Effect of Using Micro Denier Polyester Filament Yarns on Low Stress Mechanical Properties of Fabrics

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Abstract- An investigation of the effect of micro denier polyester yarns on the handle of polyester cotton fabrics is reported. These yarns were used in weft with polyester cotton as warp. It has been found that with the exception of shear properties, all the other mechanical properties have been found to be similar. There is no change in handle of fabrics. Drape remains the same for micro denier fabrics and air permeability values are low in comparison with regular yarn fabrics.

I. INTRODUCTION

Micro denier polyester yarns are produced to provide better comfort to the fabrics. These yarns are used in weft and the denier in which these are marketed is 81. Fibre fineness affects most of the properties of fabrics such as feel, drape and moisture absorption. The effects of fibre fineness of cotton fibres on fabrics have been studied from time to time but the effect of fibre denier on the properties of fabrics has not been studied in depth. Mukesh Kumar Singh and Behera (2021) have reported on low stress mechanical and transmission behaviour of polyester filament fabrics. Amaravathi in 1997 has carried out work on polyester cotton fabrics produced from micro denier polyester yarns and presented her findings.

Mukesh Kumar Singh and Behera (2021) produced micro denier polyester fibres of varying fineness from chips in polyester spinning polyethylene terephthalate filament yarns having DPF 0.6,0.7,0.9,1.0,1.1,1.4,2.1 from the same batch of polymer. Air permeability is positively correlated with DPF in fully drawn yarn and draw textured form (DTY). Air permeability is found to be significantly good in DTY yarn than FDY having the same DPF.

Behera,Chowdhry and Sobti (1998)reported on the handle of polyester fabrics dress materials. Handle has been found to be good for fabrics produced from micro denier fibres. Drape has been found to be good.

Amaravathi (1997) carried out work on the low stress mechanical properties of micro denier polyester yarns from commercially available sources. Mukesh Kumar and Behera (2021) have not reported any comparative study between regular and micro denier fabrics. Their study is confined only to micro denier fabrics and discussion on tensile, bending, shear and friction properties. Their main focus is to highlight the differences existing among various deniers and draw textured and fully drawn yarns. Drape has not been studied by them but air permeability has been given due importance.

In this study, comparison between regular and micro denier fabrics has been made and the results are reported. The work done by the above workers was done with multi filament both in warp and weft. The present work is concerned with the properties of fabrics in which polyester cotton spun yarn was used in warp and multifilament polyester yarns were used in weft.

II. METHODOLOGY

Six polyester fabric samples were produced out of which 3 were microfilament fabrics and 3 were normal filament fabrics. Details are given in Table1. The picks per cm were varied from 25 to 31 cm each case.

Table 1
Details of fabrics

Sample No.	Warp (Tex)	Weft (Tex)	Total denier	No.of filaments	DPF	GSM	Thread per cm	
							Warp	Weft
1	13	9	80	32	2.35	67	35	25
2	13	9	80	32	2.35	69	35	28
3	13	9	80	32	2.35	75	35	31
4	13	9	80	100	0.8	68	35	25
5	13	9	80	100	0.8	71	35	28
6	13	9	80	100	0.8	73	35	31

- Processing of fabrics

The six samples were scoured heat set, dyed and given a peach finish. Standard procedures were followed.

- Fabric Evaluation
- Evaluation of fabric constructional parameters.

Constructional parameters such as thread density areal density were determined using standard techniques.

- Evaluation of Mechanical properties

- Drape

The test was performed on a Eureka drape tester. Drape co-efficient was calculated as below.
Drape co-efficient (%) = As – Ad / AD –Ad, where
AD = the area of the specimen
Ad = the area of the supporting disk
As = the actual projected area of the specimen.

- Air permeability was measured in accordance with ASTM standard(1980)
- Evaluation of fabric low stress mechanical properties.

A Kawabata fabric evaluation tester was used for this purpose. Tensile, shear, bending, compression and surface characteristics were measured as follows:

Tensile and Shear testing
Sample size (20 X20 cm) maximum tensile strain 100% maximum shear strain (Shear force at 0.5 degrees) tensile strain rate 0.2 mm/sec. Shear strain rate 0.417 mm/sec.

Testing of Compression properties rate of compression 1 mm/ 50 sec maximum compression was 0.5 g/cm.

Testing of bending properties rate of curvature 0.5 cm/ sec. Clamp interval 1 cm , fabric speed , 1 mm/sec.

Testing of surface properties maximum speed 3 cm vertical load on surface roughness detectors 5 g; weight of surface roughness detector 10 g.

Other test parameters were kept standard as specified by the KES instrument. Details of low stress properties with their symbol obtained from the Kawabata system are given in Table 2.

Table 2
Fabric Mechanics Attributes

Test	Low Stress properties	Notation
Tensile Test	1.Extensibility 2.Linearity 3.Tensile energy 4.Tensile resilience	EM LT WT RT
Shear test	5.Shear stiffness 6.Hysteresis at 0.5 degree shear angle 7.Hysteress at 5 degree shear angle	G 2HG 2Hg 5
Bending test	8.Bending rigidity 9.Hysteresis of bending moment	B 2 HB
Compressibility test	10.Lineariety of compression thickness curve 11.Compressional energy 12.Compression resilience	LC W RC

Surface Characteristics	13.Coefficient of friction 14.Mean deviation & MIU 15.Geometric roughness	M1U MMD SMD

Fabric Construction	16.Weight/ Unit area 17.Fabric Thickness	W T

Table – 3 Tensile Properties:

KES-F Data	Regular			Micro		
Picks/cm	25	28	31	25	28	31
Tensile						
LT-1	0.80	0.90	0.71	0.82	0.84	0.96
LT-2	0.88	0.91	0.92	0.88	0.87	0.88
LT	0.84	0.90	0.81	0.85	0.85	0.92
WT-1(J/m²)	0.059	0.074	0.054	0.069	0.069	0.064
WT-2(J/m²)	0.372	0.323	0.358	0.333	0.274	0.245
WT (J/m²)	0.216	0.198	0.206	0.201	0.172	0.154
RT-1 (%)	75.00	95.00	81.67	78.57	83.33	69.05
RT-2 (%)	71.11	66.73	65.75	69.13	64.06	64.10
RT (%)	73.06	80.86	73.71	73.85	73.85	66.58
EMT-1 (%)	0.33	1.32	0.31	0.34	0.33	0.27
EMT-2 (%)	1.69	1.43	1.56	1.51	1.26	1.11
EMT (%)	1.01	0.88	0.93	0.92	0.80	0.69

Table - 4 Bending and Shear Properties:

KES-F Data	Regular			Micro		
Picks/cm	25	28	31	25	28	31
Bending						
B-1 (µN.m)	20.27	11.26	12.91	12.90	16.48	8.89
B-2 (µN.m)	02.46	2.84	2.41	2.96	4.86	4.65
B (µN.m)	11.36	7.05	7.66	7.94	10.67	6.52
2HB-1	1.983	1.228	1.589	1.215	1.724	0.862
2HB-2	0.113	0.124	0.078	0.181	0.297	0.350
2HB (mN)	1.048	0.676	0.834	0.698	1.011	0.606
Shear						
G-1 (N/m)	1.0229	0.9702	1.0780	0.9322	1.4565	1.5116
G-2 (N/m)	0.6933	0.8857	1.0522	0.8722	1.2287	1.3463
G (N/m)	0.8581	0.9280	1.0651	0.9022	1.3426	1.4290
2HG-1 (N/m)	0.7129	0.7423	0.7938	0.7987	1.1809	1.0266
2HG-2 (N/m)	1.2397	1.4871	1.6243	1.7885	1.9282	2.2026
2HG (N/m)	0.9763	1.1147	1.2091	1.2936	1.5545	1.6145
2HG5-1 (N/m)	3.9175	3.4276	3.8441	3.4692	5.3973	5.5541

2HG5-2 (N/m)	2.6166	3.3075	3.8073	3.3197	4.7089	5.0764
2HG5 (N/m)	3.2671	3.3675	3.8257	3.3945	5.0531	5.3153

Table – 5 Surface and Compression Properties:

KES-F Data	Regular			Micro		
Picks/cm	25	28	31	25	28	31
Surface						
MIU-1	0.1639	0.1637	0.173	0.1529	0.1479	0.1563
MIU-2	0.1460	0.1333	0.1423	0.1568	0.1462	0.1543
MIU	0.1550	0.1485	0.1576	0.1548	0.1471	0.1553
MMD-1	0.0130	0.0127	0.0117	0.0101	0.0107	0.0104
MMD-2	0.0254	0.0144	0.0219	0.0258	0.0198	0.0232
MMD	0.0192	0.0135	0.0168	0.0180	0.0153	0.0168
SMD-1 (µm)	3.99	2.71	2.39	2.89	3.59	2.53
SMD-2 (µm)	8.71	8.36	7.55	9.23	8.15	8.13
SMD (µm)	6.35	5.53	4.97	6.06	5.87	5.33
Compression						
LC	0.57	0.56	0.51	0.60	0.53	0.56
WC (J/m^2)ʒ	0.034	0.031	0.029	0.034	0.032	0.029
RC (%)	72.52	74.89	68.93	71.3	76.59	73.23
Thickness (T_0 mm)	0.39	0.38	0.40	0.39	0.38	0.37
Thickness(Tm mm)	0.27	0.261	0.281	0.254	0.251	0.283
Weight (mg/cm^2)	6.79	6.94	7.54	6.79	7.10	7.32
Air permeability (cm/s)	84	62	47	61	47	32
Drape Coefficient %	64	64	66	64	64	64

There is not much difference in the tensile properties between regular and micro denier fabrics. WT and EMT in weft way show a distinct increase compared to warp. RT shows a decrease in weft way in all the cases (Table 3)

- Bending and Shear properties

The bending and shear properties, particularly at low stress level, play an important role due to the interference of frictional restraint at the cross over points of the warp and weft threads. Therefore, low stress bending and shear properties are not only dependent on the stiffness of the materials but also dependent on the surface geometry of the warp and weft yarn. Bending and shear properties are given in Table 4. Bending rigidity values are higher for micro denier fabrics in comparison with regular fabrics. Bending hysteresis also show higher values. Shear properties show higher values particularly with higher pick density. With the increase in pick density, shear hysteresis values tend to increase. This is due to greater number of filaments present which prevent the slippage of intersection points resulting in higher shear hysteresis.

- Surface Properties

The surface properties in terms of surface friction (MIU and MMD) and surface roughness (SMD) are given in Table 5. Not much difference is noticed and the values are similar.

- Compressional Properties

Values of LC, WC, RC and %C are given in Table 5 from which it is evident that the values for regular and micro denier fabrics are similar. Handle values are found to be similar.

III. DISCUSSION

From the above, it is clear that the use of micro denier fibres has not led to any substantial improvement in fabric properties. This is due to the fact that micro denier yarns have been used in weft only Mukesh Kumar Singh, Behera, Chowdhry,Sobti have used micro denier fibres in warp and weft and thus the effects were found to be different, Air permeability values are low for microfilament fabrics.

CONCLUSION

The results show that there is not much difference between regular and micro denier fabrics on the basis of their low stress mechanical properties.

REFERENCES

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