption and transport of liquid moisture, but how it really helps to transmit the moisture, have been studied in this work. Super micro polyester (288 filament), Polyester (34 filament), cotton and modal have been chosen as different blending fibers and 10 fabrics with different blend proportion fabrics were developed. Moisture management property of the fabrics was examined using a MMT instrument. From the experimental result it has been observed that, water absorbency and water spreading rate of the fabric increases with the increase in number of hydrophilic group in the material and multi denier of the filaments.

KEY WORDS

Moisture management test, fleece knitted fabric, multi filament polyester yarn, cellulosic fibre yarn, inner and outer layer fabric blend.

INTRODUCTION

Moisture management is one of the key performance criteria in today's apparel industry. It is defined as the ability of a garment to transport moisture away from the skin to the garment's outer surface. This action prevents perspiration from remaining next to the skin [10]. In hot conditions, trapped moisture may heat up and lead to fatigue or diminished performance. In cold conditions, trapped moisture will drop in temperature and cause chilling and hypothermia. Excess moisture may also cause the garment to become heavy, as well as cause damage to the skin from chafing [4].

When we start to sweat, our body humidity is more or less absorbed by the textile which we are wearing. If the humidity remains in the fabric and is not transported to the surface for evaporation, cooling cannot occur. The body warms up and even more sweat is produced, after exercise the body cools down and sweating ceases. However, any humidity retained in the clothing evaporates after a while, even if the body does not need to be cooled anymore and then we start to freeze. In consequence of the described problems in temperature regulation, our goal is to develop the optimized sportswear, it transport humidity to the outer surface as fast as possible to evaporate the humidity as quickly as possible and to make the skin feel dry [5].

Transport of water in fabric can takes place in two different ways, one is along the plane of the fabric and the other is perpendicular to the plane of fabric. Hence, wicking can happen in two ways Longitudinal wicking (along the plane of the fabric) and transverse wicking (perpendicular to the plane of the fabric) [4]. The mechanism by which moisture is transported in textiles is similar to the wicking of a liquid in capillaries. Capillary action is determined by two fundamental properties like capillary its diameter and surface energy of its inside face. [6]

The smaller the diameter or the greater the surface energy, the greater the tendency of a liquid to move up the capillary. Hence, the narrower the spaces between these fibres, the greater the ability of the textile to wick moisture. Fabric constructions, which effectively form narrow capillaries, pick up moisture easily. Such constructions include fabrics made from micro fibres, which are packed closely together. However, capillary action ceases when all parts of a garment are equally wet. The surface energy in a textile structure is determined largely by the chemical structure of the exposed surface of the fibre, as follows;

- Hydrophilic fibres have a high surface energy and consequently they pick up moisture more readily than hydrophobic fibres.

- Hydrophobic fibres, by contrast, have low surface energy and repel moisture. Special finishing processes can be used to increase the difference in surface energy between the face of a fabric and the back of the fabric to enhance its ability to wick [6].

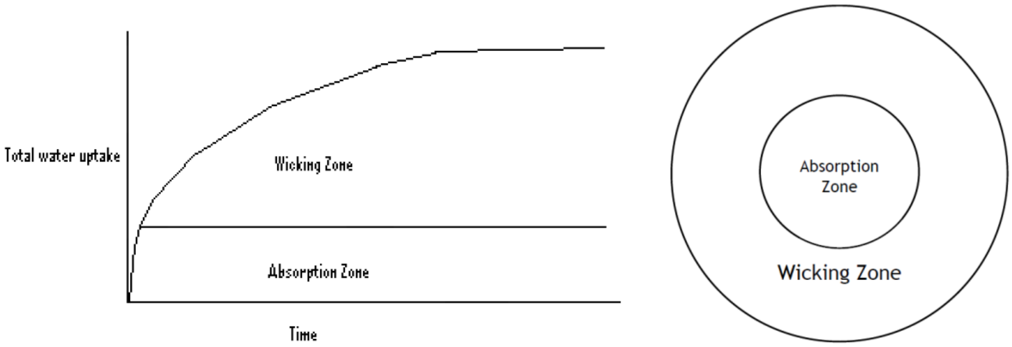

Fig.1 Observed Absorption and Wicking in fabric

D´Silva et. al. have developed a test method which provides information on both absorption and in plane wicking simultaneously. The absorption-wicking curve obtained form this typical instrument is given in Fig(1) [7].

For every active sport, synthetic fibres preferred because they do not retain moisture and therefore do not get heavy upon sweating like cotton does. Synthetic sports uniforms also have better dimensional stability. With the advanced technology, however, natural fibres like cotton and Tencel are making a comeback in high-performance, outdoor activities. For example, cotton can be made wind proof, breathable, and water resistant. For heavier fabrics, such as track suits and jogging suits made with nylon, polyester, acrylic, and their blends with acetate, cotton and wool are used. These fabrics maybe brushed inside for warmth and are cut loosely for comfort [9].

There are several factors, which affect moisture transport in a fabric. The most important are: Fibre type, Cloth construction or weave, Weight or thickness of the material and Presence of chemical treatments [6]

The micro fibre blends exhibits rapidity or higher rates of moisture management ability which greatly influences the thermo physiological and wear comfort of garments worn next to skin. Presence of a small amount of micro polyester enhances the moisture management and dry ability of the micro lyocell blended fabrics. Hence these fabrics can be effectively used in sportswear and bed linens for effective moisture management and drying properties [8].

Materials and Methods:

The Knitted active wear made in fleece and single jersey with following verities of fibre like Super Micro Polyester (288 filament), Polyester (34 filament), Cotton and Modal.In fleece fabric the super micro polyester fibre is blended with other verities in inner and outer layer of the fabric. These fleece fabrics moisture management properties are compared with the fleece fabrics are made by the same yarn which present in inner and outer layer. Dyed yarn are used to produce the fleece fabric.

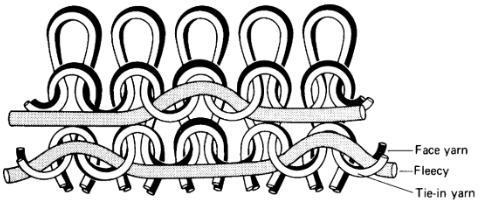

Table 1 Fabric details

F. No	Outer	Inner	Technical Specification	Fabric Code
1	Super Micro Polyester	Cotton	Count: Super Micro Polyester: 155D, Cotton: 34s Gauge: 24,Dia: 20,Feeder:60, M/C: Unitex	F-C/SMP
2	Super Micro Polyester	Modal	Count: Super Micro Polyester: 155D, Modal:34s Gauge: 24,Dia: 20, Feeder:60, M/C: Unitex	F-M/SMP
3	Super Micro Polyester	Polyester	Count: Super Micro Polyester: 155D, Polyester: 155D Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-P/SMP
4	Cotton	Super Micro Polyester	Count: Super Micro Polyester: 155D, Cotton: 34s Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-SMP/C
5	Modal	Super Micro Polyester	Count: Super Micro Polyester: 155D, Modal: 34s Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-SMP/M
6	Polyester	Super Micro Polyester	Count: Super Micro Polyester: 155D, Polyester: 155D Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-SMP/P
7	Super Micro Polyester	Super Micro Polyester	Count: Super Micro Polyester: 155D Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-SMP/SMP
8	Cotton	Cotton	Count: Cotton: 34s Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-C/C
9	Modal	Modal	Count: Modal: 34s Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-M/M
10	Polyester	Polyester	Count: Polyester: 155D Gauge: 24, Dia: 20, Feeder:60, M/C: Unitex	F-P/P

Fabric Assessment Methods:

The following table shows the standard test method which carried out to find out the moisture management behavior of the knitted fabric.

Table 2 Test Methods and its standards

S.No	Test	Standard
1	Moisture Management	AATCC:195-2009
2	Air Permeability	ASTM: D 737-96
3	Knitted Fabric Course Count (CPI)	ASTM: WK30250
4	Knitted Fabric Wales Count (WPI)	ASTM: WK30250
5	Fabric Thickness	ASTM: D 1777-96
6	Fabric Areal Density (GSM)	ASTM: 3776-96
7	Fabric Shrinkage	AATCC: 96-2009

Moisture Management Test:

A new method and instrument called the moisture management tester (MMT) has been developed to evaluate textile moisture management properties. This method can be used to quantitatively measure liquid moisture transfer in a fabric in three directions in one step like Spreading outward on the inner surface of the fabric, Transferring through the fabric from the inside to the outer surface and Spreading outward on the outer surface and finally evaporating.

AATCC has officially announced the approval of Test Method 195: Liquid Moisture Management Properties of Textile Materials. This test method is a procedure for the measurement, evaluation and classification of liquid moisture management properties of textile fabrics. It is suitable for measuring the performance of knitted, woven, and non woven fabrics.

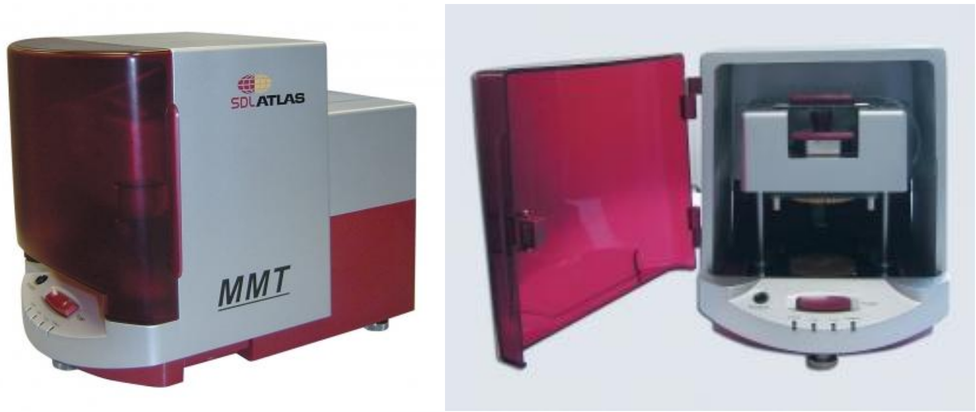

Fig.2 Moisture Management Tester

Ten moisture management indices can be used to characterize the moisture management properties of a fabric like Top wetting time, Bottom wetting time, Top absorption rate, Bottom absorption rate, Top maximum wetted radius, Bottom maximum wetted radius, Top spreading speed, Bottom spreading speed, Accumulative one-way transport index and Overall moisture management capability (OMMC).

The fabric structural and geometrical properties, fabric physical properties, fabric shrinkage and fabric air permeability tests are also carried out as per the standard test method.

RESULTS AND DISCUSSIONS:

The fabric structural and geometrical properties, fabric shrinkage and air permeability and moisture management tests results are shown in the table 3 & 4

The test results are discussed according to the fabric groups formed in the table 5, and the ANOVA two way analyses also carried out group wise and the result tabulated in table 6.

Table 5 Fabric grouping table

Group-1	Group-2
F-C/SMP(Cotton/Super Micro Polyester)	F-SMP/SMP(Super Micro Polyester/ Super Micro Polyester)
F-M/SMP(Modal/Super Micro Polyester)	F-C/C(Cotton/Cotton)
F-P/SMP(Polyester/Super Micro Polyester)	F-M/M(Modal/Modal)
F-SMP/C(Super Micro Polyester/Cotton)	F-P/P(Polyester/Polyester)
F-SMP/M(Super Micro Polyester/Modal)	
F-SMP/P(Super Micro Polyester/Polyester)	

Table 3 Fabric Test results.

Fabric Code	Course Per Inch (CPI)	Wales Per Inch (WPI)	Fabric Thickness (mm)	Fabric Areal Density (GSM)	Fabric Shrinkage (%)		Air Permeability (cm³/s/cm²)
					Length Direction	Width Direction	
F-C/SMP	41	40	0.54	194	7.3	-3.85	5.99
F-M/SMP	40	42	0.70	227	8.7	-5.3	6.65
F-P/SMP	40	48	0.72	217	8.7	-9.09	7.48
F-SMP/C	38	43	0.57	198	17.92	-5.66	5.90
F-SMP/M	41	41	0.61	232	19.05	-5.66	6.24
F-SMP/P	41	40	0.59	196	2.04	-1.57	6.86
F-SMP/SMP	40	43	0.56	213	2.04	-1.96	5.74
F-C/C	37	44	0.59	196	25	-12.28	7.28
F-M/M	44	41	0.71	250	16.28	-1.96	6.20
F-P/P	45	48	0.72	239	0.81	-1.96	7.69

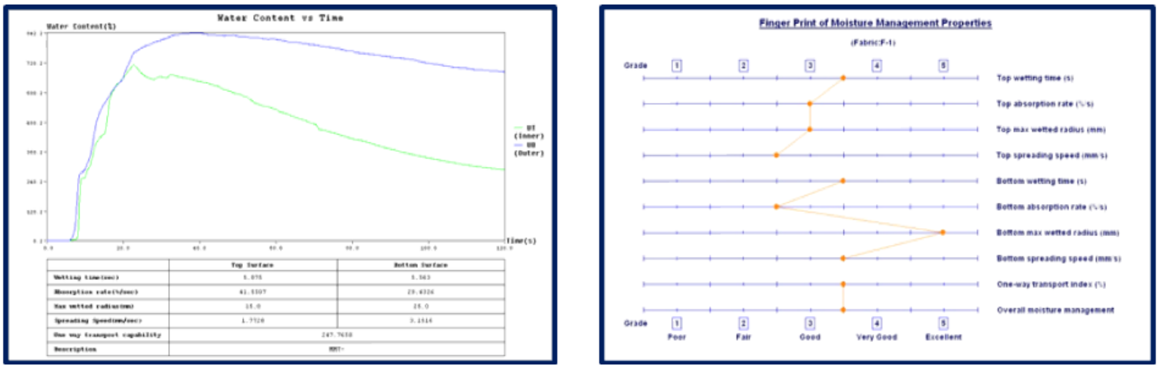

Fig.3MMT results graph for fabric F – C/SMP

Table 4 Moisture management test results

Fabric Code	Inner Wetting Time (s)	Outer Wetting Time (s)	Inner Absorption Rate (% / s)	Outer Absorption Rate (% / s)	Inner Max Wetted Radius (mm)	Outer Max Wetted Radius (mm)	Inner Spreading Speed (mm/s)	Outer Spreading Speed (mm/s)	Accumulative one-way transport index (%)	OMMC
F-C/SMP	5.875	5.563	41.5507	29.4326	15	25	1.7728	3.1516	247.7658	0.5641
F-M/SMP	9	4.922	26.9617	42.3626	10	25	1.2183	3.5221	344.825	0.7388
F-P/SMP	13.234	6.125	28.8377	54.1731	5	30	0.373	4.1138	563.0541	0.8727
F-SMP/C	26.766	8.438	27.8996	54.2149	10	15	0.3863	0.9115	330.7349	0.5459
F-SMP/M	7.156	5.797	36.4905	37.8656	10	20	1.1005	2.4561	264.9581	0.5487
F-SMP/P	7.64	6.281	43.9469	42.4792	25	25	2.5195	2.7498	10.2164	0.3029
F-SMP/SMP	8.516	7.235	51.9838	47.77	20	25	1.8553	2.9881	176.108	0.5218
F-C/C	40.672	8.125	21.0988	89.6557	10	15	0.2511	0.8686	529.1705	0.7213
F-M/M	9.875	5.719	36.2965	42.3706	10	20	1.0511	2.3076	314.9194	0.6043
F-P/P	119.953	11.234	0	63.919	0	25	0	2.0801	636.3667	0.7398

Table 6 Fabric group wise ANOVA Result

Parameter	**ρ - Value**	
	Group 1	**Group 2**
Between Fabric (WT)	0.280268	0.445841
Between Wetting Time	0.10763	0.239077
Between Fabric (AR)	0.946594	0.821912
Between Absorption Rate	0.211411	0.175177
Between Fabric (WR)	0.5	0.5
Between Wetted Radius	0.027429	0.097863
Between Fabric (SS)	0.388182	0.070828
Between Spreading Speed	0.028875	0.024656

Anova two way analysis without replication test has done at 5% confident level. If the ρ value is less than 0.05, then there is significant difference. If ρ value is more than the 0.05, then there is no significant difference.

Group – 1 - FABRICS:

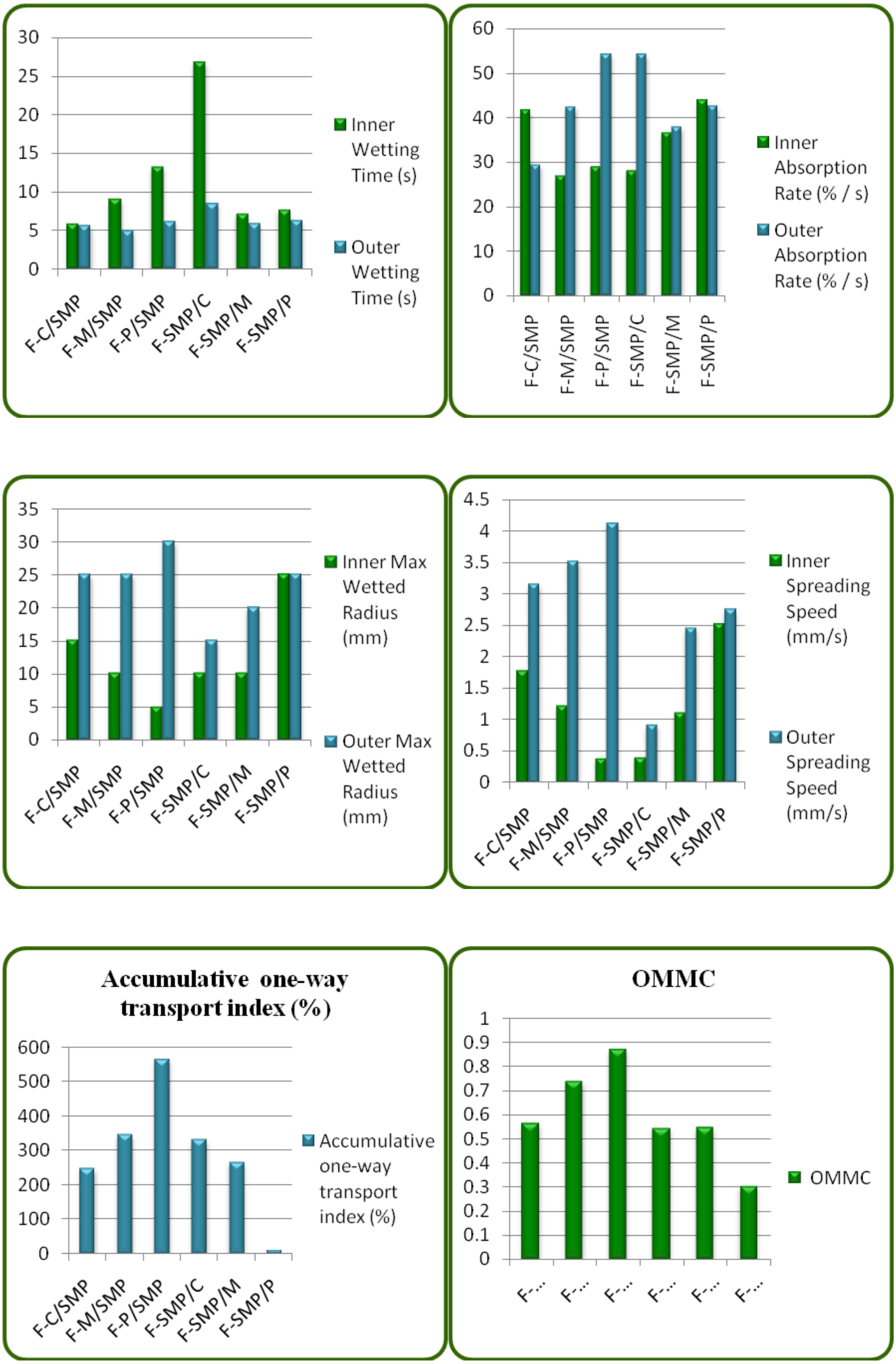

Fig.3MMT results graph for super micro blended by inner and outer layer fabrics

1. Super micro polyester gives less wetting time and good absorption rate in the outer layer than the inner layer. Its absorbency characteristic is better than the normal polyester.
2. In the outer layer super micro polyester spreading speed is very good compare to all other fibre.
3. Super micro polyester has less one way moisture transport capacity. So it is not freely allow the moisture outside.
3. Normal Polyester fibre takes more wetting time, when it is in the inner layer, because it has less moisture absorption rate in the inner layer, but its outer wetting time and absorption rate is good, and it is slightly less than the super micro polyester.
4. Normal Polyester fibres inner spreading speed is less, and gives more one way transport capacity than the other fibre, which means it allow the moisture freely outside. Compare to super micro polyester this outer spreading speed is less.
5. Cotton has less wetting time and more absorbency rate in the both inner and outer layer. Cotton inner spreading speed is more than the modal,. But modal have more outer spreading speed.
6. In this group of fabric outer wetted radius is more than the inner wetting radius.
7. Overall Moisture Management Capability (OMMC) is depends upon the absorption rate, one-way transport capability and spreading speed. The results shows that the outer layer super micro polyester fleece fabrics have more OMMC value than the inner layer super micro polyester fleece fabrics.
8. Cotton and modal not showing much OMMC value difference in outer layer, but inner layer modal have good OMMC value.
9. Here Fabric GSM is not making any changes in the results. Because the results are purely based on the number of layers the fabric which has.
10. Anova two way analysis shows that there is significant difference between inner and outer spreading speed and spreading area. Other parameters which are showing no significant difference.

Group -2 - FABRICS:

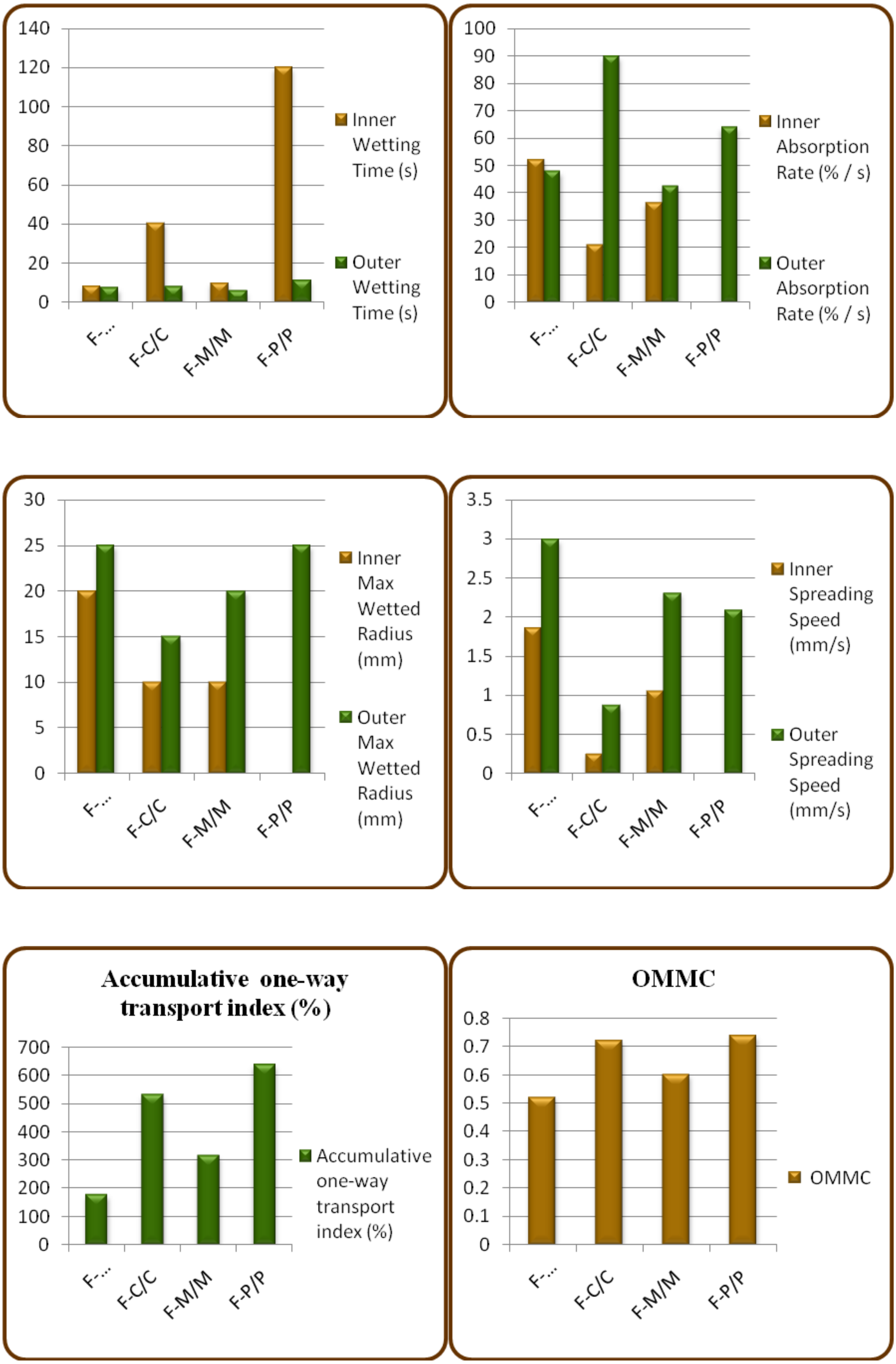

Fig.4MMT results graph for same fibre in inner and outer layer fleece fabrics

1. Polyester take more inner wetting time than the all other fibres, the inner wetting time is almost 120 sec (experiment duration), that means there is no wetting, absorption, and spreading in the inner layer, but it gives more one way transport capability than the all other fibre, that means moisture is easily transport to outside.
2. Polyester takes more outer wetting time than all other fibre, it gives less outer spreading speed and more outer absorption rate than the super micro polyester.
3. Super micro polyester have less wetting time and good outer spreading speed than the other fibres, but it gives almost equal absorption rate in both inner and outer layer. The one way transport capability also less compare to all other fibre. This results affect the moisture transport characteristic form inner layer to outer layer.
4. Similarly modal have almost equal inner and outer absorption rate, but cotton have less inner absorption rate and more outer absorption rate, here the cotton have more one way transport capability than the modal. Because of modal's absorbency character it is not transporting the moisture to outer layer easily.
5. The Overall Moisture Management Capability (OMMC) of polyester is slightly better in this group, cotton and modal also gives the moderate OMMC values.
6. In fleece group, cotton and modal outer layer fabrics have more shrinkage. If these yarns present in inner and outer layer fabrics have more shrinkage, this will results increase in GSM, but the fabric GSM is not making any changes on the results. Because here the results are purely based on the number of layers and cotton fabrics which is less GSM allows the moisture outside easily.
7. For fleece fabric concern, we can say cotton is good moisture management fabric than the modal and for polyester fewer filaments is suitable in the inner layer.
8. Based on the results (group1&2), the degree of brushing and fibre fineness also play the important role in the result of one way transport capability and inner absorption rate.
9. Anova two way analysis shows that there is significant difference between inner and outer spreading speed. The other parameters there are no significant difference.

CONCLUSIONS:

1. Moisture management of textiles is dependent on wetting time, absorption, spreading area of outer surface, spreading speed of the outer surface and one way transport capability.

2. Wicking is a property, which should be essentially good to get a satisfactory moisture management effect. It depends on various factors, like type of yarn, yarn density, yarn twist, fibre cross section etc.

3. The value of moisture holding, water absorbing or spreading in the inner surface means, fabric won't try quickly and it gives discomfort to the wearer. The fabric is very sticky and gives lot of discomfort.

4. The multifilament fibre is suitable for outer layer of the fabric gives fast transport of sweat and gives more comfort to the wearer. It is not suitable for inner layer.

5. The fabric inner and outer layer made by supper micro polyester has less air permeability value among all other fleece fabric. This fabric (F-SMP/SMP) is more suitable of winter wear to protect from the wind.

6. Multifilament fabric is most suitable for winter and cold season wear.

7. In fleece fabric group, polyester fabrics have more air permeability than the cellulosic fabric, the reason is polyester fibres have uniform cross section and less hairiness. Cellulosic fibres have more hairiness as well as more convolutions. This will protect the air. Especially cotton has more hairiness than the modal.

8. The degree of brushing and fibre fineness also plays the important role in the result of one way transport capability and inner absorption rate

9. Fabric GSM is not making any changes on the results of fleece fabric.

10. Compare to cellulosic fleece fabric, synthetic fleece fabric performs better in moisture management transport.

11. Compare to cotton and modal, cotton gives better moisture management performance in the fleece fabric. Therefore when sweat production is high, a higher proportion of polyester micro fiber will be helpful.

13. Small modal proportion will act for the quick absorption of the perspiration from the skin and higher polyester proportion will help to spread the absorbed liquid to the outer surface of the fabric, due to its high wicking and water spreading property.

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