한국의류산업학회지
제1권 제3호, 1999
<연구논문>

J. Kor. Soc. Cloth. Ind.
Vol. 1, No. 3, pp.280-287(1999)

Effect of Knitting Condition on the Deformation Behavior of the Weft-knitted Fabrics

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위편성포의 변형거동에 관한 연구

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Abstract : The aims of this research were to study on the relationship between the mechanical properties and the deformation behavior of weft-knitted fabrics as a function of knit structure and knit density. Eighteen weft-knitted fabrics were produced with six different knit structures (1×1 rib, half-cardigan rib, half-milano rib, interlock, single-pique, and crossmiss interlock) and three different knit densities (loose, medium, tight). The mechanical properties of these samples were measured using the KES-F system. The 2HB/W increased as knit density was raised. The increase was greater for the double knit fabrics in all samples. Half-milano rib and crossmiss interlock samples showed the lowest 2HG/G values. The double knits were smaller than those of single knits indicate a higher degree of surface smoothness. The ratio of compression energy to weight per unit area of the double knits had lower values than the single knits.

Key words : knit density, knit structure, mechanical property, deformation behavior

1. Introduction

Designers and consumers require certain characteristics in the fabrics used for winter outerwear such as sweaters, knit shirts, and tops. Desirable characteristics for these garments include durability, comfort, aesthetic appeal, and ease of care.

Knitted fabrics perform well due to their desirable properties such as strength, elasticity, flexibility, thermal insulation properties, wrinkle resistance, and launderability. Weft-knitted fabrics can be produced by using simple processes and have a very versatile structure, thereby increasing the variety of knit fabrics available. Because of this variety, the structural characteristics of weft-knitted fabrics can be varied greatly. An investigation of the characteristics of a variety of weft-knitted fabrics to identify those that exhibit the best properties for winter outerwear will assist in the most appropriate choices for textile manufactures and designers.

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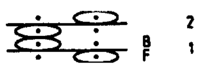
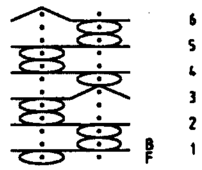
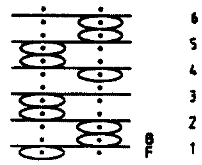
It has been reported that the mechanical properties of knitted fabrics vary with knit structures, fibers, yarns, and densities which in turn affect the knitted fabric's hand significantly (Gibson and Postle, 1978; Hallos *et al.*, 1990; Knapton , 1968; Park *et al.*, 1995). The results of research conducted by Kawabata (1980) and his collaborators probably represent the most thorough investigation of hand values in relation to mechanical properties.

Knapton *et al.* (1968) reported that the dimensional stability and knit performance of knitted fabrics were influenced by structural components such as knit structures, loop lengths, and cover factors. Kwon and Kim (1994) examined the effects of knitting conditions such as changes in course density resulting from changes in the tension of yarn feeding and yarn count on the mechanical properties and hand of knitted fabrics.

Currently, most of knitted fabrics for outerwear have diverse constructions with combinations of tuck and welt loops. On the basis of the existing studies of knit structures, more research is needed in the area concerning the effect of knitting conditions and diverse knit structures on the mechanical properties and the deformation behavior of knitted fabrics.

Table 1. Structural characteristics of sample knitted fabrics

	Structure	SCSL (cm)	MTF	Weight (g/cm²)	Knitting density (walexcourse/cm)	Notation[a)]
Single Knit	1×1 rib	2.578	5.95	0.059	6.31×3.70	
		2.427	6.32	0.062	6.74×4.11	
		2.222	6.91	0.066	7.50×4.71	
	Half-cardigan rib	3.708	8.28	0.055	3.04×2.74	
		3.455	8.89	0.058	3.49×3.35	
		3.193	9.62	0.062	3.75×3.85	
	Half-milano rib	4.173	7.36	0.063	4.40×4.92	
		3.941	7.79	0.065	4.45×5.58	
		3.675	8.35	0.067	4.58×6.44	
Double knit	Interlock	2.848	10.78	0.068	3.43×3.31	
		2.752	11.16	0.073	3.66×3.60	
		2.538	12.10	0.082	3.70×4.23	
	Single-pique	6.801	6.77	0.075	2.65×3.01	
		6.724	6.84	0.081	2.85×3.31	
		6.244	7.38	0.086	3.02×3.53	
	Crossmiss interlock	7.186	6.41	0.085	3.48×2.84	
		6.736	6.84	0.088	3.66×3.23	
		6.510	7.07	0.090	3.85×3.73	

a) F=Front needle bed, B=Back needle bed, =plain loop, =tuck loop, =miss loop

In addition to these characteristics, the aesthetic appeal of the garment is a result of the way in which the fabric follows the contours of the body. The silhouette of the garment is dependent on the fabric characteristics and the pattern shapes used to make the garment. Studies of fabric characteristics and their impact on garment silhouette are also needed.

In this study eighteen weft-knitted fabrics were produced with different knit structures (1×1 rib, half-cardigan rib, half-milano rib, interlock, single-pique, and crossmiss interlock) and three different knit densities (loose, medium, tight). The aims of this research are to investigate relationships between the knit structure and knit density to confirm deformation behavior.

2. Experimental

2.1. Knitting yarn and knitting conditions

One hundred percent cotton yarn (2/20's) was used to knit all of the samples and these were knit at 24 traverse/min. with 84 inch fabric width & 7 gauge (SHIMA SEKI-214KI) in an electric weft knitting machine (latch-needle-flat-bed machine).

A total of eighteen weft-knitted fabrics were produced with different knit structures and knit densities controlled by machine tightness factors. That is to say, six different weft-knitted fabrics were prepared in three types of single knit and three types of double knit. Each knit structure had three different machine tightness factors (loose, medium, and tight).

The single knit samples were knitted as a 1×1 rib, a half-cardigan rib which combined the 1×1 rib and tuck stitch, and a half-milano rib which combined the 1×1 rib with a miss stitch. For the double knit, the following 3 samples were chosen: a basic interlock, a single-pique in which the interlock was combined with a long and short needle tuck, and a crossmiss interlock in which the interlock was combined with a long and short needle miss. The knitted fabrics and their structural characteristics are shown in Table 1.

2.2. Relaxation treatment

The knitted fabrics from the knitting machine were air dried for 48 hours, in the standard conditions (20°C; 60% R.H.). The knitted fabrics were treated to eleven cycles of mechanical relaxation using repeated washings and tumble drying as suggested by Heap *et al.* (1983, 1985).

Table 2. MFT (machine tightness factor) and SCSL (structural-cell stitch length) of sample knitted fabrics

Structure of knitted fabric		MTF			SCSL(cm)		
		L	M	T	L	M	T
Single knit	1×1 rib	5.951	6.312	6.916	2.578	2.427	2.222
	Half-cardigan rib	8.282	8.898	9.621	3.708	3.455	3.193
	Half-milano rib	7.362	7.793	8.349	4.173	3.941	3.675
Double knit	Interlock	10.778	11.162	2.103	2.848	2.752	2.538
	Single-pique	6.774	6.839	7.382	6.801	6.724	6.244
	Crossmiss interlock	6.411	6.835	7.074	7.196	6.736	6.510

L.=loose, M.=medium, T.=tight

Table 3. KES characteristic values of basic mechanical properties

Property	Symbol	Characteristic value	Unit	Apparatus
Tensile	LT	Tensile linearity	none	KES-FB1
	WT	Tensile energy	g.cm/cm^2	
	RT	Tensile resilience	%	
Bending	B	Bending rigidity	gf.cm^2/cm	KES-FB2
	2HB	Bending hysteresis	gf.cm^2/cm	
Shearing	G	Shear stiffness	gf/cm^2.degree	KES-FB1
	2HG	Hysteresis of shear force at 0.5 of shear angle	gf/cm	
	2HG5	Hysteresis of shear force at 5 of shear angle	gf/cm	
Compression	LC	Compressional linearity	none	KES-FB3
	WC	Compressional energy	gf.cm/cm^2	
	RC	Compressional resilience	%	
Surface	MIU	Coefficient of friction	none	KES-FB4
	MMD	Mean deviation of MIU	none	
	SMD	Geometrical roughness	μm	
Thickness & Weight	T	Fabric thickness	mm	KES-FB3
	W	Fabric weight	mg/cm^2	Balance

For washing, 0.5% detergent (Persil, 5 mg/1 *l*) was added and the fabrics were washed for 60 minutes at 60°C in a revolving drum type washing machine (Bloomberg Co.). After the final spin cycle was completed, the samples were tumble dried in the dryer for 90 minutes at 70°C. This process was continued until the fabrics did not change in size, after which their mechanical properties were measured. The fabrics were then stored for 48 hours under standard conditions.

2.3. Structural cell loop length (SCSL) and machine tightness factor (MTF) measurements

After knitting, the loop length of knitted fabrics was measured by unit loop length: first, marking the sample in 100 wale intervals, then unraveling the sample and applying pre-tension at the ends of the yarn, measuring this yarn, and dividing by 100. The loop length obtained from 10 measurements was used in the following equation to obtain SCSL and MTF (Knapton, 1968; Postal, 1968). The SCSL and MTF for samples used in this study are shown in Table 2.

SCSL(cm)=(total length of thread used in 1 cycle of knitting/N)×Nt

$$MTF = [(\sqrt{N}) \times Nt)/SCSL]$$

where, N = Tex of yarn

Nt = number of needles needed for minimum repeat unit of knitting

2.4. Mechanical property measurements

The mechanical properties of the 18 weft-knitted fabrics with varying knit structures and densities were measured using the KES-F system. Sixteen categories of measurements were made under standard measurement conditions for the knitted fabric's tensile, bending, shear, compression, surface properties, and thickness and weight. Where anisotropy is a consideration, the measurements of tensile, bending, shear, and surface properties were measured in both wale and course directions. Sample sizes of 20 cm × 20 cm were used for measurements of the five properties except for the bending property measurements. For bending property measurements a 5 cm×5 cm sample size was used due to the strong bending tendency of the fabrics. After the measurements were completed, all values were converted. The mechanical properties are

Table 4. The mechanical properties of single knits for samples

Property	Knit structure	1×1 rib			Half-cardigan rib			Half-milano rib		
		loose	medium	tight	loose	medium	tight	loose	medium	tight
Tensile	LT-W	0.3143	0.3613	0.3757	0.2949	0.3211	0.3380	0.3535	0.4030	0.4118
	LR-C	0.3560	0.3810	0.3795	0.3187	0.3612	0.3700	0.3825	0.4065	0.4206
	LT	0.3352	0.3711	0.3776	0.3068	0.3412	0.3540	0.3680	0.4047	0.4162
	WT-W	20.1390	43.9040	48.5100	61.0540	68.6000	71.8400	45.4720	39.6900	58.3100
	WT-C	22.2460	63.5200	94.2760	56.8400	52.0382	65.0500	66.5420	86.1420	133.7700
	WT	21.1925	53.7120	71.3930	58.9470	60.3190	68.4450	56.0070	62.9160	96.0400
	RT-W	24.3309	39.0625	36.3636	28.5714	31.5000	50.5000	27.1552	32.5926	26.8000
	RT-C	23.1000	16.6061	24.9480	25.0010	25.0472	22.7357	22.2386	19.7952	27.5000
	RT	23.7155	27.8343	30.6558	26.7857	28.2735	36.6178	24.6969	26.1939	27.1500
Bending	B-W	0.8138	1.0336	1.1729	0.5074	0.5904	0.6666	0.7836	1.2162	1.5227
	B-C	0.1168	0.1824	0.2191	0.1617	0.2799	0.2185	0.2309	0.3030	0.3373
	B	0.4653	0.6080	0.6965	0.3345	0.4351	0.4426	0.5073	0.7596	0.9300
	2HB-W	0.8659	1.1755	1.2777	0.6901	0.7901	0.8130	0.9130	1.3716	1.4896
	2HB-C	0.1390	0.1721	0.2244	0.1795	0.4077	0.5155	0.2715	0.4477	0.4937
	2HB	0.5024	0.6738	0.7510	0.4348	0.5989	0.6643	0.5922	0.9097	0.9909
Shear	G-W	0.2744	0.3210	0.3945	0.3724	0.4361	0.5067	0.3356	0.4141	0.5194
	G-C	0.1960	0.2205	0.3087	0.3307	0.3846	0.4459	0.3479	0.3381	0.4288
	G	0.2352	0.2707	0.3516	0.3516	0.4104	0.4753	0.3418	0.3761	0.4741
	2HG-W	0.8624	1.0143	1.2985	1.3622	1.5386	1.8767	1.0339	1.2593	1.4896
	2HG-C	0.8623	0.8575	1.5239	1.1907	1.4602	1.7199	1.2593	1.3279	1.6023
	2HG	0.8624	0.9359	1.4112	1.2765	1.4994	1.7983	1.1466	1.2936	1.5459
	2HG5-W	0.9506	1.1221	1.4504	1.4651	1.6758	2.0090	1.1221	1.3083	1.6905
	2HG5-C	0.9261	0.9457	1.6268	1.3279	1.6023	1.8767	1.3573	1.4259	1.7591
	2HG5	0.9384	1.0339	1.5386	1.3965	1.6391	1.9429	1.2396	1.3671	1.7248
Surface	MIU-W	0.4572	0.4929	0.5071	0.4900	0.4900	0.4890	0.5460	0.5472	0.5500
	MIU-C	0.4220	0.4520	0.5560	0.4260	0.4760	0.5009	0.5680	0.5510	0.5420
	MIU	0.4396	0.4725	0.5316	0.4580	0.4830	0.4945	0.5570	0.5491	0.5460
	MMD-W	0.0166	0.0172	0.0179	0.0152	0.0172	0.0185	0.0174	0.0190	0.0192
	MMD-C	0.0194	0.0219	0.0263	0.0174	0.0218	0.0264	0.0242	0.0316	0.0336
	MMD	0.0180	0.0196	0.0221	0.0163	0.0195	0.0225	0.0208	0.0253	0.0264
	SMD-W	4.5620	4.5620	5.5170	7.9960	8.9280	10.7700	6.4580	6.8270	8.3400
	SMD-C	10.2200	10.2200	12.1630	10.4960	11.0440	13.3760	13.4660	15.8170	19.2960
	SMD	7.3910	7.3910	8.8400	9.2460	9.9860	12.0730	9.9620	11.3220	13.8180
Compression	LC	0.6100	0.5950	0.6022	0.4264	0.4906	0.6089	0.5879	0.6144	0.5900
	WC	1.9904	1.9629	1.4955	2.0070	2.0070	1.9169	2.0070	1.7189	1.6208
	RC	39.9311	39.3621	31.2131	36.4311	34.5424	27.8201	29.2123	31.3686	27.1334
Thickness & Weight	T	4.1501	4.2278	4.2993	4.0021	4.1125	4.2119	3.9821	4.0210	4.1121
	W	59.0132	62.2310	66.1009	55.1254	58.4950	62.1232	63.9341	65.3411	67.1254

The letters C and W represent the course and wale direction of each knitted fabric.

listed in Table 3.

3. Results and Discussion

3.1. Mechanical properties of weft-knitted fabrics

Eighteen kinds of weft-knitted fabrics with varying knit structures and densities were constructed. Their tensile, bending, compression, surface properties, thickness, and weight were measured using KES-F system under standard measurement conditions. The results are shown in Tables 4 and 5, for single knit and double knit samples.

Tensile : High modulus and tensile resilience (RT) values indicate that the fabric is less likely to relax when external forces are applied. Knitted fabrics with high RT have greater dimensional stability with low relaxation and high resilience characteristics. Table 4 shows that although the tensile linearity (LT) values of the single knit samples are generally less than the LT values of the double knit samples, LT and tensile energy (WT) increased respectively with knit density. This effect was more noticeable in the single knit samples than in double knit samples. As the knit density increased, the tensile resilience also increased by increasing dimensional stability. The half-milano rib, single pique, and crossmiss interlock with the combined tuck and miss loop had lower stretch properties in the course direction than those constructed with a knit loop.

This results in a lower degree of tensile resilience in the course direction.

Bending : As can be seen in Table 4, B and 2HB of single knit fabrics increased with knit density. Similar tendencies can also be seen in the double knit samples. The differences between B and 2HB indicate a much lower bending rigidity and hysteresis of bending moment in single knit than in double knit samples. Therefore, the single knit structure has greater ability to conform to the curved surface of a human body. The lower bending rigidity in the course direction is attributed to the action of the loops in the wale direction. Based on knit structure, the differences in bending rigidity between wale and course direction were highest for the 1×1 rib and interlock samples, which were constructed with knit loops. The difference was greater in the wale direction. The half-milano rib and crossmiss interlock, which were constructed by combining the knit loop and miss loop, showed higher bending rigidity than 1×1 rib in both course and wale directions.

Shear : Shear properties are important factors affecting drape characteristics of the fabric. These are represented by shear modulus (G) and shear hyteresis (2HG, 2HG5) which are related to elasticity and plasticity, respectively. As seen in Table 4, 5 the shear properties of knitted fabrics, such as bending properties, increased with knit density. This increase was greater for the single knit

Table 5. The mechanical properties of double knits for samples

Property	Knit structure	Interlock			Single-pique			Crossmiss interlock		
		loose	medium	tight	loose	medium	tight	loose	medium	tight
Tensile	LT-W	0.3831	0.3789	0.4100	0.3417	0.3547	0.3719	0.3364	0.3672	0.3725
	LR-C	0.3944	0.3880	0.3748	0.3680	0.3600	0.3484	0.3677	0.3993	0.4093
	LT	0.3887	0.3885	0.3540	0.3540	0.3574	0.3601	0.3521	0.3832	0.3912
	WT-W	66.4440	68.7960	69.2900	63.7980	56.0560	53.1116	49.7840	49.2940	47.8240
	WT-C	96.2360	98.6900	99.8700	54.0960	58.0800	66.1500	57.1800	57.9180	65.2680
	WT	81.3400	83.7430	84.5800	58.9470	57.0680	59.6330	53.4820	53.6060	56.5460
	RT-W	9.8820	12.1083	12.1000	14.7465	19.0559	21.9557	14.5669	14.5129	22.7459
	RT-C	15.4786	16.9000	16.9000	14.8551	20.6000	21.0370	14.1000	14.7208	22.8228
	RT	12.6803	14.5041	14.5000	14.8008	19.8280	21.4964	14.3335	14.6169	22.7844
Bending	B-W	1.7875	1.9605	2.9596	1.8502	1.7062	3.1669	2.7375	4.0371	4.1439
	B-C	0.3356	0.1984	0.5880	0.4258	0.7909	0.8884	0.2950	1.0158	0.9702
	B	1.0616	1.0795	1.7738	1.1380	1.2485	2.0254	1.5163	2.5264	2.5570
	2HB-W	1.7763	2.4201	3.5741	2.3167	2.8572	3.6314	3.3643	4.3120	4.6080
	2HB-C	0.5365	0.7272	0.6590	0.9339	0.9531	1.1559	1.2451	1.3921	1.6128
	2HB	1.1564	1.5737	2.1165	1.6253	1.9051	2.3937	2.3047	2.8520	3.1130
Shear	G-W	0.4336	0.5194	0.6345	0.5120	0.5904	0.7276	0.4827	0.7423	0.7914
	G-C	0.4189	0.4924	0.5488	0.5218	0.5684	0.7000	0.4410	0.5856	0.6713
	G	0.4263	0.5059	0.5917	0.5170	0.5794	0.7138	0.4618	0.6639	0.7313
	2HG-W	1.4259	1.6758	2.1315	1.7003	1.8816	2.3226	1.4504	2.3177	2.2785
	2HG-C	1.6905	2.1266	2.2638	2.0237	2.2099	2.5500	1.7101	2.2001	2.4255
	2HG	1.5582	1.9012	2.1976	1.8620	2.0457	2.4363	1.5803	2.2589	2.3520
	2HG5-W	1.5533	1.8521	2.3814	1.8641	2.1119	2.6264	1.6709	2.6460	2.6558
	2HG5-C	1.7983	2.2687	2.4500	2.1805	2.4206	2.9900	1.8767	2.4157	2.6705
	2HG5	1.6758	2.0629	2.4157	2.0223	2.2663	2.8082	1.7738	2.5308	2.6632
Surface	MIU-W	0.4008	0.4092	0.4510	0.4430	0.4547	0.4750	0.3655	0.3700	0.3783
	MIU-C	0.4245	0.4380	0.4700	0.4459	0.4542	0.4590	0.4596	0.4600	0.4532
	MIU	0.4127	0.4236	0.4605	0.4444	0.4545	0.4670	0.4126	0.4100	0.4158
	MMD-W	0.0130	0.0133	0.0158	0.0167	0.0167	0.0186	0.0133	0.0138	0.0147
	MMD-C	0.0220	0.0225	0.0246	0.0218	0.0203	0.0253	0.0228	0.0241	0.0259
	MMD	0.0175	0.0179	0.0202	0.0192	0.0185	0.0219	0.0181	0.0190	0.0203
	SMD-W	3.7583	3.9249	4.3020	1.5043	1.4259	1.4600	0.9751	1.2990	1.6856
	SMD-C	9.2463	10.0352	10.4990	1.7787	1.8767	1.9210	1.4749	1.6270	1.7003
	SMD	6.5023	6.9801	7.4005	1.6415	1.6513	1.6905	1.2250	1.4630	1.6930
Compression	LC	0.6643	0.6961	0.6652	0.6656	0.7965	0.7117	0.7515	0.7206	0.7589
	WC	2.0070	1.9600	1.5072	2.0070	2.0070	1.6170	1.7846	1.6023	1.3710
	RC	28.71	27.8411	29.9616	34.7700	32.8380	30.7636	34.1794	30.4221	29.4892
Thickess& Weight	T	4.6387	4.7213	4.8121	4.5123	4.6215	4.7632	4.5019	4.5832	4.6232
	W	68.2132	73.2111	82.8789	75.2312	81.2312	86.1988	85.4543	88.2312	90.1211

The letters C and W represent the course and wale direction of each knitted fabric.

samples than the double knit samples. A higher loop density results in an increase in shear properties. Higher loop density increases slippage between yarns or fibers, warp-weft contact, and fiber contact in the intersections. The shear modulus of samples with varying knit structures decreased in the following order: half-cardigan rib, half-milano rib, and 1×1 rib for the single knit; and single pique, crossmiss interlock, and interlock for the double knit. The shear modulus in half-cardigan rib, single pique, and crossmiss interlock was greater than 1×1 rib and interlock. These results are similar to the results of high bending modulus in wale and course directions for the samples with tuck and miss loops.

Compression : Compression, referring to the knitted fabrics resilience and fullness, is an important factor in determining the comfort and hand of fabric. Table 4~5 shows that the mean values of compression energy (WC) and resilience (RC) decreased as knit density increased. This may be due to the knitted fabrics curved loop structure as higher densities result in smaller stitch space, lower resilience, and lower compression energy. These compression values did not show large differences among the different knit structures.

Surface : Surface properties are related to the fabrics smoothness and are represented by the surface coefficient of friction (MIU), the standard deviation of MIU, and changes in surface roughness. Table 4~5 show these values are sharp increase as knit density increases. These trends were observed for all knit weave samples, regardless of knit structure. When values were compared for the wale and course directions, the SMD values in the wale direction were much lower. In addition, large surface structure differences between knit loop, tuck loop and miss loop were not detected. This can be attributed to the obvious surface roughness of weft-knitted fabrics in the wale direction which makes it difficult to detect changes in the surface properties arising from fine loop structure differences. The differences between SMD values in the wale and course directions decreased in the following order based on the knit structure; half-milano rib, 1×1 rib, and half-cardigan rib for the single knit samples; and interlock, crossmiss interlock, and single-pique for the double knit samples.

3.2. The mechanical properties and the deformation behavior of weft knits

The deformation behavior of fabrics is derived from each fabrics mechanical properties. To measure the wear properties which are related to such deformation behavior, not only the basic mechanical property values, but also the interactions between these values must be taken into consideration. These relationships between mechanical values are known to affect the clothings appearance properties such as dimensional stability, drape, and wrinkle recovery. Fig. 1, 2, 3, and 4 show how to total mechanical property values affect the deformation behavior of weft-knitted fabrics, including ratios of curve hysteresis per weight per unit area, plastic and elastic component of shear properties, coefficient of friction to surface roughness, compression energy to weight per unit area. These ratios are summarized according to knit structure and knit density.

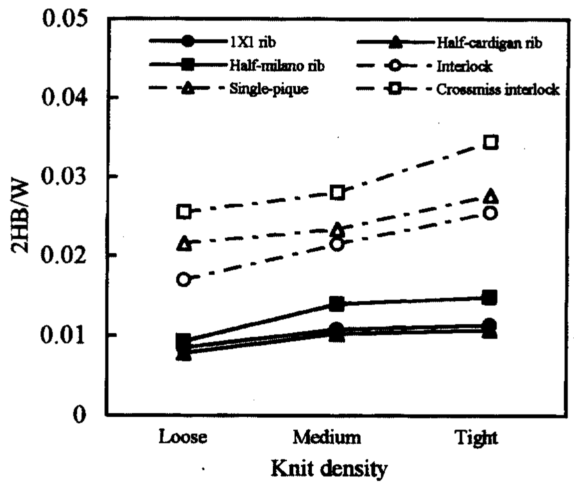


Fig. 1. The 2HB/W of weft knitted fabrics for the samples.

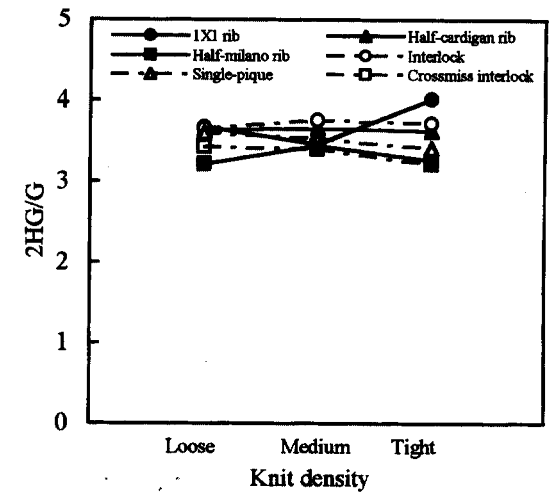


Fig. 2. The 2HG/G of weft knitted fabrics for the samples.

The ratio of curve hysteresis per weight per unit area (2HB/W) shown in Fig. 1 influences the drape of the fabric and is related to the non-elastic component. In all knit weave samples, 2HB/W increased as knit density was raised. The increase was greater for the double knit fabrics. In the single knit samples, 2HB/W increased in

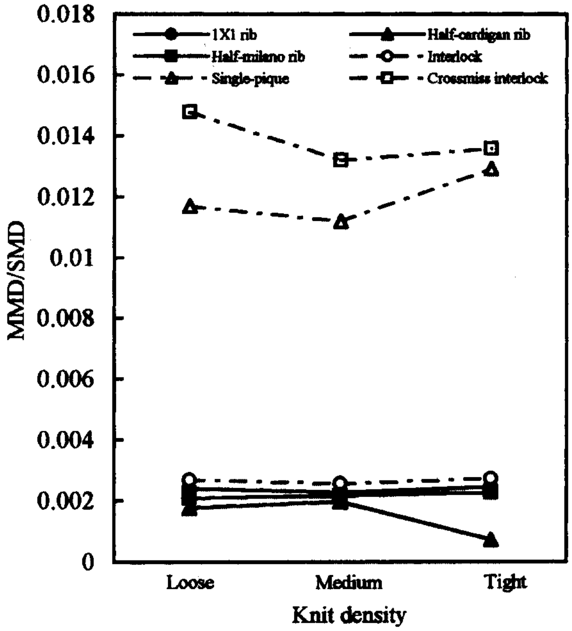


Fig. 3. The MMD/SMD of weft knitted fabrics for the samples.

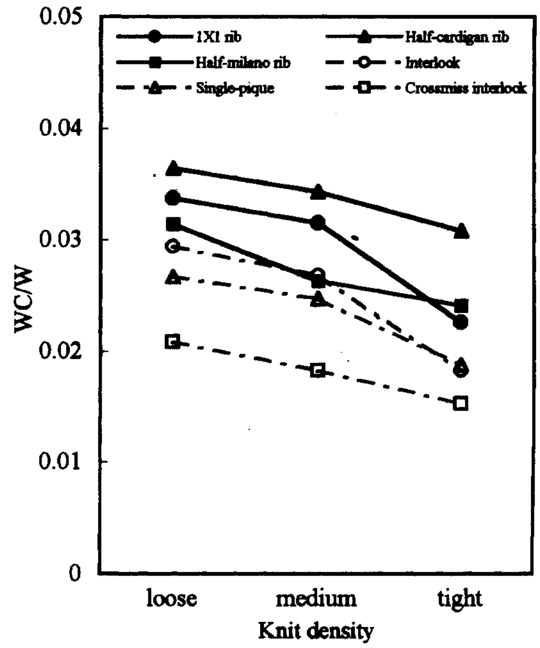


Fig. 4. The WC/W of weft knitted for the samples.

the order of half-cardigan rib, 1×1 rib, and half-milano rib in the single knit, while the double knit sample ratios increased in the order of interlock, single-pique, and crossmiss interlock.

These results indicate that as the density of knitted fabrics increased, drape values decreased as resulting in a decrease in the liveliness of the fabric during wear. In addition, such behavior was more apparent for samples with combined knit, tuck, and miss stitch. The decrease in the drape and resilience movement due to tuck and miss was more noticeable for the double knitted fabrics. Therefore, it is desirable to have a knit loop structure and a low knit density in order to obtain weft-knitted fabrics with good drape and liveliness.

The ratios of plastic and elastic component of shear properties (2HG/G), presented in Fig. 2 show high values of 3 or greater. Clearly, the weft-knitted fabrics used in this research had flexible bending dimensions; thus, displayed superior volume and silhouette forming ability. Half-milano rib and crossmiss interlock samples showed the lowest 2HG/G values. These results suggest that the knit structure with a miss loop results in smoother bending dimensions than the knit structure with knit or tuck stitches.

In Fig. 3, MMD/SMD is the ratio of coefficient of friction to surface roughness, and is related to the surface property of the fabrics smoothness. This ratio decreased with knit density. This suggests a more even surface of the fabric with higher knit density. Also, the ratios for double knit samples were smaller than those of single knit samples indicate a higher degree of surface smoothness.

The distribution of the ratio of compression energy to weight per unit area (WC/C), which represents fabric malleable property are shown in Fig. 4. The ratio decreased with knit density for all knit structure samples. The double knit fabrics had lower values than single knit fabrics. These results suggest that single knit weft-knitted fabrics with lower knit density are more malleable to compression and have higher air content, i.e. greater volume.

4. Conclusions

To study the effect of knitting condition on the mechanical properties and the deformation behavior of weft-knits, eighteen different kinds of weft-knitted fabrics were produced with varying knit structures and knit densities. The following conclusions may be drawn from this study.

The tensile linearity values of the single knit samples are generally less than the LT values of the double knit samples, LT and tensile energy increased respectively with knit density. Knitted fabrics with high RT have greater dimensional stability with low relaxation and high resilience characteristics. The bending properties of weft-knitted fabrics increased with knit density. Single knit structures had much lower bending moment and bending hysteresis than double knit structure. The shear properties of weft-knitted fabrics increased with knit density and the double knit fabrics showed higher values than single knits.

The greater shear modulus was observed in the wale direction compared to the course direction. The compression values such as compression strain, stress, and modulus for weft-knitted fabrics decreased with knit density. This was attributed to the fact that the fabrics structure with curved loops leads to decreasing compression resilience and compression energy. The surface properties such as surface softness and smoothness of weft-knitted fabrics increased with knit density for all fabrics. The low SMD values in the wale direction were due to the roughness between wales in the fabric.

In all knit weave samples, 2HB/W increased as knit density was raised. This increase was greater for the double knit fabrics. Half-milano rib and crossmiss interlock samples showed the lowest 2HG/G values. The double knit samples were smaller than those of single knit samples indicate a higher degree of surface smoothness.

국문요약 : 본 연구의 목적은 위편성포의 역학적 성질값들의 조합값이 직물의 변형거동에 어떠한 영향을 미치는지에 대하여 편성조직과 편성밀도를 달리하여 살펴보고자 하였다. 위편성포 6종류를 선택하여(1×1 고무편, 편반편, 편대편, 인터록편, 싱글피케, 크로스미스 인터록) 각각 편성밀도를 3가지(loose, medium, tight)로 달리하여 총 18종류의 위편성포를 제작하였다. 단위면적당 무게에 대한 굽힘 히스테리시스의 비인 2HB/W는 모든 편성조직에서 편성밀도가 증가함에 따라 커지며 싱글니트보다는 더블니트에서 더 큰 값을 보인다. 전단성질중 탄성성분에 대한 소성성분의 비인 2HG/G는 모든 편성조직과 편성밀도에서 3이상의 매우 높은 값을 나타냈다. 표면의 요철변동에 대한 마찰계수의 변동비, 즉 MMD/SMD값은 편성밀도가 커질수록 감소하여 표면상태가 평활해짐을 알 수 있으며 더블니트가 싱글니트보다 더 적은 값을 나타내어 표면의 평활도가 훨씬 우수한 것으로 나타났다.

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(1996년 6월 17일 접수)