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The Physical Properties of Woven Fabrics for Emotional Garment According to the Weaving Loom Characteristics

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1. Introduction

Many efforts for making good quality fabrics for emotional garment have been performed by SME weavers and finishers. And weaving machinery companies are researching about loom mechanism applied by low warp and filling tensions and loom mechanism for good quality fabrics. The fabric defects complained by garment manufacturers are stop marks, streaky phenomena on the warp direction, thickness variation and color differences between edges on the right and left sides of the fabrics, which are partly due to the tension variation of warp and filling directions. Therefore, many researches(Basu, 1987; Islam & Bandara, 1996, 1999) related to the fabric defects and weaving loom mechanism were carried out and many patents related to the loom were presented by loom makers. Many researches related to the warp and filling tensions during weaving were performed with relation to the fabric defects. Fabric physical property is largely affected by various factors such as constituent yarn physical property and fabric structural parameters. But, the fabric physical property for emotional garment is also affected by weaving loom characteristics. Among weaving loom characteristics, warp and weft yarn tensions during weaving are the most important parameters which affects fabric physical properties and quality. And warp and weft yarn tensions are different according to loom characteristics i.e. according to air-jet, rapier and projectile. Even though same rapier loom, these tensions are slightly different according to the mechanism of rapier loom. Many researches(Islam & Bandara, 1996, 1999) related to the warp and weft yarn tensions during weaving were carried out with relation to the stop marks and other fabric quality. On the other hand, air-jet insertion in air-jet loom and its mechanical mechanism were also performed with variation of the air flow and weft yarn tension.(Natarajan et al, 1993; Adanur & Mohamed, 1988, 1991, 1992)

Recently, many simulation studies(Belforte et al, 2009; Simon et al, 2005, 2009) related to the air-jet nozzle on the air-jet loom were investigated. And new concept and recent innovations in loom were also studied.(Bilisik & Mohamed, 2009; Gokarneshan et al, 2010; Kopias, 2008) The warp yarn tension and weavability related to the end break during weaving were studied with relation of yarn physical property and weave limit.(Lappage, 2005; He et al, 2004; Bilisik & Demiryurek, 2011; Seyam, 2003) But, the fabric property related to the yarn tension on the air-jet loom was investigated using yarn tension meter(DEFAT) by Sabit Adanur and Jing Qi. Weft yarn tension was measured with yarn physical parameters such as yarn count, twist multiplier, yarn hairiness and yarn elongation. Fabric physical properties such as weight and thickness, air permeability, dimensional stability and abrasion resistance were analysed with average weft yarn tension of air-jet loom. Fabric stiffness, drape coefficient and wrinkle recovery were also measured and discussed with average weft yarn tension. Many weavers are using foreign looms made by Japan, and European countries such as Italy, Germany and Belzium. Especially, polyester fabrics woven by rapier looms show many defects such as thickness differences and color differences between edges on the right and left sides of the fabrics. Many weavers are thinking that the physical properties of fabrics including these defects are also different between fabrics woven by these various kinds of looms. And they are wondering how is the tension difference among various looms and how is the difference of the fabric mechanical properties according to the looms and the fabric positions with relation to the warp and weft weaving tensions on the various looms, respectively. But, any investigations about fabric physical properties according to the loom characteristics and about warp and weft tension variations according to the warp position among looms were not found yet. Therefore, this topic surveys the fabric physical properties according to the weaving looms, for this purpose, warp and filling yarn tensions during weaving were measured on the various looms and the fabric mechanical properties due to warp and weft tension differences were analysed using KES-FB system. In addition, weavability was also analysed by measuring warp tension variation according to the looms and the warp position. And the relationship between shed amount and warp tension on one fixed heald frame was surveyed according to the various looms and also fabric thickness according to the fabric width was measured for analysing fabric thickness variation with weaving loom characteristics.

2. The importance of the fabric mechanical properties for emotional garment's formability

The fabric formability of the worsted and wool/polyester blend fabrics widely used for suit garment for men and women is very important physical property. Formability is defined as ability of the fabric to be re-shaped from a plane fabric to the 3D form of clothing(Pavlinic, 2006). Fabric formability was predicted by many researchers(Lindeberg, 1960; Niwa et al, 1998; Shishoo, 1989; Postle & Dhingra, 1989; Ly et al, 1991). And fabric mechanical properties were used in the predicting fabric formability by Lindberg et al(Lindeberg, 1960), Niwa et al(Niwa, 1998), Yokura et al(Yokura, 1990) and Morooka et al(Morooka & Niwa, 1978). Lindberg formerly proposed formability by fabric bending and compression properties.

But, many equations related to the garment formability were suggested after developing KES-FB and FAST systems which are measuring devices of fabric mechanical properties.

Postle et al and Ly et al proposed formability equations using fabric mechanical properties measured by FAST system. Shishoo et al also suggested formability equation using KES-FB System. But, Niwa et al have published many papers related to the garment formability as a TAV(total appearance value) using fabric mechanical properties measured by KES-FB System.

On the other hand, many researches about mechanical property of the woven fabric according to the yarn and fabric parameters were carried out using KE-FB and FAST systems (Oh & Kim,1993). Among them, the PET synthetic fabric mechanical properties according to weft filament yarn twists, yarn denier and fabric density were analysed and discussed with these yarn and fabric structural parameters. On the other hand, the worsted fabric mechanical properties according to the looms such as rapier and air jet were also analysed and discussed with weaving machine characteristics (Kim & Kang, 2004; Kim & Jung, 2005). Similar studies were also performed using the PET and PET/Tencel woven fabrics (Kim et al., 2004). The researches related to the fabric mechanical property according to the dyeing and finishing processes were also carried out (Kim et al., 1995; Oh et al., 1993). According to the these studies, many factors such as the fabric structural parameters and processing parameters on the weaving and dyeing and finishing processes affects on the fabric mechanical properties which are governing garment's physical properties. Among these process parameters, weaving process is one important process which affects the fabric mechanical properties due to warp and weft tensions during weaving.

On the other hand, the large companies for production of worsted fabric have sequential production line such as spinning, weaving, dyeing and finishing processes, but some small companies have only one production line such as weaving, dyeing or finishing. So, large fabric lot processed in large companies is divided and delivered to the small companies by small fabric lot. Therefore, large quantity of fabrics are woven by various looms such as projectile, rapier and air-jet in various small weaving companies, and then, they are finished by various small finishing companies. It is known that these production system makes fabric physical properties such as hand, fabric thickness and shrinkage non-homogeneous. It is investigated that these non-homogeneity of the fabric physical properties may be originated from the difference of loom even though the loom setting is same.

Many researches related to the warp and weft yarn tensions during weaving were performed with relation to the stop marks on the fabrics. Among them, Helmut Weinsdörfer investigated that the distribution of the warp end tension over the warp width and how it is influenced by the weaving machine setting. This analysis carried out on the poplin fabric using Sulzer projectile loom and a comparative investigations performed on a downproof fabric using a flexible rapier loom with rod type temples and a projectile loom with needle temples. In addition, he studied warp yarn tension variation according to the shed geometry, warp brake setting and loom speed using narrow fabric loom(Jacob Muller). But these researches are only contributed to the weavability related to the mechanism of weaving machine, and there were no investigations about fabric physical properties according to the warp and weft tension differences on the positions of the fabrics such as center and edges and according to the different looms itself. Many weavers are using various kinds of looms made by Japan, and European countries such as Italy, Germany and Belzium. Especially, polyester fabrics woven by rapier looms show many defects such as thickness differences and color differences between edges on the right and left sides of the fabrics. Many weavers are thinking that the physical properties of fabrics including these defects are also different between fabrics woven by various types of looms.

3. Experimental

3.1 Worsted fabrics

3.1.1 Weaving of worsted fabrics on the air-jet and rapier looms

Worsted fabrics specimens were woven using Picanol rapier loom(model GTX-4-R) and air-jet loom(model PAT-4-R-A), respectively. Table 1 shows loom characteristics used for making fabric specimens and Table 2 shows fabric design related to the yarn and fabric structural parameters.

Loom characteristics	**Rapier GTX-4-R**	**Air jet PAT-4-R-A**
Harness motion	Electronic dobby	Electronic dobby
Weft insertion	Rapier	Main nozzle & relay nozzle
Let off motion	Let off continuously with electronic control	Let off continuously with electronic control
Winding grey fabrics system	Max. diameter : 600mm Range of density : 4.5~340ppi	Max. diameter : 600mm Range of density : 5.8~183ppi
Micro processor	Pick finding, let off tension	Pick finding, let off tension

Table 1. The Characteristics of loom used for making the specimen.

Fiber composition	**Yarn count**		**Yarn twist (tpm)**		**Fabric structure**	**Density (per 10 Cm)**		
							Grey fabric	**Finished fabric**
Wool 100%	Wp	Nm	Wp	Z770/	5 harness,	Wp	338	376.9
	Wf	2/72	Wf	S830	satin	Wf	220	224.4

Table 2. Specification of weave design

3.1.2 Finishing process of the worsted fabrics

The grey fabrics woven by rapier and air-jet looms were overlocked for processing in the finishing process simultaneously. Table 3 shows the finishing process and its condition.

Processes	**Conditions**
Gas singeing	100 m/min., gas 9 bar, both side singed
Sewing for making sack	12 mm/stitch
Scouring	Soaping for 20 min., rinsing for 30 min., Soaping for 45 min., rinsing for 50 min.
Continuous crabbing	80℃, 90℃, 95℃, 95℃, 95℃, 20℃
Shearing	20 m/min., 2 times for surface, once for back
Continuous decatizing	20 m/min.
Kier decatizing	19 m/min., pressure 30 kg/㎠

Table 3. Finishing processes and conditions

The specimens for measuring fabric mechanical properties were prepared by grey and finished fabrics woven by rapier and air-jet looms, respectively. Table 4 shows preparation of specimens and Fig. 1 shows the position on the fabrics related to the specimen number shown in the Table 4. 5 kinds of specimens were selected as one center position and 4 sides positions.

Fabric	Loom	Sample No.	Remark	Fabric	Loom	Sample No.	Remark
Ingray fabric (A)	Rapier (a)	1	Center	Finished fabric (B)	Rapier (a)	1	Center
		2	Side			2	Side
		3	Side			3	Side
		4	Side			4	Side
		5	Side			5	Side
	Air-jet (b)	6	Center		Air-jet (b)	6	Center
		7	Side			7	Side
		8	Side			8	Side
		9	Side			9	Side
		10	Side			10	Side

Table 4. Preparation of specimen.

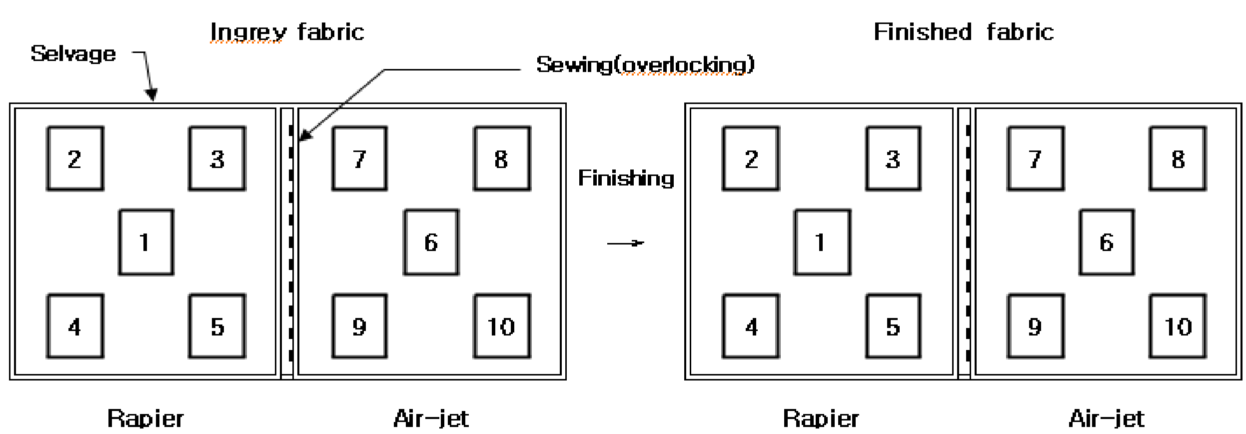


Fig. 1. Sampling position of specimen.

3.1.3 Weaving of the worsted fabrics on the projectile and air-jet looms

For surveying the warp and weft tension differences between projectile and air-jet looms and analysing the mechanical properties of the worsted fabrics for emotional garment with relation of these two looms characteristics, worsted fabric specimens were woven using projectile(Sulzer) and air-jet looms(Picanol PAT and OMNI), respectively. Table 5 shows looms characteristics used in this experiment. Table 6 shows specification of weave pattern.

	Projectile	Air jet	
	Sulzer-pu	Picanol	
		Pat	Omni
R P M	360	630	700
Reed width(mm)	2200	1830	
Harness motion	Mechanical dobby	Electronic dobby	
Weft insertion	projectile	Nozzle & sub nozzle	
Let-off motion	Electronic let-off	Electronic let-off	
Range of picking(mm)	9.1 - 230	5.8 - 183	
Microprocessor	Let off motion	Pick find, let off m/o	

Table 5. The characteristics of looms used for the test

Fiber Composition		Yarn count & TPM(Nm/tpm)	Fabric structure	Density (per 10cm)		Remark
				Grey fabric	Finished	
WP	Wool 93% Nylon 7%	1/40, 770 sirofil	5 harness satin	378	421	WP: 18^D×5=90 WF:68 pick/in Width: 70.3″66.0″59.0″ Length: 97.5m 96.5y 91.0y
WF	Wool 100%	1/30, 1020		268	283	

Table 6. Specification of weave pattern

3.1.4 Finishing process of the worsted fabrics

Grey fabrics woven by Sulzer and two air-jet looms were cut by 3 yards, respectively and these were overlocked for processing in the finishing processes. Table 7 shows the finishing process for making finished fabrics. The specimens for measuring fabric mechanical properties were prepared by grey and finished fabrics woven by Sulzer and two air-jet looms, respectively. Fig. 2 shows the sampling positions on the fabrics for measuring fabric mechanical properties.

Process	Conditions
Gas singeing	100 m/min, gas pressure: 9 bar, both side singed
Solvent scouring	25 m/min,
Scouring	50°C, Soaping for 20min, rinsing for 30min Soaping for 45min, rinsing for 50min
Dry	110°C, Over feeding ratio 5%
Fabric dyeing	100°C,
Dry	110°C, Over feeding ratio 5%
Shearing	20 m/min, 2 times for surface, ones for back
Continuous decatizing	15 m/min,
Kier decatizing	19 m/min, pressure: 30kg/cm^2

Table 7. Finishing process and conditions

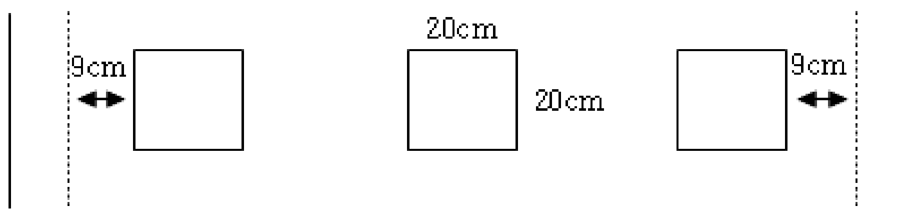


Fig. 2. Preparation of specimens for KES-FB System test.

3.1.5 Weaving of the worsted fabrics on the three kinds of rapier looms

For surveying the warp and weft tension differences among 3 types of rapier looms and analyzing the mechanical properties of these worsted fabrics for emotional garment with relation of these 3 kinds of rapier looms characteristics, 5 harness satin weave worsted fabrics were woven using FAST-R, THEMA-11-E and Picanol-GTX looms, respectively. Table 8 shows the specification of weave pattern of these worsted fabrics. Table 9 shows the characteristics of these 3 kinds of looms. Finishing process was same as shown in Table 7.

Fiber Composition		Yarn count (Nm, tpm)	Fabric structure	Density (per 10cm)		Remark
				grey fabric	finished	
WP	wool 93% nylon 7%	1/40, 770 sirofil	5 harness satin	378	421	WP: 18^{D}×5=90ends WF: 68picks Width: 70.3″66.0″59.0″ Length: 97.5m 96.5y 91.0y
WF	Wool 100%	1/30, 1020		268	283	

Table 8. Specification of weave pattern

Division	Loom		
	FAST-R	THEMA-11-E	PICANOL-GTX
R P M	520	550	580
Reed width (mm)	2200	2100	1900
Harness motion	electronic dobby	electronic dobby	electronic dobby
Weft insertion	rapier	rapier	rapier
Let-off motion	Electronic let-off	Electronic let-off	Electronic let-off
Range of picking (mm)	4.8 - 282	7.6 - 198	4.5 - 340
Microprocessor	pick find let off m/o	pick find let off m/o	pick find let off m/o

Table 9. The characteristics of loom used for the test

The sampling position on the fabrics for measuring fabric mechanical properties was same as shown in Fig. 2.

3.2 Polyester filament fabrics

3.2.1 Weaving of PET filament fabrics by 2 kinds of rapier looms (Omega® and Picanol®)

PET fabrics were woven using 2 kinds of rapier looms (Omega® and Picanol®) for analysing the tension differences and fabric mechanical properties due to warp and weft tension differences. Table 10 shows weave design of woven fabrics. Table 11 shows the characteristics of two rapier looms.

Fiber composition		Yarn count	Fabric structure	Density/inch		Remark
				Grey	Finished	
Warp	Polyester 100 %	75D / 36F	5 Harness	168	261	42D ×4 =168end/in Pick: 86pick/in
Weft	Polyester 93.5 % Polyurethane 6.5 %	100D/192F + 30D spandex covering		86	98	

Table 10. Specification of weave design

Division \ Loom	OMEGA (Textec, Korea)	PICANOL-GTX (Belgium)
Maximum RPM	520	580
Maximum reed width	2100 (mm)	1900 (mm)
Harness motion	Electronic dobby	Electronic dobby
Let off motion	Electronic let off	Electronic let off
Microprocessor	Pick find motion Let off motion	Pick find motion Let off motion

note: running speed : 470rpm

Table 11. The characteristics of loom used in this study

3.2.2 Finishing process of the PET fabrics

These grey fabrics woven by two rapier looms were processed on the finishing process which is shown in Table 12.

Process	Condition
Cylinder dryer	130 ℃ × 60 m/min
Scouring	Speed : 35 m/min , Temperature : 60-95-60℃
Pre-setting	210 ℃ × 27 m/min
Dyeing	130 ℃ × 40 min
Final-setting	210 ℃ × 30 m/min

Table 12. Finishing processes and conditions

3.2.3 Weaving of PET filament fabrics on the 2 kinds of rapier looms (Omega® and Vamatex®)

For surveying the tension differences between Omega and Vamatex looms and analysing fabric mechanical properties using KES-FB system according to warp and weft tension differences, fabric was designed as 5 harness satin weave using 150d/48f warp and 200d/384f weft polyester filaments, and was woven by Omega®-Panter rapier loom by Textec Co. Ltd and P1001es rapier loom by Vamatex Co. Ltd., respectively.

These grey fabrics were processed on the same dyeing and finishing processes which was shown in Table 12. Weavability was also analysed by measuring warp tension variation according to the warp position. The relationship between shed amount and the warp tension on one fixed heald frame was surveyed, and the relationship between end breaks and warp and weft tensions was also discussed.

Table 13 shows specification of weave pattern. Table 14 and Fig. 3 show the characteristics of rapier looms used in this study.

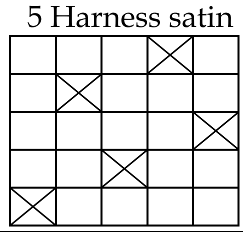
	Fiber Composition	Yarn Count	Fabric Structure	Density/inch	
				Grey	Finished
Warp	Polyester 100%	150^D / 48^F	5 Harness satin	102.5	158
Weft	Polyester 93.5% Polyurethane 6.5%	$200^D/384^F$ + 40^D spandex		72	83

Table 13. Specification of weave pattern

Division \ Loom	Omega-Panter	Vamatex-P1001es
R.P.M (Max.)	466 (520)	423 (580)
Maximum reed width	2100	1900
Harness motion	Electronic dobby	
Let-off motion	Electronic let-off	
Microprocessor	Pick find motion Let-off motion	

Table 14. The characteristics of rapier looms used in this study

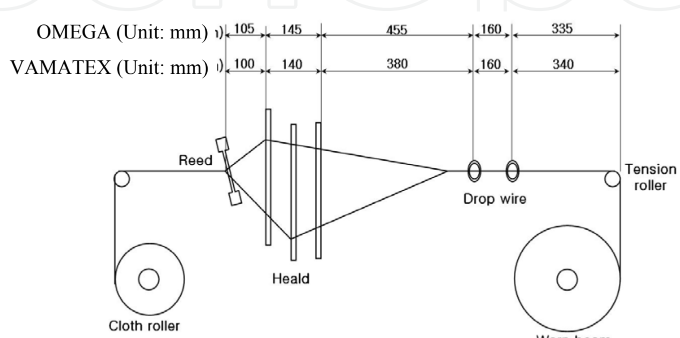


Fig. 3. Specification of test looms.

4. Measurement and assessment

4.1 Assessment in the weaving process

4.1.1 Warp and weft tensions

Weaving tensions on 7 kinds of weaving machines were measured using Dafat tension meter which is shown in Fig. 4. Measured position was between tension roller and drop wire on the loom. Various yarn tensions on the each heald frame from 1st to 5th were measured at the vicinity of the center of loom.

Yarn tension along full width of each loom was also measured on the 5th heald frame from left side to right on the back of the loom. The weaving efficiency in each loom was measured by number of end breaks both warp and weft per 100,000 picks.

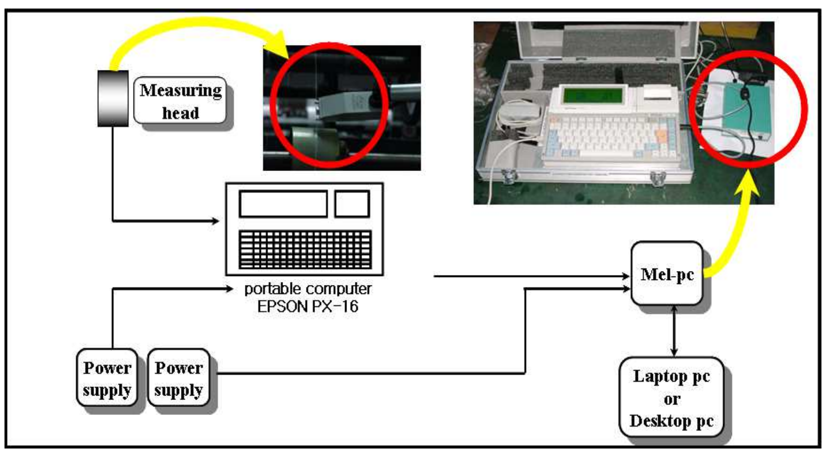


Fig. 4. DEFAT tension meter

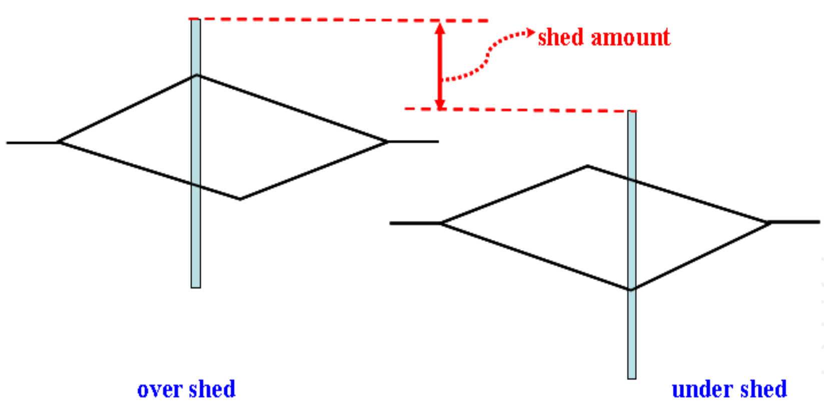


Fig. 5. Diagram of shed amount

4.1.2 Measurement of shed amount

At the upper state of the heald frame, the distance from the fixed guide of heald frame to the upper line of frame is the amount of upper shedding, the lowest state of the heald frame is the amount of lower shedding.

The warp movement is calculated by the difference between the amount of upper shedding and lower shedding, which is shown in Fig. 5.

4.1.3 Process shrinkages on the warp and weft directions

Fabric shrinkages of PET on the warp and weft directions in the each step on the dyeing and finishing processes were calculated using warp and weft fabric densities as equation (1) and (2) shown in bellows.

Warp shrinkage (%)

$$= \frac{\text{Weft density before process step} - \text{Weft density after process step}}{\text{Weft density before process step}} \times 100 \quad (1)$$

Weft shrinkage (%)

$$= \frac{\text{Fabric width before process step} - \text{Fabric width after process step}}{\text{Fabric width before process step}} \times 100 \quad (2)$$

4.2 Measurement of fabric physical properties

4.2.1 Fabric thickness

The positions for measuring fabric thickness to the direction of the fabric width and to the longitudinal direction on the right and left sides of the fabric were selected as shown in Fig. 6 and Fig. 7. The specimens for measuring fabric mechanical properties were prepared as shown in Fig. 8.

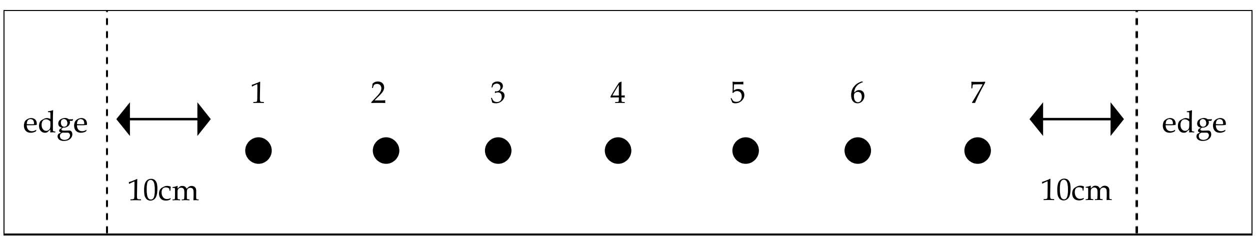


Fig. 6. Measured points of thickness to the direction of the fabric width.

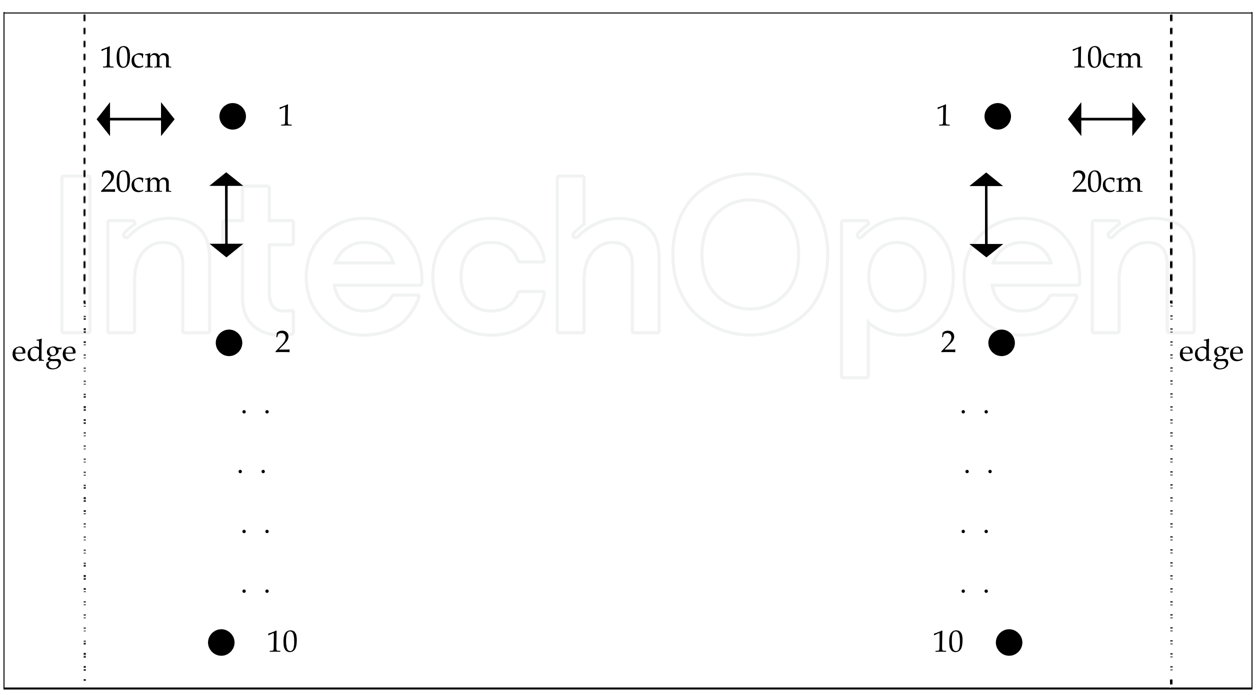


Fig. 7. Measured points of thickness on the right & left sides of Fabric

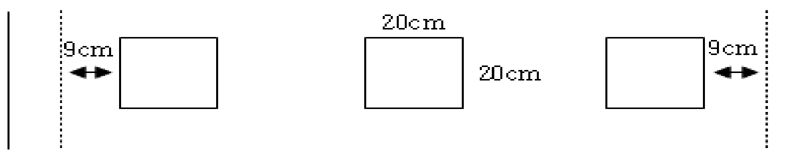


Fig. 8. Preparation of specimens for the test using KES-FB System

4.2.2 Fabric mechanical properties

16 mechanical properties of gray and finished fabrics such as tensile, bending, shear, compression and surface woven from 7 kinds of looms were measured by KES-FB system.

5. Results and discussions

5.1 Loom efficiency of worsted fabrics

5.1.1 Projectile and air-jet loom

Table 15 shows loom efficiency and stop number of each loom. Fig. 9 and 10 show rpm, efficiency and percentage of end break of Table 15.

Division	Loom	RPM	Effi.	Keeping looms /person	Pick	Loom stop number				Stop %	
					Hour	Total	Warp	Weft	Other	Warp	Weft
Proje-ctile	SULZER-PU	300	85.5	8	100,000	34.1	21.0	4.9	8.2	61.6	14.4
					hour	5.3	3.2	0.8	1.3		
Air - Jet	PICANOL-OMNI	500	67.0	10	100,000	46.6	9.9	35.8	0.9	21.2	76.8
					hour	9.4	2.0	7.2	0.2		
	PICANOL-PAT	520	65.0	10	100,000	46.2	22.2	21.6	2.4	48.1	46.8
					hour	9.4	4.4	4.4	0.5		

Table 15. Efficiency and stop number of weaving loom for the test

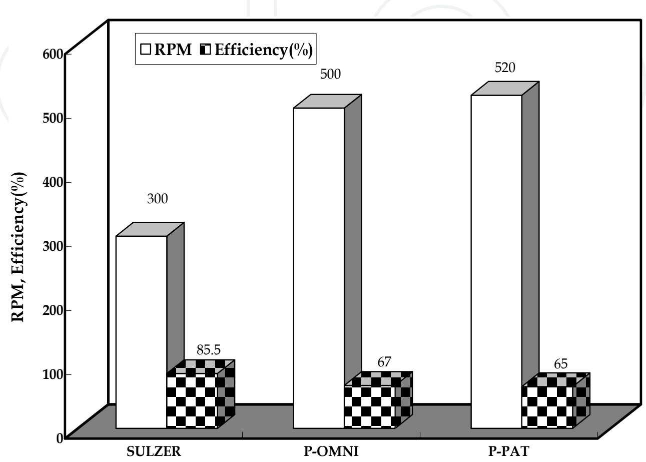


Fig. 9. Diagram between rpm and efficiency of various looms

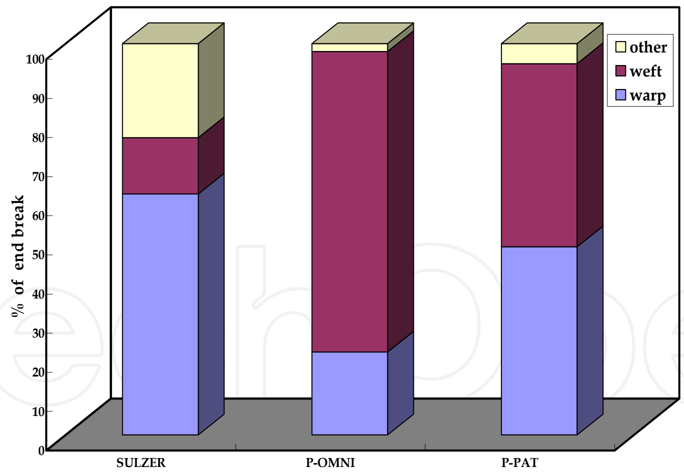


Fig. 10. Percentage of end break of warp and weft to the three looms

As shown in Fig. 9, Sulzer shows high efficiency, on the one hand, air-jet looms, both P-Omni and P-PAT show low efficiency. As shown in Fig. 10, Sulzer loom has high warp-break but air-jet loom has high weft-break.

5.1.2 Rapier looms

Table 16 shows loom efficiency and stop number of each rapier looms. Fig. 11 and 12 show rpm, efficiency and percentage of end break of Table 16.

Loom	RPM	Effi.	Keeping loom/person	Pick	Loom stop number				Stop %	
				hour	total	warp	weft	other	warp	weft
FAST - R	382	82.1	7	100,000	30.4	20.9	8.2	1.3	68.8	27.0
				hour	5.8	4.0	1.5	0.3		
THEMA-11-E	399	75.6	8	100,000	45.1	28.4	11.1	5.6	63.0	24.6
				hour	8.1	5.1	2.0	1.0		
PICANOL-GTX	402	67.8	10	100,000	41.7	31.7	6.2	3.8	76.0	14.9
				hour	6.8	5.2	1.0	0.6		

Table 16. Efficiency and stop number of weaving loom for the test

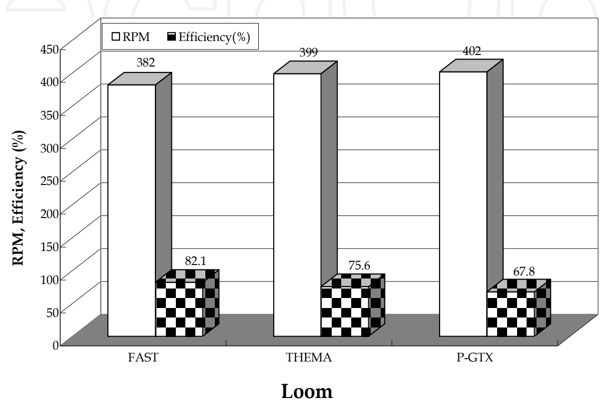


Fig. 11. Diagram between rpm and efficiency of test looms

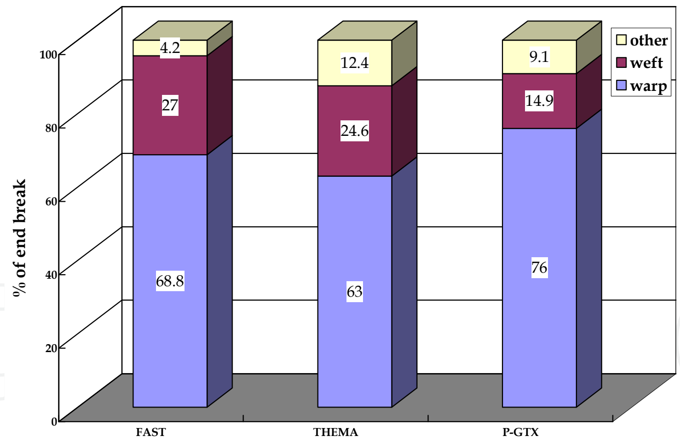


Fig. 12. Percentage of end break of warp & weft to the three looms

As shown in Table 16, warp breaks are much higher than weft breaks. It is shown that the loom efficiency of FAST is the highest. The reason why seems to be low rpm and low keeping loom per person of FAST loom. It is also seen in Fig. 11 and 12 that Picanol has high warp break and FAST has high weft break compared to other looms.

5.2 Warp and weft tensions of the worsted fabrics according to the loom characteristics

5.2.1 Projectile and air-jet looms

Fig. 13 shows warp tension variation according to the warp position on the Sulzer loom. As shown in Fig. 13, warp yarn tension variation on the vicinity of the center part of the fabric is higher than those of left and right parts of the fabrics and the tension of the right side of fabric is a little lower than that of left side of fabric. The warp yarn tension variation between right and left sides of fabric makes color difference between right and left of fabric, this phenomena deteriorates garment quality in clothing factory.

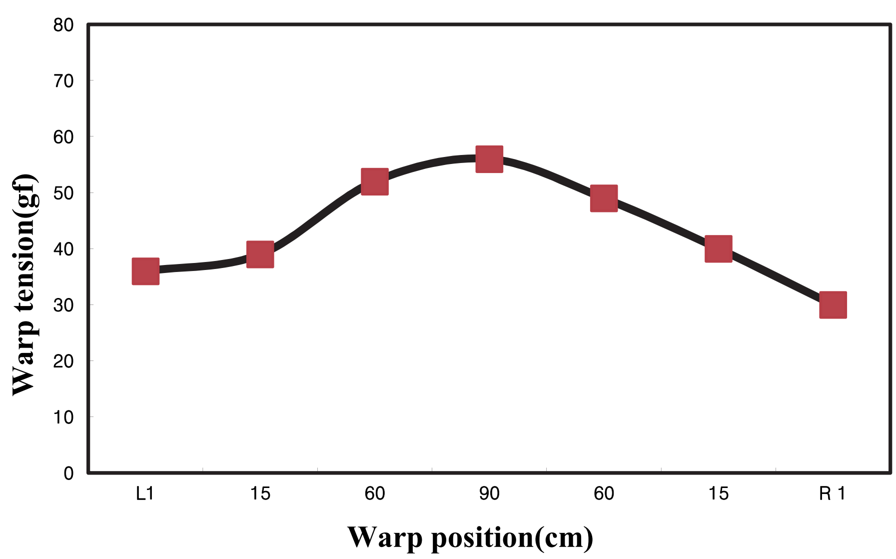
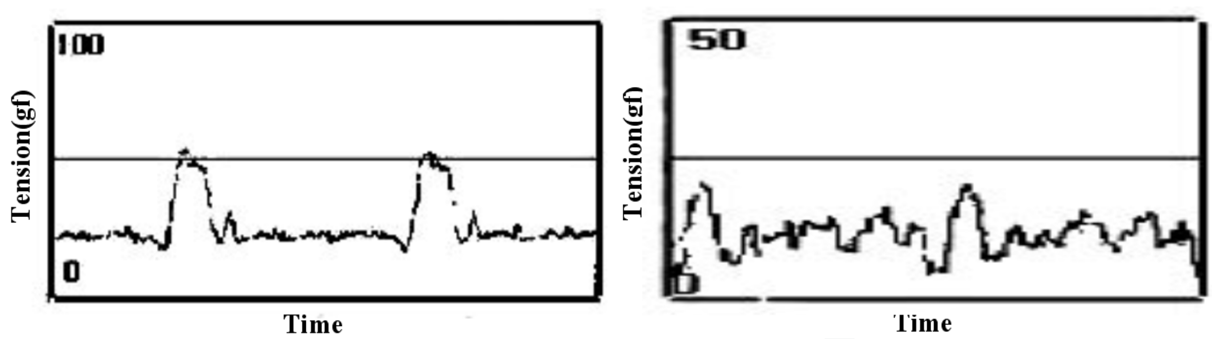


Fig. 13. Warp tension according to the warp position (SULZER Loom)

Fig. 14. shows one cycle warp tension variation which was measured on the 15cm position to the left of the loom.



Projectile(SULZER) Air-jet(PICANOL)

Fig. 14. The graphs of warp yarn tension of two looms

The warp tension variation during one cycle of the Sulzer loom was ranged between 22gf and 52gf, but, Picanol loom was ranged from 6gf to 23gf and shows 4 kinds of successive peaks, on the other hand, Sulzer has one large peak.

Table 17 shows shedding amount and warp tension of the each loom with bar and ring temple respectively. It was shown that warp tensions were slightly increased with increasing shedding amount in both Picanol Omni and PAT, But in Sulzer loom, is preferably decreased with increasing shedding amount.

Loom		Heald position	1	2	3	4	5	Average	Percentage	Warp breakage	Percentage
Bar temple	P-OMNI	Shedding amount(mm)	73	82	93	102	118	93.6	108.1	9.9	47.4
		Tension(gf)	36	36	39	40	43	38.0	115.2		
Ring temple	SUL-PU	Shedding amount(mm)	85	86	86	90	88	89.0	102.8	21.0	100.5
		Tension(gf)	66	65	58	59	56	60.8	184.2		
	P-PAT	Shedding amount(mm)	87	92	104	111	17	102.2	118.0	22.2	106.2
		Tension(gf)	40	45	54	50	56	49.0	148.5		

Table 17. The shedding amount and warp tension of the test weaving looms

Fig. 15. shows relationship between warp yarn tension and shed amount of each looms.

As shown in Fig. 15, the shed amount of P-Omni loom with bar temple is larger than that of Sulzer loom with ring temple, but warp tension of P-Omni has lower value by 37% compared to Sulzer, and also has lower value by 23% compared to P-PAT loom. This phenomena demsnstrates that air-jet loom with bar temple can contribute to the increase of weavability.

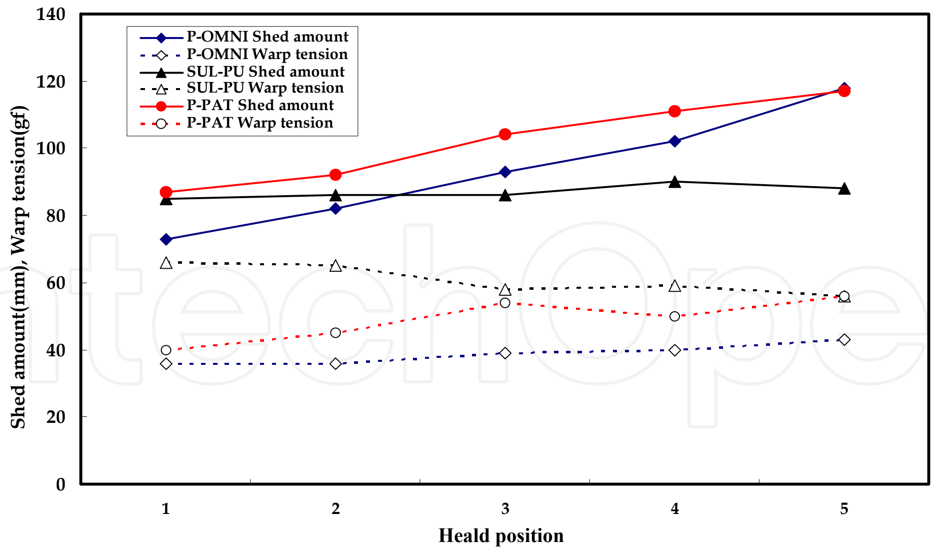


Fig. 15. Relation between warp yarn tension and amount of shed

Fig. 16 shows one cycle weft tension variation of Sulzer loom. As shown in Fig. 16, one peak is revealed by an instant tension during flying of projectile. The weft tension variations of ari-jet looms (P-PAT and P-Omni) could not measure because of much movement of nozzle.

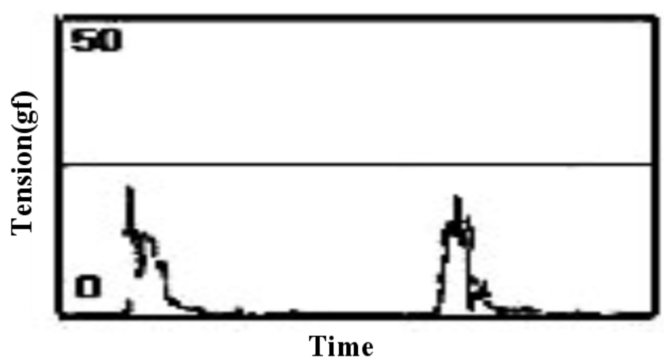


Fig. 16. The graph of weft yarn tension of sulzer loom

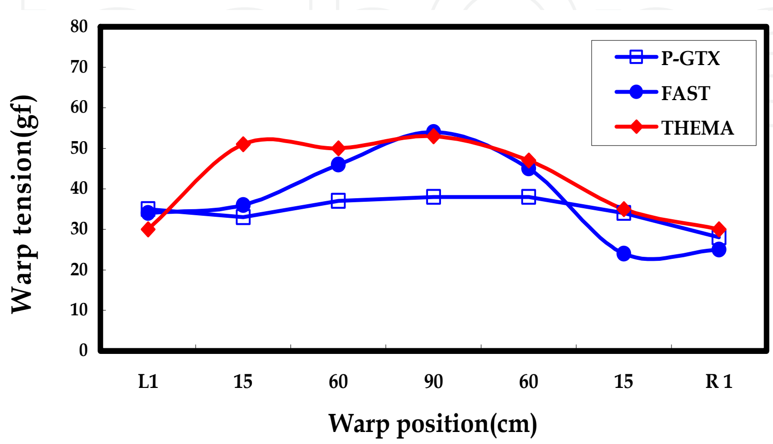


Fig. 17. Warp tension according to the warp position

5.2.2 Rapier loom

Fig. 17. shows warp tension variations at the full widths of the 3 types of looms (P-GTX, FAST, THEMA looms).

As shown in Fig.17, warp tension variation of Picanol loom(P-GTX) attached with bar temple according to the position of loom width direction is smaller than those of FAST and THEMA looms attached with ring temples. It was shown that the warp tensions on central part of the looms is much higher than those on left and right sides of the looms both FAST and THEMA looms used by ring temples. The tension on the right side of the loom is about 10% lower than that on left side of the loom. Fig.18 shows one-cycle warp tension variation of the 3 types of rapier looms on the 15cm position from left side of the loom.

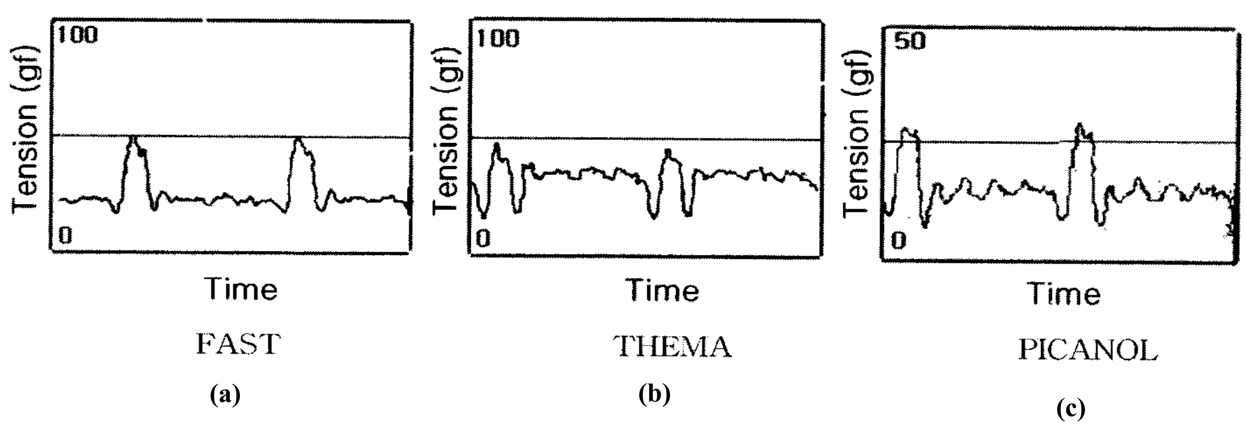


Fig. 18. The graph of warp yarn tension on the three rapier looms.

As shown in Fig.18, tension on FAST loom was distributed ranged between 25gf and 50gf, and ranged between 35gf and 49gf for THEMA loom, and ranged between 13gf and 28gf for Picanol. Especially, the tension variation on the Picanol loom revealed 4 types continuous small peaks and one large peak, of which weave design was 5 harness satin. For comparing warp tension variation according to the weave pattern, warp tension variation according to the loom position and loom types was measured on the 7th heald frame with 8 harness satin weave pattern and 2/60Nm warp yarn count.

Fig.19 shows warp tension variations on the THEMA and P-GTX looms. As shown in Fig.19 warp yarn tension of the 8 harness satin was much higher than those of 5 harness satin(Fig.13). It was shown that yarn tension change according to the warp position on the Picanol loom with bar temple was much less than that of the THEMA loom with ring temple.

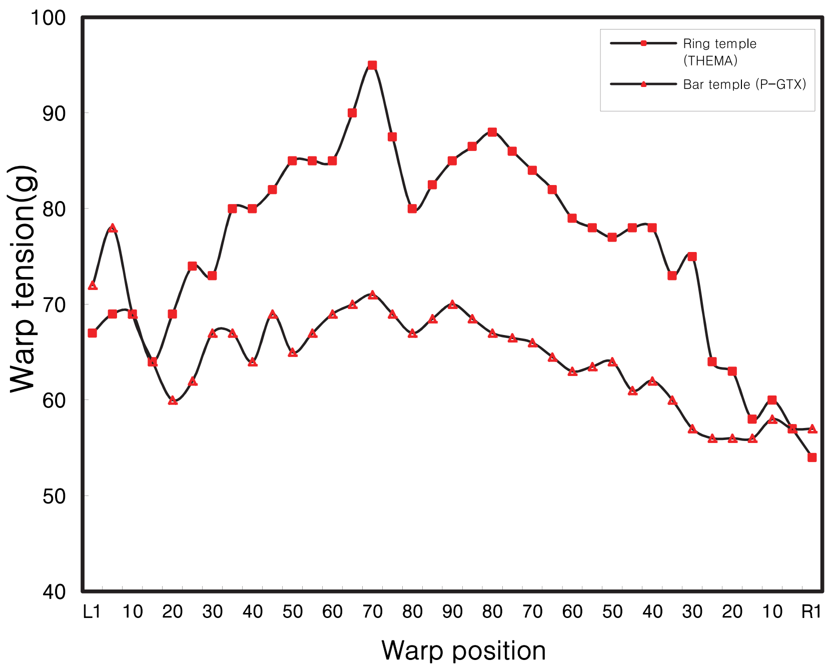


Fig. 19. Warp tension variation of warp position according to the loom with temple.

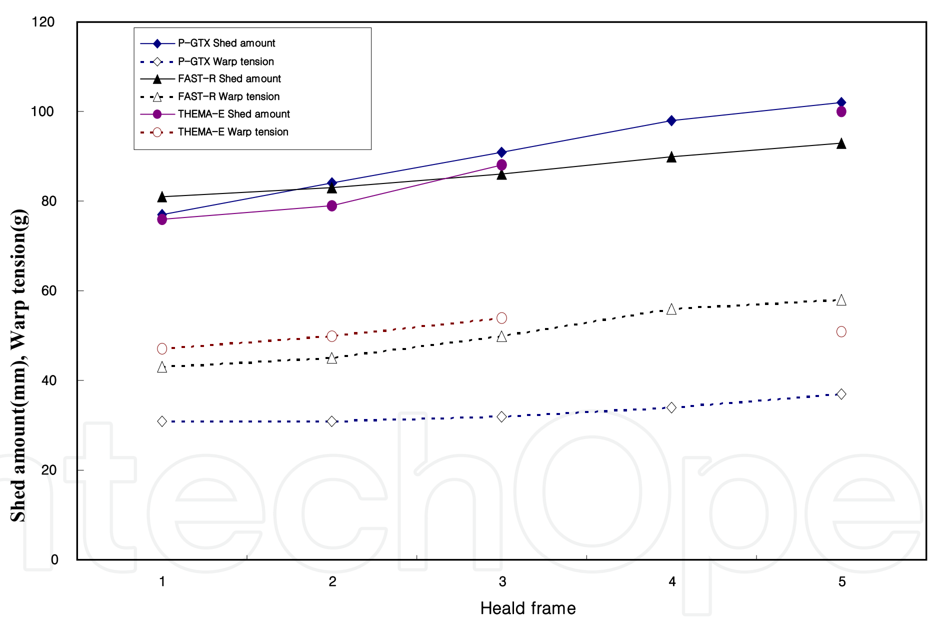


Fig. 20. Relation between warp yarn tension and amount of shed.

Table 18 shows shedding amount and warp tension of the 3 types of rapier looms attached with bar and ring temples. Fig.20 shows these variations according to the heald frame.

As shown in Fig.20, shedding amount was increased from 1st heald frame to 6th one, and warp tension was also increased from 1st heald frame to 6th one, which means that warp tension is proportional to shedding amount. Table19 shows weft tension and end break of weft on the 3 kinds of rapier looms.

Loom			Heald number							
			1	2	3	4	5	6	mean	end break of warp
Bar temple	P-GTX	Shedding amount(mm)	77	84	91	98	102	-	90.4	31.7
		warp tension(gf)	31	31	32	34	37	-	33.0	
Ring temple	FAST-R	Shedding amount(mm)	81	83	86	90	93	-	86.6	20.9
		warp tension(gf)	43	45	50	56	58	-	50.4	
	THEMA-E	Shedding amount (mm)	76	79	88	-	100	105	89.6	28.4
		warp tension(gf)	47	50	54	-	51	53	51.0	

Table 18. The shedding amount and warp tension of the test weaving looms

Loom		FAST-R	THEMA-E	PICANOL-GTX
Weft tension	Max.	84	84	99
	Min.	0	0	0
RPM		382	399	402
Break number of weft		8.2	11.1	6.2

Table 19. Weft tension and end break of weft on the 3 looms.

Fig.21 shows histogram of these data.

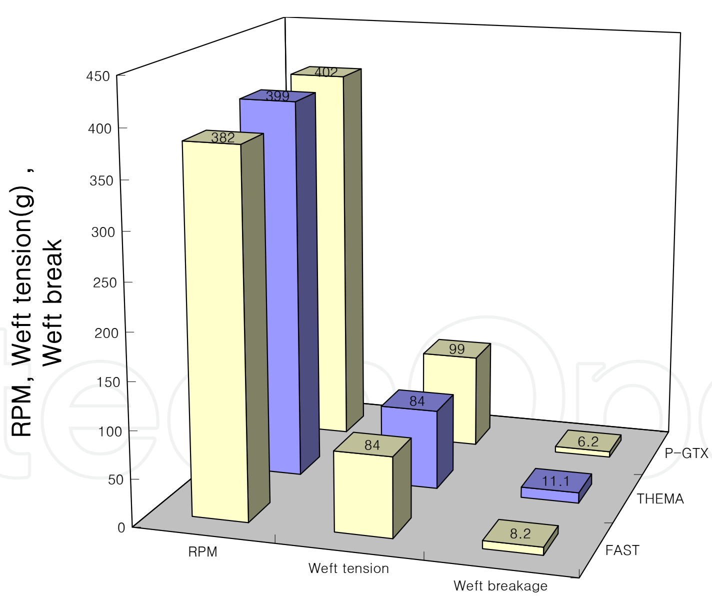


Fig. 21. Diagram between end break and yarn tension of weft to the three test looms.

It was shown that loom rpm and weft tension are less correlated and end break of weft on the Picanol was less than those of FAST and THEMA even though weft yarn tension of Picanol was highest.

Fig.22 shows one cycle weft tension variation on the 3 kinds of rapier looms.

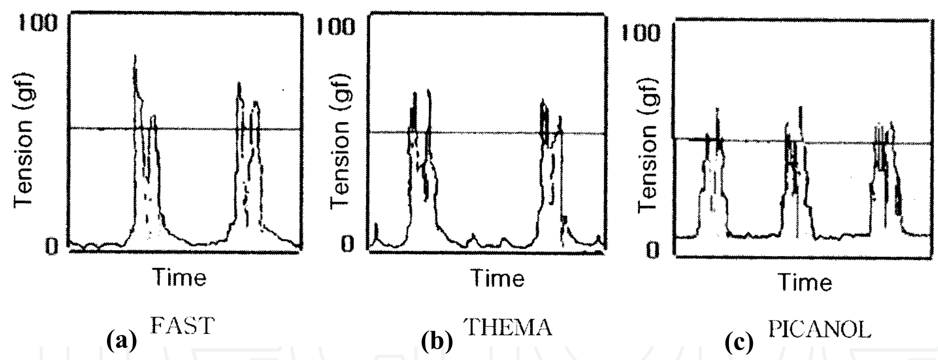


Fig. 22. The graph of weft yarn tension variation of three rapier looms.

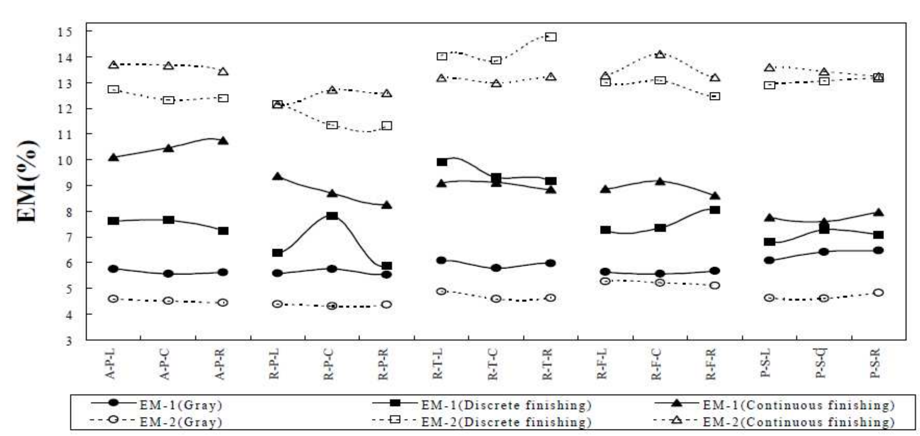
As shown in Fig.22, 2 kinds of high peaks revealed on the rapier looms, weft is gripped on the gripper, at this moment, tension is highly loaded and 1st rapier handed the weft yarn to 2nd rapier, 2nd high yarn tension peak is at this moment highly loaded, so 2 kinds of peaks are shown on this Fig.22.

And it was shown that maximum peak tension was ranged from 65gf to 70gf, but in FAST loom, ranged from 85gf to 90gf and Pocanol shows the lowest tension value.

5.3 The physical properties of the worsted fabrics according to the loom characteristics

5.3.1 Fabric extensibility

For surveying the effects of the looms and finishing process to the fabric extensibility, tensile properties of gray and finished fabrics were measured using KES-FB system. For five kinds of looms, gray fabrics of left, center and right sides on the fabric were used as a specimens and then gray fabrics were processed on the finishing process. The processing method in the finishing was adopted by two ways. One way was continuous processing with five kinds of gray fabrics by sewing(overlocking) as shown in Fig. 1, the other way was discrete processing with five kinds of gray fabrics. Fig.23 shows extensibility of these gray and finished fabrics with various looms.



Note : A-P-L : Air jet Picanol (OMNI) Left R-P-C : Rapier Picanol (GTX) Center
R-T-R : Rapier Thema (11E) Right R-F-L : Rapier Fast (11E) Left
P-S-C : Projectile Sulzer (PU) Center **1: warp, 2: weft**

Fig. 23. Fabric extensibility with various looms. (EM-1 : Warp, EM-2 : Weft)

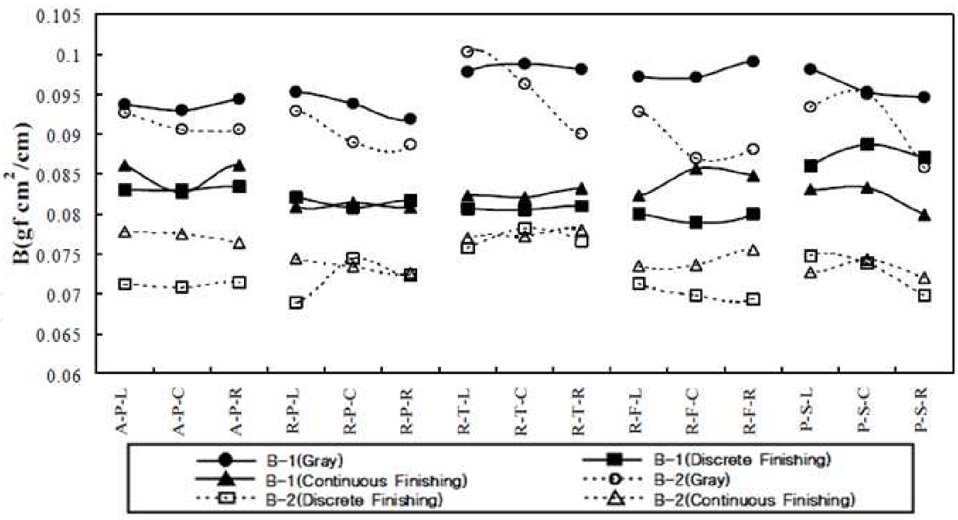


Fig. 24. Bending property of gray and finished fabrics woven by various looms.

As shown in Fig.23, for the warp extensibility of gray fabric, projectile(Sulzer) and rapier(THEMA) showed high values, then these looms showed high warp yarn tension and low shed amount for weaving as shown in Fig.15 and 20.

This means that the higher warp yarn tension and the lower shed amount, the more extensible of gray fabric. And the variation of extensibility on the right, center and left sides of gray fabric woven by Sulzer and THEMA weaving looms is also larger than those of other looms.

But, it is shown that these variations of gray fabric among various looms are less than those due to the method of finishing process. As shown in Fig.23, the warp extensibility of finished fabric for the continuous (—▲—) and discrete (—■—) finishing shows quite difference compared to gray fabric. And comparing between continuous and discrete finishing, the variation of warp extensibility among various looms by continuous finishing (—▲—) is smaller than that of discrete finishing (—■—). That results means that discrete finishing makes fabric extensibility deviating each other.

Especially, the variation on the right, center and left sides of fabric of warp extensibility of finished fabric (—▲—) woven by air-jet(Picanol A-P-L,C,R) and rapier(Picanol-GTX R-P-L,C,R) looms is larger than that of other looms. And comparing with weft extensibility of finished fabric between continuous and discrete finishing processes, continuous finishing is more even than that of discrete finishing. Among five looms, the variation of fabric extensibility of air-jet(Picanol-OMNI, A-P-L,C,R) and projectile(Sulzer, P-S-L,C,R) looms is the smallest both warp and weft directions, gray and finished fabrics, continuous and discrete finishing, respectively.

5.3.2 Fabric bending property

Fig.24 shows bending property of gray and finished fabrics woven by various looms.

First, at the state of gray fabric, warp bending rigidity of gray fabric woven by Picanol looms(air-jet and rapier), which showed low warp yarn tension as shown in Fig.15 and 20, shows low values compared with other rapier looms(THEMA, FAST) and projectile(Sulzer). After gray fabric were finished, the effects of high tension during weaving were remained for the case of continuous finishing, i.e. the variation of bending rigidity among right, center and left sides on the fabrics woven by Rapier looms(Picanol and THEMA) was not shown on the finished fabrics, which showed lower warp tension variation during weaving as shown in Fig.13 and 17. For the rapier(FAST) and projectile(Sulzer) looms, the bending rigidities on the center of the finished fabrics showed the highest values comparing to the right and left sides on the fabrics, which is originated from high warp tension during weaving. And it is shown that there was no variation of the bending rigidity according to the finishing method for the fabrics subjected under low warp yarn tension during weaving, on the other hand, for the fabrics subjected under the high warp yarn tension during weaving, the variation was high as shown in Fig.24.

5.3.3 Fabric shear property

Fig.25 shows shear rigidities of gray and finished fabrics with various looms.

Shear modulus of gray fabrics like bending rigidity showed the variation according to the weaving looms as shown in Fig.25, i.e. High weaving tension makes shear modulus of gray fabric high, i. e. shear modulus of gray fabrics (—●—) woven by Picanol (air-jet and rapier), which showed low warp tension during weaving, were lower than those of gray fabrics woven by other rapier looms (Thema, FAST) and projectile (Sulzer) as shown in Fig.25. But these variations disappeared after finishing, then shear modulus of finished fabric between continuous (—▲—) and discrete (—■—) finishing showed large difference. These phenomena demonstrate the importance of finishing process to the fabric shear property, which can be compared to the importance of weaving process to the fabric bending property.

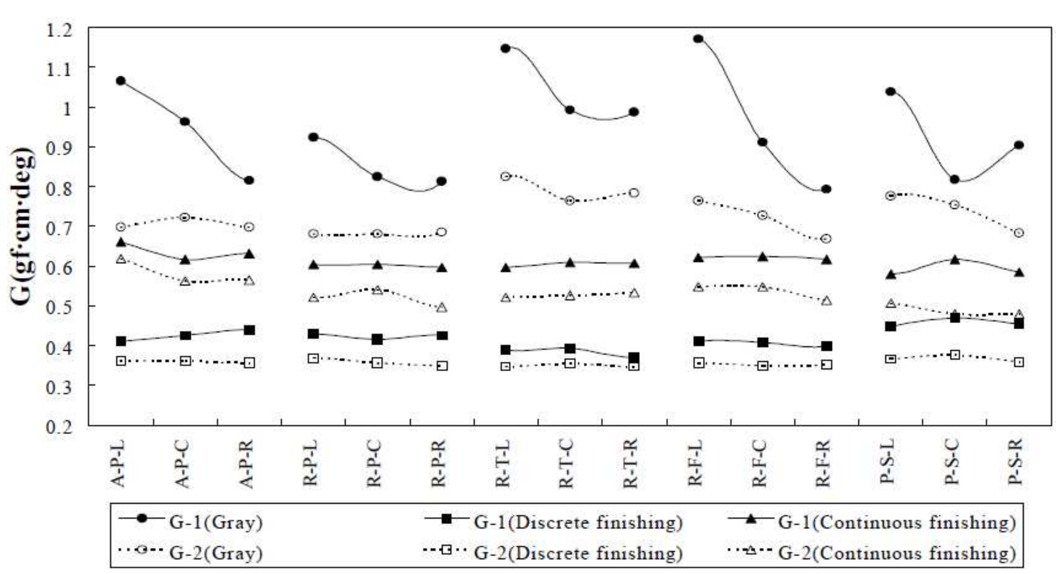


Fig. 25. Shear rigidities of gray and finished fabrics with various looms.

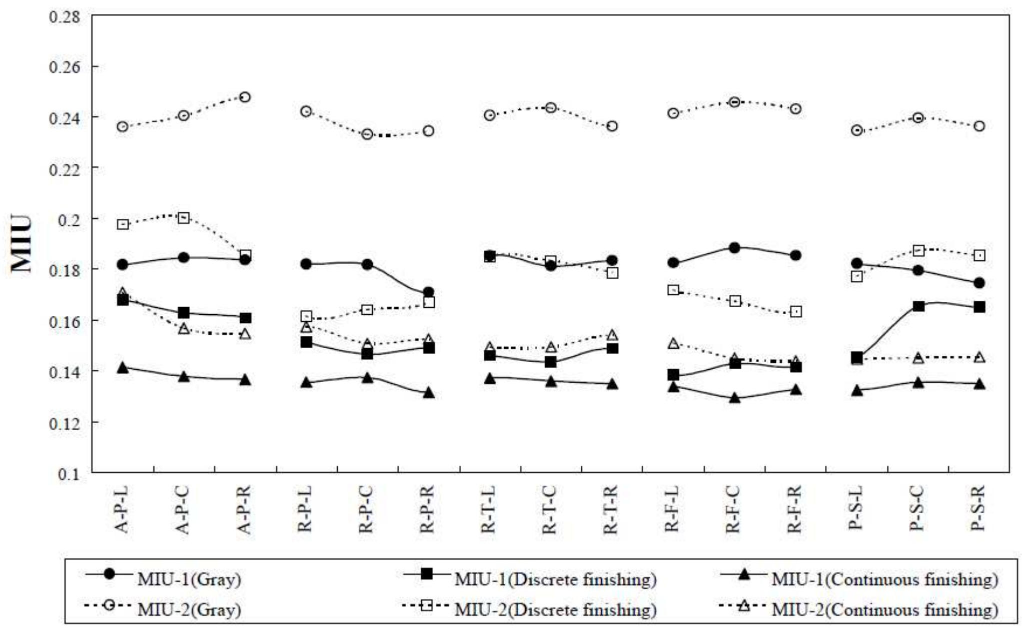


Fig. 26. Coefficient of friction of gray and finished fabrics with various looms.

5.3.4 Fabric surface property

Fig.26 shows coefficient of friction of gray and finished fabrics woven by various looms.

As shown in Fig.26, the variation of coefficient of friction (MIU) of gray fabrics (—●—) according to the various looms was less than that between right and left sides on the fabric, and the variation of the MIU of finished fabrics by continuous method (—▲—) according to the various looms was also much less than that between right and left sides on the fabrics. But the variation of finished fabric by discrete finishing method (—■—) showed big differences according to various looms and right, center and left sides on the fabric. This result means that discrete finishing makes fabric surface property deviating.

These phenomena also demonstrate the importance of finishing process to the fabric surface property.

5.3.5 Fabric thickness

Fig.27 shows fabric thickness of gray and finished fabrics with various looms.

As shown in Fig.27, the variation of the fabric thickness after continuous finishing (—▲—) did not show anymore among various looms and right, center and left sides on the same fabric. But for the discrete finishing (—■—), these variation was shown among looms and according to the position on the fabric. This shows that finishing process is still important like weaving tension for the control of even fabric thickness.

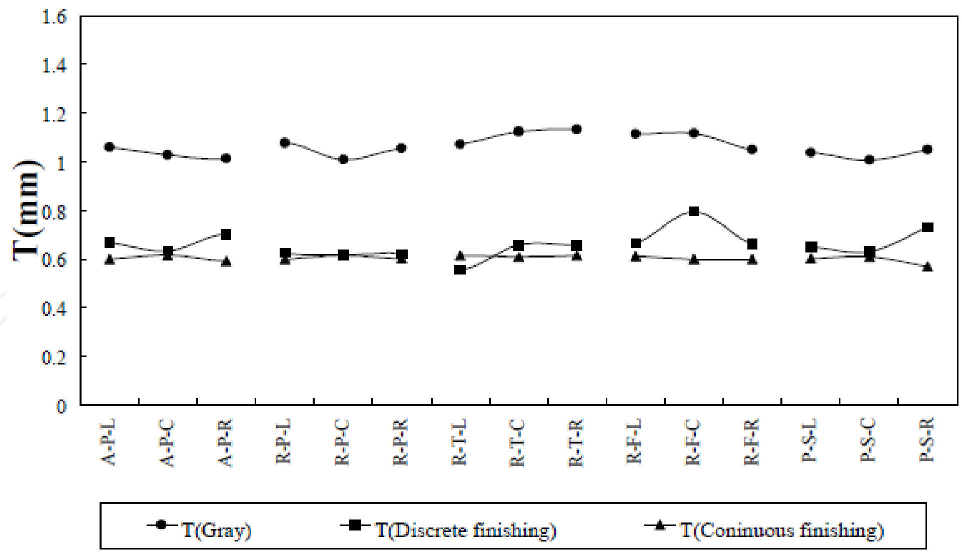


Fig. 27. The fabric thickness according to the various looms.

5.4 Loom efficiency and warp and weft tension variations of PET fabrics

5.4.1 Omega and Picanol rapier looms

Table 20 shows the efficiency and stop number of 2 rapier weaving looms (Omega and Picanol) during weaving PET fabric. Fig.28 shows warp tension according to the warp position on the 2 kinds of rapier looms.

Division Loom	RPM	EFF (%)	Stop number of loom				Stop (%)		Remark
			Warp	Weft	Other	Total	Warp	Weft	
OMEGA	470	95.62	2.8	2.8	2.8	8.4	33.3	33.3	WP: 75D
	465	73.74	39	4	27	70	55.7	5.7	
	461	98.57	0	0	2	2	0	0	
	465	97.18	3	0	3	6	50.0	0	
	461	85.26	0	24	14	38	0	63.2	
Average	464.4	92.07	8.8	6	9.6	24.4	36.1	24.6	
PICANOL-GTX	472	96.85	9.7	2.8	-	12.5	77.6	22.4	WP: 75D
	466	95.85	3	6	1	10	30.0	60.0	
	470	94.62	3	2	1	6	50.0	33.3	
	469	89.44	2	22	2	26	7.7	84.6	
	461	83.64	2	33	1	36	5.6	91.7	
Average	467.6	92.08	3.4	13	1	17.4	19.5	74.7	

Table 20. Efficiency and stop number of weaving loom during the test

As seen in Table 20, efficiency showed same value as 92% both Picanol and Omega looms, respectively. It is shown that warp breakage of Omega loom was much higher than that of Picanol loom. On the other hand, weft breakage of Omega was less than that of Picanol. The reason why is due to high warp tension of Omega loom and high weft tension of Picanol loom as shown in Fig.28 and 31. As shown in Fig.28, the warp tension according to the full width of Omega loom was much higher than that of Picanol. And the warp tensions of center parts of the loom were higher than those of both edges of fabric. It is explained that the filling yarn in the middle was held firm and tightly stretched by both sides, as it has to be beaten into the warp ends, in the edge zones, the filling can relax a little from the selvedge, the extent of relax is dependent on the filling insertion system, temples and the selvedge clap, as a result, the filling is woven in a little less firmly in the middle than at the selvedges, this means that they must bind more firmly in the center than at the edges, however the length of all the warp ends coming from the warp beam are practically the same length, those in the middle must elongated more. And it is shown that the average warp tension on center area of the Omega loom is 40~45gf and 35~40gf for Picanol loom, on edge part of the Omega loom is 30~35gf, 25~30gf for Picanol loom, so Omega loom shows 15~20gf higher tension than that of Picanol loom. In addition, high tension variation on edge part of Omega loom is shown, on the other hand tension variation on center part of Picanol loom is also shown. Fig. 29 shows real warp tension variations of Omega and Picanol looms, respectively. It is shown that Omega's warp yarn tension is much higher than that of Picanol. And 4 successive peaks and one high peak are shown both Omega and Picanol looms.

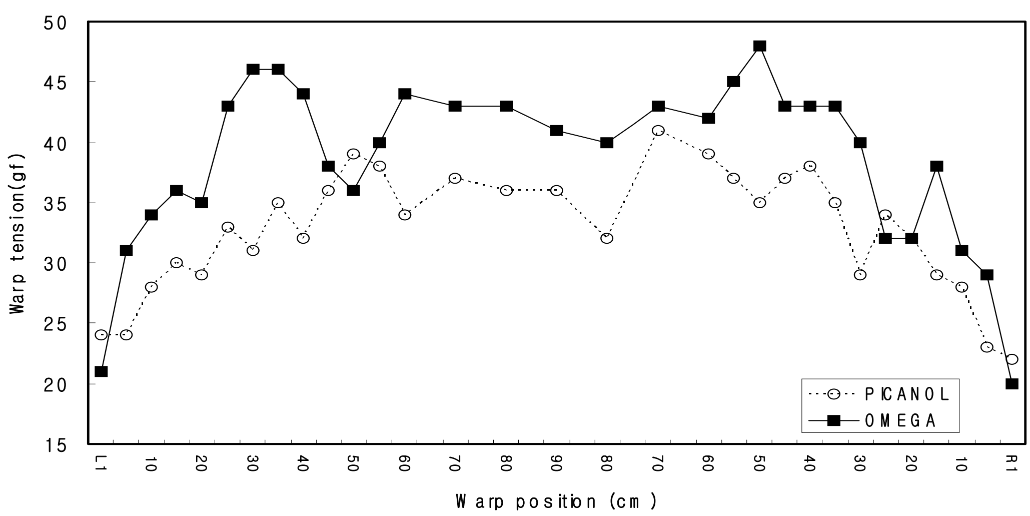
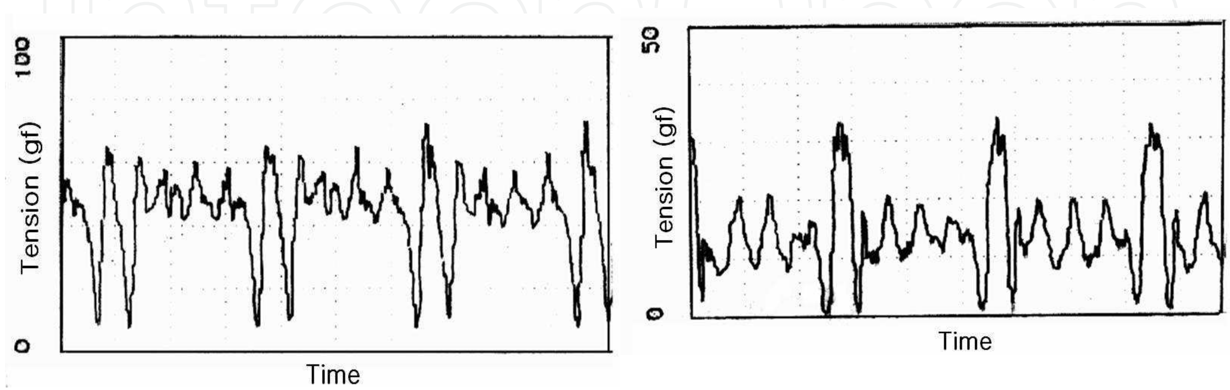


Fig. 28. Warp tension according to the warp position.



(a) Omega (b) Picanol

Fig. 29. The graph of warp yarn tension of OMEGA and Picanol rapier looms.

Fig. 30 shows the shed amount and warp tension of each 10 heald frames at the center part of the loom both Picanol and Omega looms, respectively. As shown in Fig.30, shed amounts both Picanol and Omega looms were increased from front heald to back one even though warp tension of each heald is almost same, but very slowly increased. That means that there is some relationship between shed movement and warp yarn tension on the each heald frame, and it is needed for clean shedding. Fig. 31 shows weft yarn tension variation of Omega and Picanol, respectively. As shown in Fig. 31, weft yarn tension of Picanol was higher than that of Omega. And it was shown that Picanol has distinct 2 peaks but Omega has unstable and subtle 4 or 5 peaks.

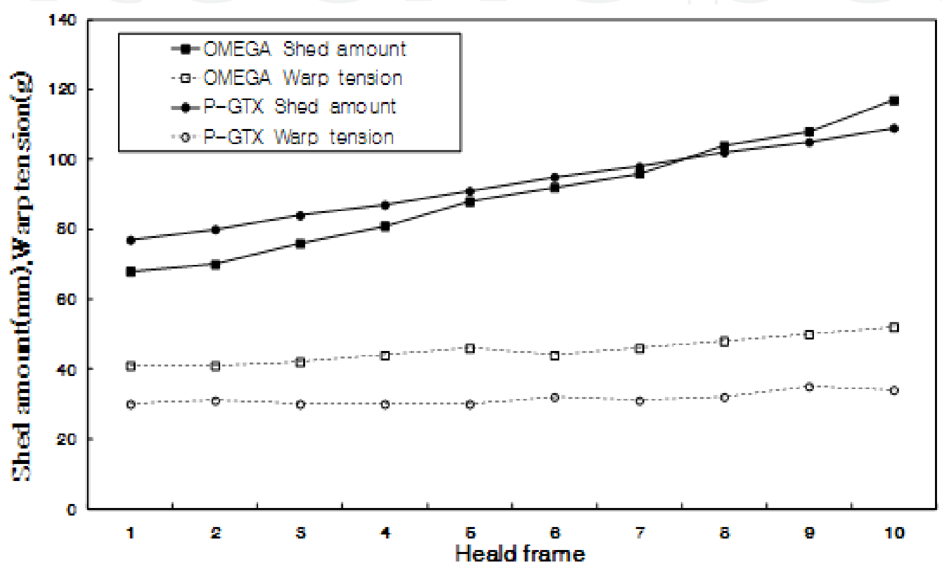
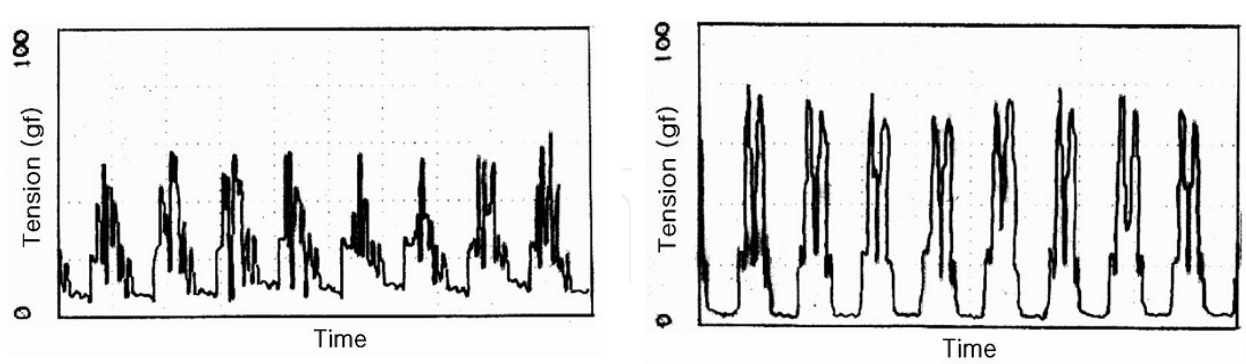


Fig. 30. Relation between warp yarn tension and amount of shed.



(a) Omega (b) Picanol

Fig. 31. The graph of weft yarn tension of Omega and Picanol rapier looms.

5.4.2 Omega and Vamatex rapier looms

Table 21 shows the efficiency and stop number of two rapier looms (Omega and Vamatex). Fig. 32 shows warp tension according to the warp position on the Omega and Vamatex looms.

Loom	RPM	Efficiency (%)	Stop number of loom				Stop (%)	
			Warp	Weft	Other	Total	Warp	Weft
Omega	466	97.45	13	3	0	16	81.2	18.8
Vamatex	423	99.57	3	0	0	3	100	0

Table 21. Efficiency and stop number of weaving loom for the test

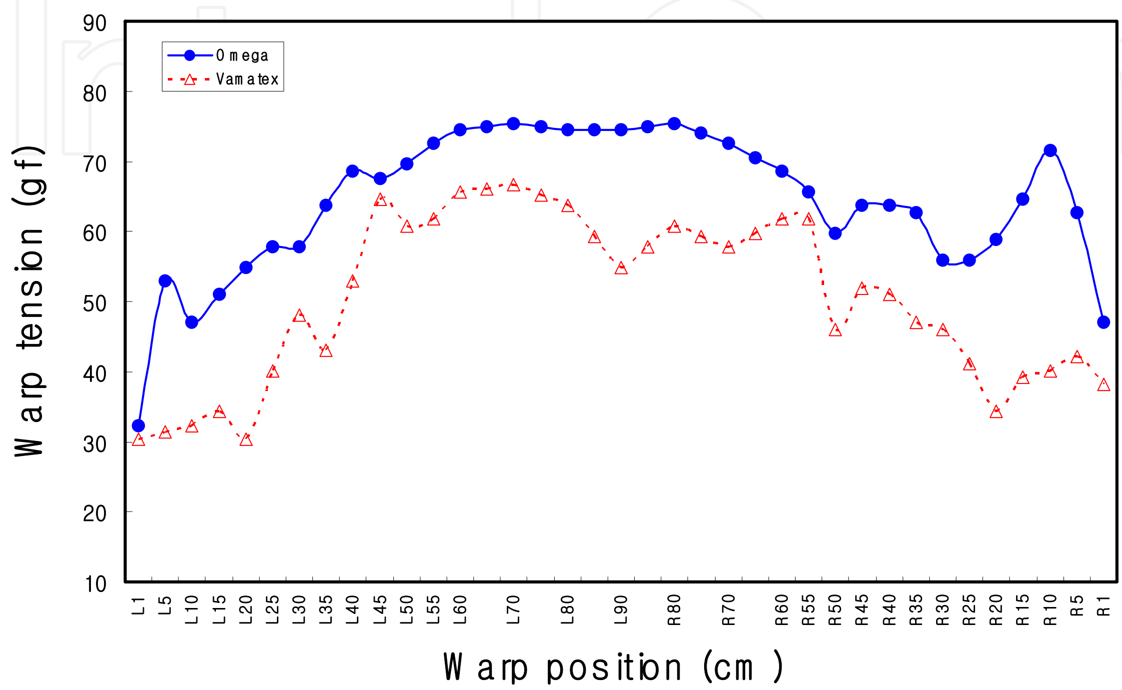
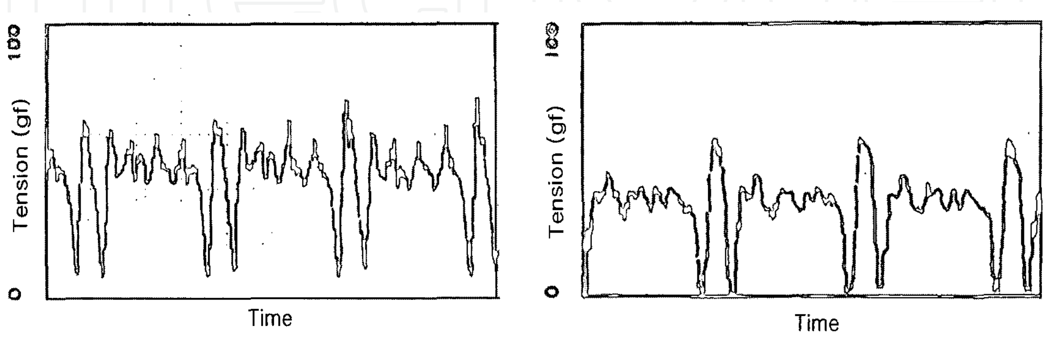


Fig. 32. Warp tension according to warp position

As shown in Table 21 and Fig. 32, efficiency shows 97.45% and 99.57%, respectively. The warp tensions according to the full width of Omega loom were higher than those of Vamatex. And it was shown that the warp tension of center part of the loom was higher than those of both edges parts of the loom. Fig. 33 shows one cycle warp yarn tension variation of 2 types of rapier looms. As shown in Fig. 33, warp yarn tension distribution in Omega was ranged from 50gf to 60gf, but ranged from 40gf to 60gf for the Vamatex. And four or five successive peaks and one high peak were shown in the Fig. 33.



(a) Omega (b) Vamatex

Fig. 33. The variation of warp yarn tension of rapier looms.

Table 22 and Fig.34 show the shed amount and warp tension of each 10 heald frames at the center of the loom both Omega and Vamatex.

Loom \ Heald		1	2	3	4	5	6	7	8	9	10
OMEGA -Panter	shed amount (mm)	70	74	78	82	84	87	93	98	97	98
	warp tension (gf)	72	71	76	79	80	71	71	78	80	85
VAMATEX	Shed amount (mm)	63	68	74	79	83	88	93	98	103	108
	Warp tension (gf)	48	51	49	57	57	65	61	66	64	69

Table 22. The shedding amount and warp tension of the test weaving looms

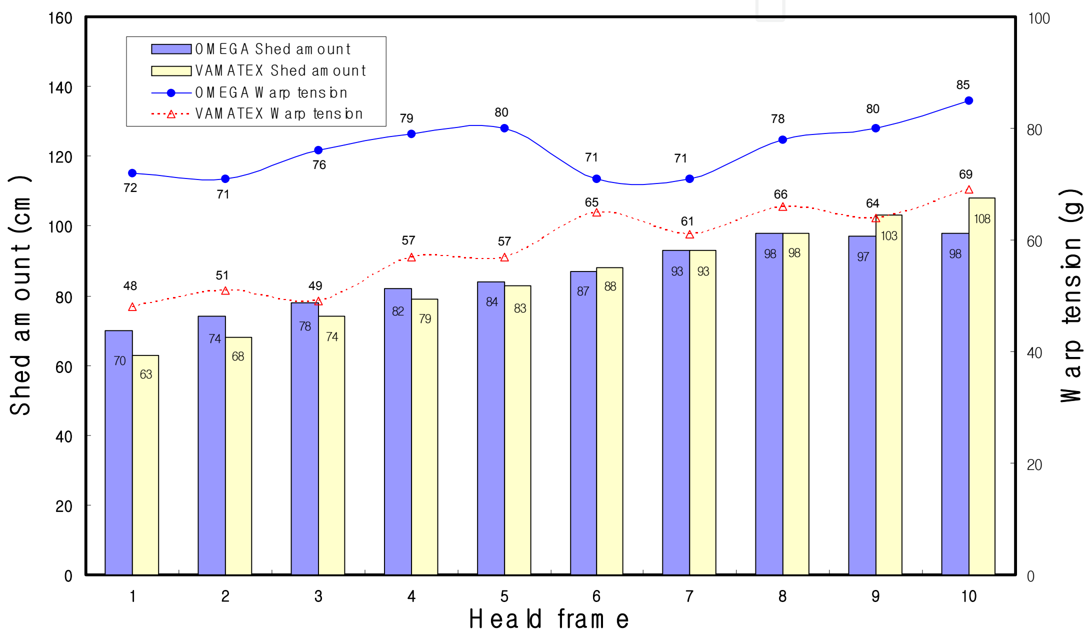


Fig. 34. Relation between warp yarn tension and shed amount.

It is shown that shed amount was increased from 1st heald to 10th one, and warp yarn tension was proportional to the shed amount.

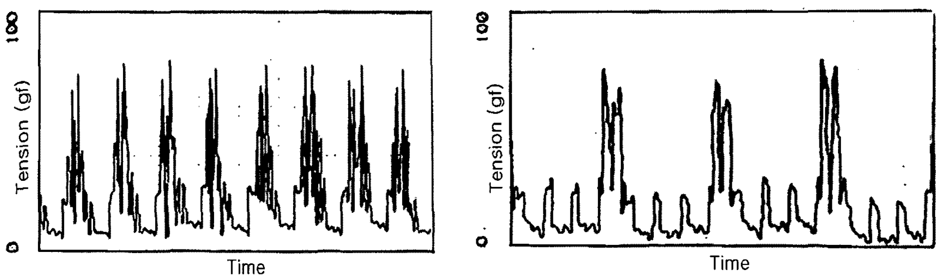
Table 23 shows weft yarn tension and end break of weft yarn on the 2 kinds of looms.

Fig. 35 shows one cycle weft yarn tension variation of the Omega and Vamatex looms.

Loom	RPM	Max. weft tension	Number of end break
Omega-Panter	466	81.0	3
Vamatex	423	81.3	0

Table 23. Weft tension and end break of weft on the two looms.

As shown in Table 23, maximum weft yarn tension was 81gf in Omega and 81.3gf in Vamatex, but end break of Omega was 3 and zero for Vamatex. The reason why seems to be due to high weft yarn tension fluctuation in Omega loom which is shown in Fig. 35. As shown in Fig.35, weft yarn tension variation of Vamatex was much more stable and lower compared to Omega loom.



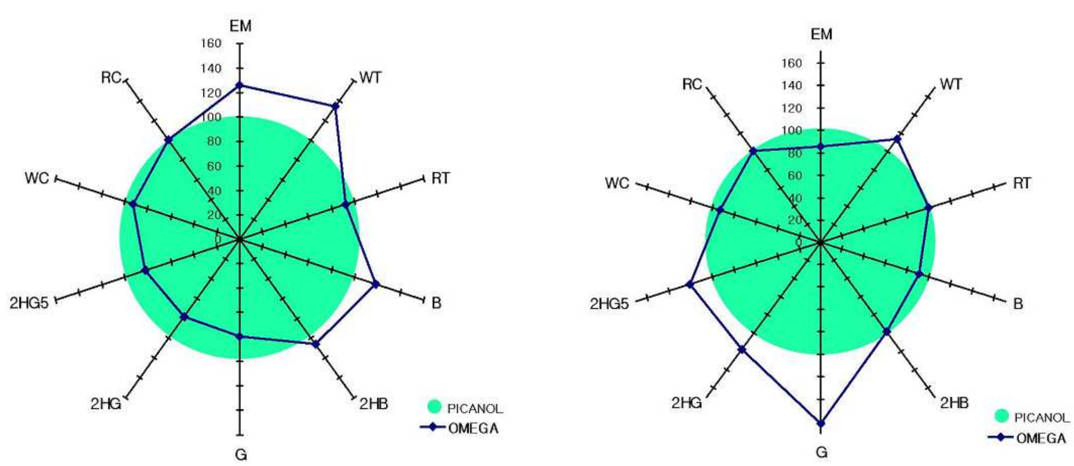
(a) Omega (b) Vamatex

Fig. 35. The variation of weft yarn tension of 2 rapier looms.

5.5 Fabric physical properties according to the rapier looms

5.5.1 Comparison between Picanol and Omega

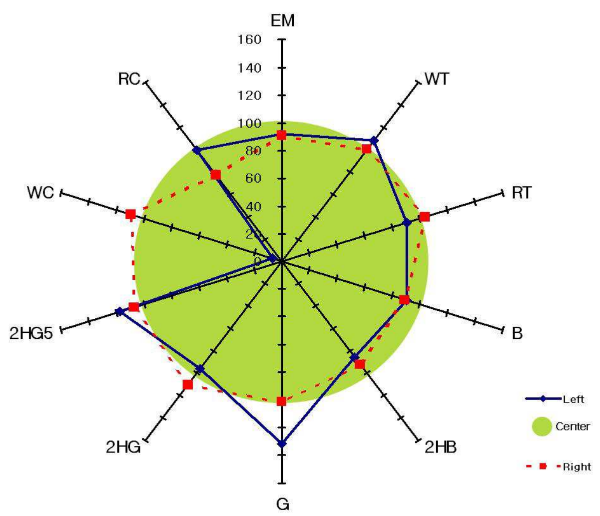
Fig. 36 shows the diagram of relative fabric mechanical properties between Picanol and Omega looms. It is shown that the tensile properties in the warp direction of the fabrics woven by Omega loom were higher than those of woven by Picanol loom, the same phenomena in bending properties were shown, which seems to be due to the higher warp tension of the Omega than Picanol loom. But that tendency was not shown in the weft direction. That phenomena shows that warp yarn tension during weaving on Omega loom affects fabric tensile and bending properties, on the other hand, weft yarn tension on Picanol loom does not affect so much. Contrary to the tensile and bending properties, the shear properties of the fabrics in the warp direction woven by Picanol loom was higher than that of woven by Omega loom, but, in the weft direction, the fabric shear properties woven by Omega loom was much higher than that of Picanol loom. And there was no difference of the compression properties between fabrics woven by Picanol and Omega looms. This result demonstrates that shear deformation of fabrics was combined with deformation of warp and weft yarns, high warp yarn tension during weaving on the Omega loom makes low shear rigidity and shear friction of the fabrics in the warp direction, and high weft yarn tension during weaving on the Picanol loom makes low shear rigidity and shear friction of the fabrics in the weft direction.



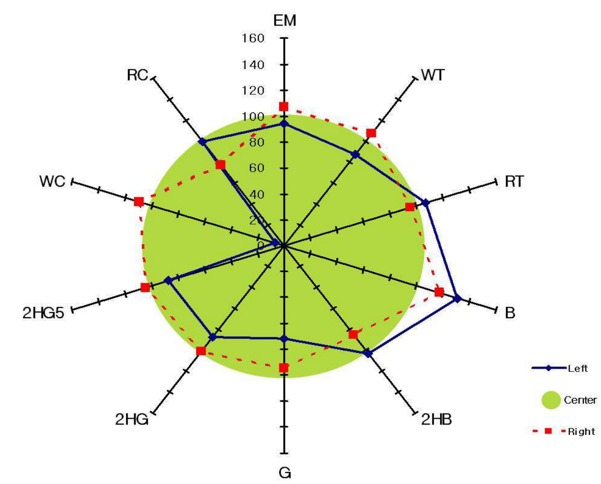
(a) warp direction (b) weft direction

Fig. 36. The diagram of relative fabric mechanical properties between Picanol and Omera looms.(Picanol: shadow(100%), — : Omega)

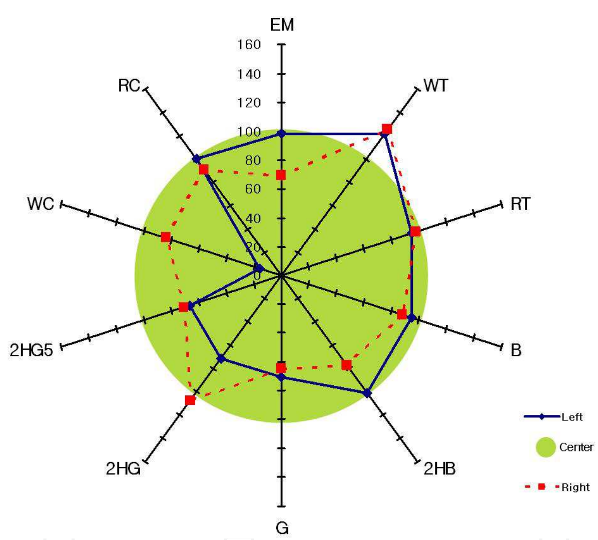
Fig. 37 shows the diagram of the fabric mechanical properties between Picanol and Omega according to the fabric positions.



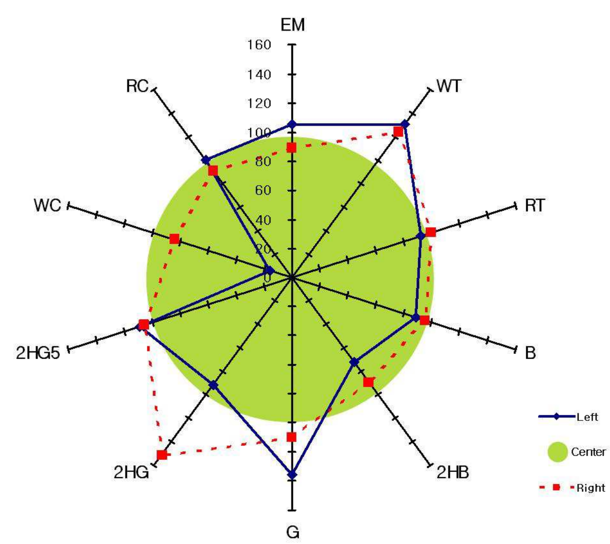
(a) warp direction (Omega)



(b) weft direction (Omega)



(c) warp direction (Picanol)



(d) weft direction (Picanol)

Fig. 37. The diagram of relative fabric mechanical properties between Picanol and Omega according to the fabric positions.(center : shadow(100%), — : left, ··· : right)

As shown in Fig. 37, concerning the tensile properties according to the fabric position such as right, center and left sides, the fabric woven by Omega loom doesn't show big difference of mechanical properties according to the fabric position, but Picanol shows big difference according to the fabric position compared with Omega. In addition, comparing Fig. 37 (a) and (c) in warp direction and Fig. 37 (b) and (d) in weft direction, the differences of the fabric mechanical properties according to the position of the fabrics woven by Picanol were higher than those of the fabrics woven by Omega loom.

It seems to be originated from high fluctuation of warp and weft yarn tensions of Picanol loom during weaving as shown in Fig. 28 and 29. Especially, the shear properties variation according to the position of the fabric woven by Picanol was larger than that of

Omega, which makes homogeneity of the fabric hand and tailorability of garment deteriorating.

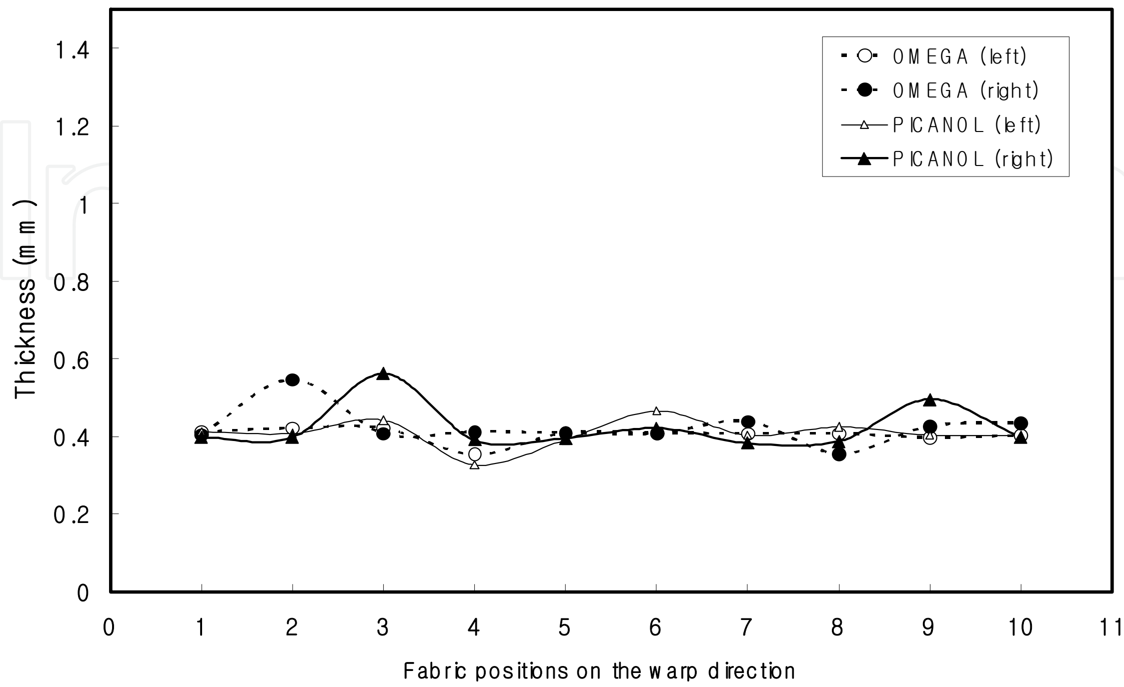
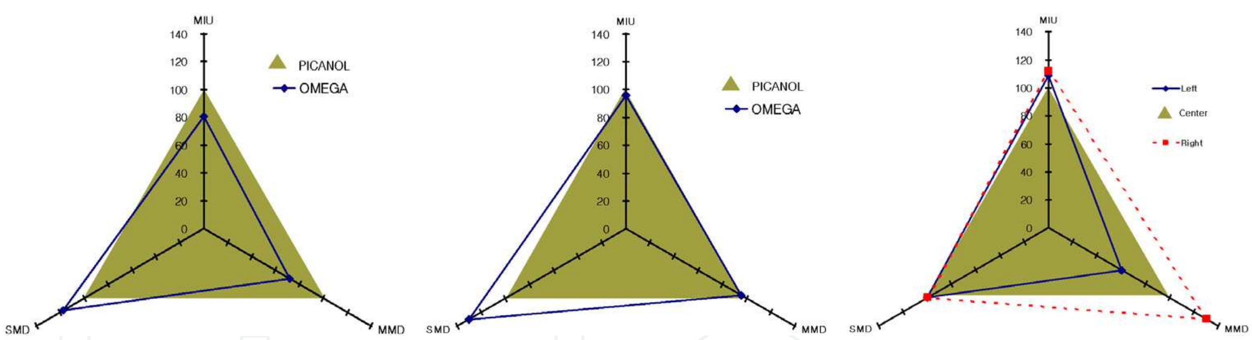
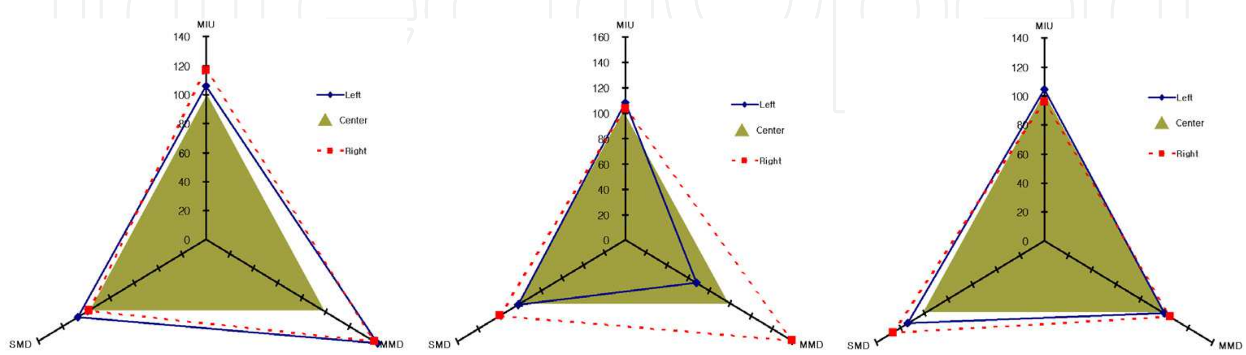


Fig. 38. The thickness variation on the right and left and sides of the finished fabrics.



(a) warp direction (b) weft direction (c) warp direction (Omega)



(d) weft direction (Omega) (e) warp direction (Picanol) (d) weft direction (Picanol)

Fig. 39. Fabric surface properties according to the looms and fabric positions.

Fig. 38 shows the thickness variation on the right and left sides of the finished fabrics on the 10 positions of the fabric warp direction. As shown in Fig.38, one or two positions along fabric warp direction on the right and left sides of the fabric showed a little thick positions comparing to the other positions of the fabrics woven by both Picanol and Omega looms.

Fig. 39 shows fabric surface properties between Picanol and Omega looms and according to the fabric positions such as right, left and center. As shown in Fig. 39, MIU(coefficient of friction) and MMD(deviation of MIU) of the fabrics woven by Omega was lower than those by Picanol loom but, SMD(surface roughness) showed higher value than Picanol. But especially the differences of these values according to the fabric positions were much higher than those of looms.

5.5.2 Comparison between Vamatex and Omega

Fig. 40 shows diagram of process shrinkage of the warp and weft directions according to loom on the each dyeing and finishing processes.

As shown in Fig. 40, any differences of each process shrinkages between Vamatex and Omega could not find, which means that two grey fabrics woven by Vamatex and Omega were proceeded at the same process conditions on the dyeing and finishing processes. It can be seen that 20% of weave contraction was occurred and 30% thermal shrinkage after scouring and drying was occurred, and 12% relaxing expansion on the pre-set, dyeing and final set was occurred.

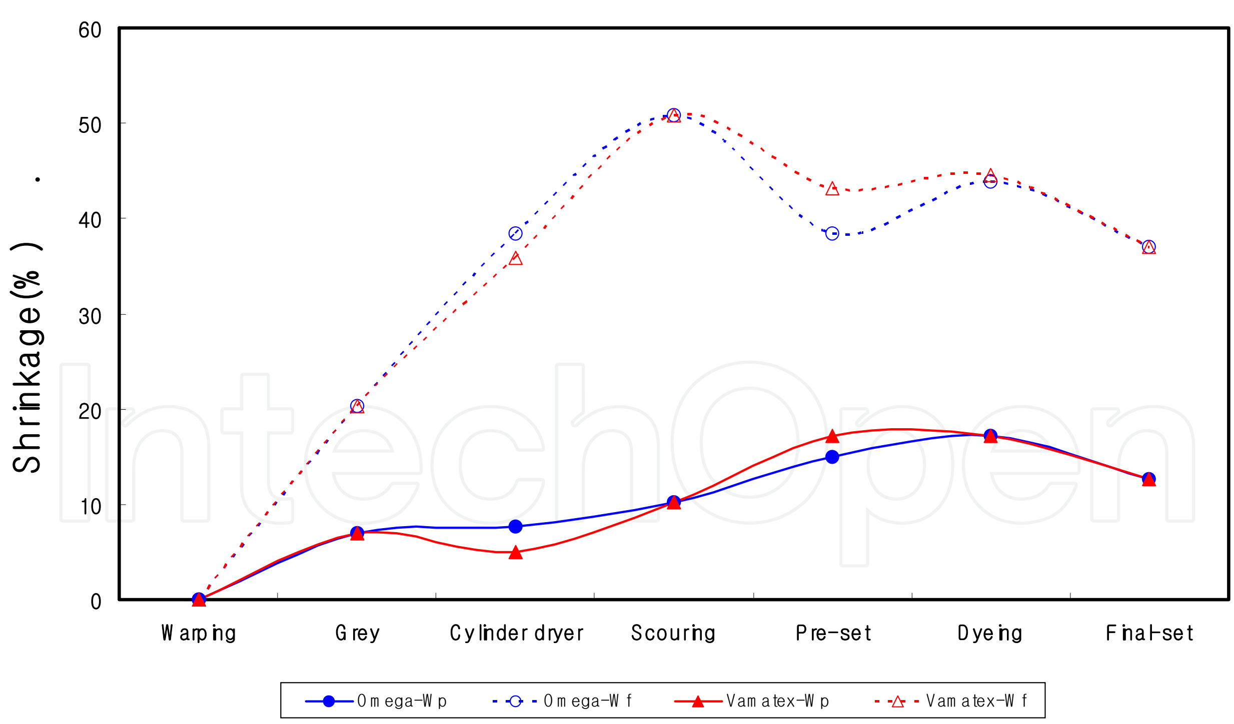
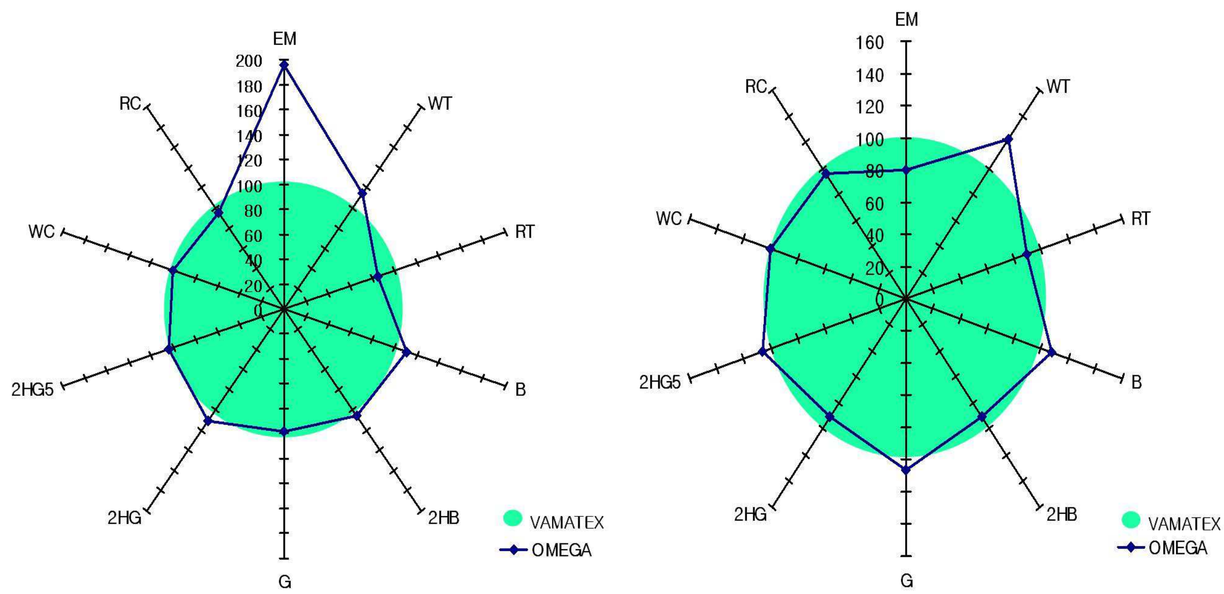


Fig. 40. Shrinkage of the fabrics according to the weaving machine.

Fig. 41 shows comparison diagram of fabric mechanical properties between Vamatex and Omega, which shows relative values of fabric woven by Omega to the mechanical properties of the fabric woven by Vamatex.



(a) warp direction (b) weft direction

Fig. 41. The diagram of relative fabric mechanical properties between Vamatex and Omega looms.

As shown in Fig. 41 (a), tensile energy (WT), and extensibility (EM) of the fabric woven by Omega were much higher than those by Vamatex on the warp direction, which seems to be due to high warp tension of the Omega loom which was shown in Fig. 33. But, this phenomena was not shown on the weft direction as shown in Fig. 41 (b), which seems to be due to the same on the weft tension between Vamatex and Omega looms which was shown in Fig. 35. The tensile resilience of Vamatex was a little higher than that of Omega, which means that elastic recovery of fabric woven by Vamatex is better than that by Omega. It was shown that the bending rigidity of fabric woven by Omega was a little higher than that by Vamatex, which is also due to high weaving tension of Omega loom which was shown in Fig. 33, Any difference of fabric shear property between Omega and Vamatex was not shown and also was not shown in fabric compressional property. These results demonstrate that fabric tensile and bending properties are affected by warp yarn tension of loom, fabric shear and compressional properties are not affected by only warp tension, which properties are affected by both warp and weft tensions.

6. Conclusion

Linear relationship between warp yarn tension and shed amount of loom for the worsted fabric was shown. Warp yarn tension variation for the worsted fabric between edge sides of fabric and center of fabric was above about 20gf, the highest at center part and the lowest at the right side as viewed in front of loom. These shed amount and warp yarn tension affect extensibility and bending rigidity of finished fabrics, i.e. the higher warp yarn tension and the lower shed amount, the more extensible gray fabric. The warp extensibility of finished fabric for the continuous and discrete finishing showed big difference, the variation of warp extensibility among various looms by continuous finishing was smaller than that of discrete finishing. Warp bending rigidity of gray fabric woven under low warp yarn tension showed low values, after finished, the effects of high warp yarn tension during weaving were remained for the case of continuous finishing. The bending rigidity on the center of the finished fabrics showed the highest values comparing to the right and left sides on the fabrics, which is originated from high yarn tension for weaving. Shear modulus of gray fabrics showed the variation according to the weaving looms, i.e. high weaving tension makes shear modulus of gray fabric high. But, these variation of shear modulus of gray fabric disappeared after finishing, this phenomena demonstrates the importance of finishing process to the fabric shear property. Fabric surface property was almost same as the fabric shear property. And finishing process is much more important than weaving tension for the control of even fabric thickness. The warp and weft tensions, shed amount among various looms for PET fabrics showed different characteristics. The tensile and bending properties in the warp direction of the fabrics woven by low tension loom showed higher values than those of high tension loom owing to the high warp yarn tension, on the other hand, shear property showed lower value. On the weft direction, contrary phenomena was shown. Concerning the variation of the mechanical properties according to the fabric positions, the fabric woven by high tension loom showed more fluctuation than that of low tension loom. It seems that these results make fabric hand and garment tailorability deteriorating. The shed amount and warp tension for PET fabrics were also increased from front heald to back one like worsted fabrics. Warp tension variation according to the warp position showed same phenomena as the worsted fabrics.

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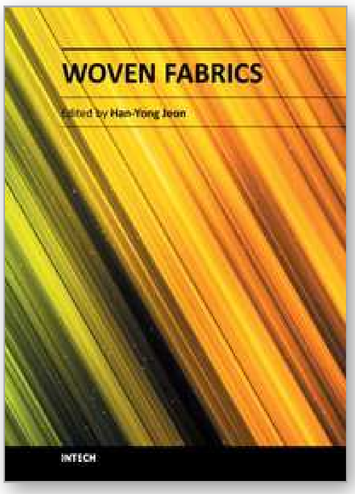

Woven Fabrics

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"Woven Fabrics" is a unique book which covers topics from traditional to advanced fabrics widely used in IT, NT, BT, ET, ST industry fields. In general, woven fabrics are known as the traditional textile fabrics for apparel manufacturing and are used widely in various fabric compositions as intermediate goods that affect human activities. The relative importance of woven fabrics as traditional textile materials is extremely large and currently application fields of woven fabrics as technical textiles are rapidly expanded by utilizing its geometric features and advantages. For example, the book covers analytical approaches to fabric design, micro and nano technology needed to make woven fabrics, as well as the concept for industrial application.

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