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〈研究論文(學術)〉

프로젝타일, 래피어 그리고 에어젯트 직기의 제직성과 직기효율

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Fabric Weavability and Machine Efficiency in the Various Weaving Machines such as Projectile, Rapiers, and Air-jet

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Abstract—This paper surveys the fabric weavability and machine efficiency in the various weaving looms such as Projectile, Rapiers, and Air-jet. Used projectile loom was Sulzer-PU, and FAST-R, THEMA-11E, and Picanol-GTX were used for Rapier looms, as the Air-Jet looms, Picanol PAT and OMNI types were used. Using these looms, 5 harness worsted satin fabrics were woven for surveying the fabric weavability and machine efficiency. Warp yarn count of fabric is 1/40Nm, Sirofil, and filling is 1/30 Nm, worsted. End breaks of warp and filling directions for the various types of looms are measured and discussed with the mechanism of each loom. Warp and filling yarn tensions are also measured and analysed with open width of shedding motion of each weaving machine. And various warp yarn tensions with open width of shedding are measured and analysed according to the warp yarn in various heald frame. These results are also discussed with temples such as bar and ring. Warp yarn tensions at the various positions on the fabric with various looms are measured and discussed with fabric mechanical properties such as tensile, bending, shear and surface.

1. INTRODUCTION

Industry of textile machinery in Korea is very fragile, especially so in loom industry for worsted fabric. So, the looms for the worsted fabric are imported from foreign countries such as Japan, Switzerland, Germany and Belgium and so on. The large companies for production worsted fabric in Korea 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 in large companies is divided and delivered to the small companies by small fabric lot. Therefore, large quantity of fabric are woven by various looms such as projectile, rapier, air-jet in various small weaving companies, next 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[1~5]. It is investigated that these non-homogeneity of the fabric physical properties may be originated from the difference of loom among various causes even though the loom setting is same[6,7].

Therefore, this paper surveys the fabric weavability and machine efficiency in the various weaving looms such as Projectile, Rapiers, and Air-jet. Using these looms, 5 harness worsted satin fabrics were woven for surveying the fabric weavability and machine efficiency. Warp yarn count of fabric is 1/40Nm, Sirofil, and filling is 1/30 Nm, worsted. End breaks of warp and filling directions for the various types of looms are measured and discussed with the mechanism of each loom. Warp and filling yarn tensions are also measured and analysed with open width of shedding motion of each weaving machine. And various warp yarn tensions with open width of shedding are measured and analysed according to the warp yarn in various heald frames. These results are also discussed with temples such as bar and ring. Warp yarn tensions at the various positions on the fabric with various looms are measured and discussed with fabric mechanical properties such as tensile, bending, shear and surface.

2. EXPERIMENTAL

2.1 Specimen preparation

Used loom setting is shown in Table 1.

Looms characteristics for specimens are shown in Table 2.

Table 1. Details of weaving design

		Warp	Weft
Fiber composition		Wool 93% Nylon 7%	Wool 100%
Yarn count (Nm)		1/40 sirofil	1/30
Fabric structure		5 harness satin	
Density (per 10cm)	Gray fabric	378	268
	Finished	421	283
Remark		Warp : $18^D \times 5 = 90$ ends/in Weft : 68 picks/in Width : 70.3 66.0 59.0 Length : 97.5m 96.5y 91.0y	

Table 2. The characteristics of looms for specimens

	PROJECTILE	AIR-JET	
	SULZER-PU	PICANOL-PAT	PICANOL-OMNI
RPM	360	630	700
Reed width	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	9.1-230	5.8-183	
Micro-Processor	Let off motion	Pick find let off motion	

	RAPIER TYPE		
	FAST-R	THEMA-11-E	PICANOL-GTX
RPM	520	550	580
Reed width	2200	2100	1900
Harness motion	Electronic dobby		
Weft insertion	Rapier		
Let-off motion	Electronic let-off		
Range of picking	4.8-282	7.6-198	4.5-340
Micro-processor	Pick find let off motion		

2.2 Finishing process

Gray fabrics were processed on the same finishing processes, each 3 yd of gray fabrics woven by 6 types of weaving machinery as shown in Table 2 were connected by over-locking for processing in the state of same finishing process. Finishing processes and production conditions are shown in Table 3.

2.3 Measurement of weaving tension

Weaving tensions on 6 kinds of weaving machines were measured using Defat tension meter. 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.

Table 3. Finishing process and conditions

Process	Condition
Gas singeing	100 m/min, Gas 9 bar both side singed
Solvent scouring	25 m/min
Scouring	50℃, soaping for 20 min rinsing for 30 min soaping for 45 min rinsing for 50 min
Dry	110℃ over feeding ratio 5%
Fabric dyeing	100℃
Dry	110℃ 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 : 30 kg/㎠

2.4 Measurement of warp movement

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.

2.5 Measurement of fabric mechanical property

16 mechanical properties of gray and finished fabrics such as tensile, bending, shear, compression and surface woven from 6 kinds of looms were measured by KES-FB system.

Table 4. Loom efficiency and r.p.m. of various looms

		RPM	Eff.	※	Pick	Loom stop number				Stop %	
					Hour	Total	warp	Weft	other	Warp	Weft
Projectile	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		
Rapier	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		
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		

Note : ※=No. of keeping looms/person

3. RESULTS AND DISCUSSIONS

3.1 Weavability of 6 kinds of looms

Table 4 shows the loom efficiency and r.p.m. of looms.

Fig. 1 shows the diagram between r.p.m. and efficiency of various looms.

As shown in Fig. 1, as r.p.m. of loom increased, efficiency of loom decreased.

Weaving efficiency of Picanol, air-jet machine shows the lowest, the reason why this phenomena is shown seems to be high r.p.m. and high keeping machine per one person i.e., 10 looms per person. Fig. 2 shows the diagram on the percentage of end breaks of warp and weft of the various looms.

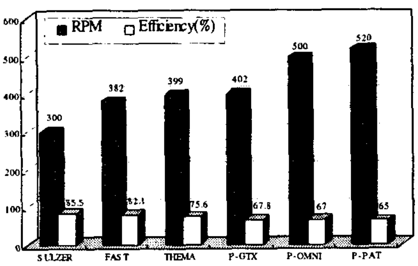


Fig. 1. The diagram between r.p.m and efficiency of various looms.

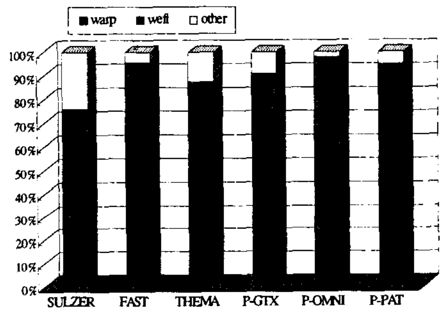


Fig. 2. Percentage of the end break of warp and weft to the various looms.

As shown in Fig. 2, the percentage of weft yarn break for the Air-Jet is higher than that of rapier and projectile looms, on the other hand, for the rapier loom, warp break is higher than that of other looms. For the air-jet loom, weft insertion makes weft yarn break, and for the rapier, rapier itself makes warp yarn break.

3.2 End break and tension of weft yarns

Table 5 shows weft yarn tension of various looms.

Table 5. Weft yarn tension of various looms

		Weft Tension (gf)		RPM	Break of weft (No.)
		Max.	Min.		
SULZER-PU		43	0	300	4.9
FAST-R		84	0	382	8.2
THEMA-11-E		84	0	399	11.1
PICANOL	GTX	99	0	402	6.2
	OMNI	—	—	500	35.8
	PAT	—	—	520	21.6

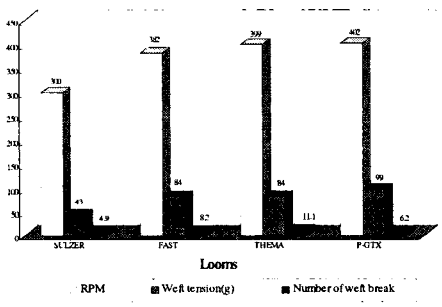


Fig. 3. Diagram of weft yarn tension, r.p.m. and no. of weft yarn break.

Fig. 3 shows the diagram of weft yarn tension, r.p.m. and number of weft yarn break of various looms as shown in Table 5.

For air-jet weaving loom, weft yarn tension could not measure because of high frequency of nozzle movement as weft yarn is inserted. As shown in Fig.3, good correlation between r.p.m. of loom and weft yarn tension is shown and this is correlated with number of weft yarn break except the Picanol-GTX loom. For the Picanol-GTX loom, even though weft yarn tension is high, 99 gf, number of weft yarn break is low, as the case of Sulzer projectile loom. This is an advantage of Picanol-GTX loom.

As shown in Table 5, number of weft break of Picanol-OMNI of air-jet loom shows 35.8, this is higher than that of Picanol-PAT. Fig. 4 shows the graph of weft tension of various rapiers and projectile looms.

As shown in Fig. 4, in Sulzer loom, an instant tension increased and quickly decreased during flying the projectile, only one mountain peak is shown, on the other hand, in case of rapier looms, yarn tension increased quickly as gripper keeps the weft yarn and as 1st and 2nd rapier meet, instant yarn tension decreased quickly to the zero yarn tension and then the yarn tension increased again as the 2nd rapier keeps the weft yarn, and as the 2nd rapier drops the weft yarn, yarn tension decreased to zero value, so two mountain peaks are shown and repeated.

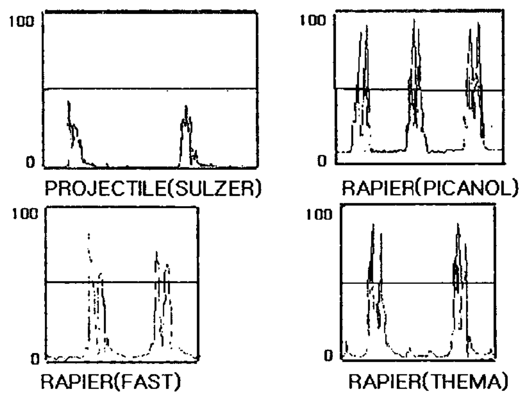


Fig. 4. The graph of weft tension of various rapiers and projectile loom.

3.3 Relationship between the amount of shed and warp yarn tension

Table 6 shows the amount of shed and warp yarn tension.

Fig. 5 shows the relationship between warp tension and the amount of shed of various looms.

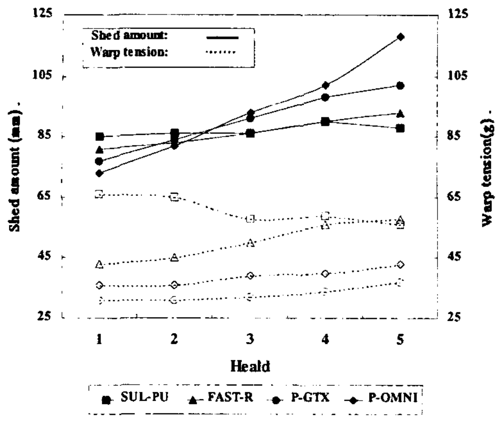


Fig. 5. Relationship between warp tension and amount of shed of various looms.

As shown in Table 6, warp tension of loom used bar temple is lower than that of ring temple by from 30 % to 50%. And as the amounts of shed increased, warp yarn tension increased also as shown in Fig. 5. Even though the amounts of shed of Picanol-GTX and Picanol-OMNI used bar temple are larger than that of rapier loom used bar temple, warp tension is lower by about 30%.

On the other hand, correlation between warp yarn tension and warp break could not find as shown in Table 6.

Fig. 6 shows the graph of warp yarn tension of various looms Fig. 6 is the result of warp tension on the yarn at 15cm from left side of loom.

Fig. 7 shows the number of warp break, the amount of average shed and warp tension shown in Table 6.

For the Sulzer and rapier looms, the ranges of the shed amount of Sulzer and FAST looms are low and the number of warp break is 21 ends, on the other hand, the range of the shed amount of P-GTX is very high and the number

Table 6. The amount of shed and warp yarn tension

			1	2	3	4	5	6	AVG.	Ratio	Warp Break	Ratio
Bar Temple	P-GTX	Shed amount	77	84	91	98	102		90.4	104.4	31.7	151.7
		Tension	31	31	32	34	37		33.0	100.0		
	P-OMNI	Shed amount	73	82	93	102	118		93.6	108.1	9.9	47.4
		Tension	36	36	39	40	43		38.0	115.2		
Ring Temple	SUL-PU	Shed amount	85	86	86	90	88		89.0	102.8	21.0	100.5
		Tension	66	65	58	59	56		60.8	184.2		
	FAST-R	Shed amount	81	83	86	90	93		86.6	100.0	20.9	100.0
		Tension	43	45	50	56	58		50.4	152.7		
	THEMA-E	Shed amount	76	79	88	-	100	105	89.6	103.5	28.4	135.9
		Tension	47	50	54	-	51	53	51.0	154.5		
	P-PAT	Shed Amount	87	92	104	111	117		102.2	118.0	22.2	106.2
		Tension	40	45	54	50	56		49.0	148.5		

of warp break is also large, 31.7 ends, this phenomena is also the same for THEMA loom.

Therefore, it seems to be well correlated between the range of shed amount and warp break i.e., the wider the range of shed amount, the larger the warp break.

On the other hand, as shown in Fig. 7, it seems that warp break is not correlated with warp yarn tension.

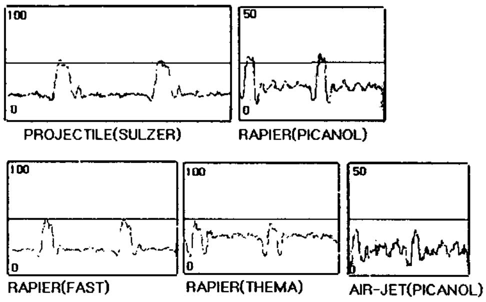


Fig. 6. The graph of warp yarn tension of various looms.

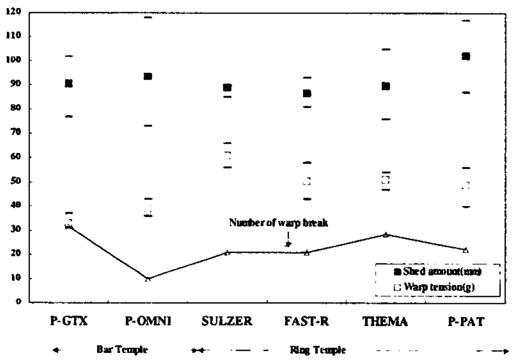


Fig. 7. The graph of number of warp break, amount of average shed and warp tension.

3.4 Warp tension variation along fabric width

Fig. 8 shows warp tension variation along fabric width of various looms.

Warp tension variation of Picanol-GTX used bar temple was not shown in Fig. 8.

On the other hand, for the Sulzer, FAST and THEMA looms used ring temples, the warp tension of the fabric center area is higher than those of left and right sides of fabric. For the surveying detail warp yarn tension, warp yarn tension was measured on the 7 th heald frame.

Fig. 9 shows detail warp yarn tension along fabric width.

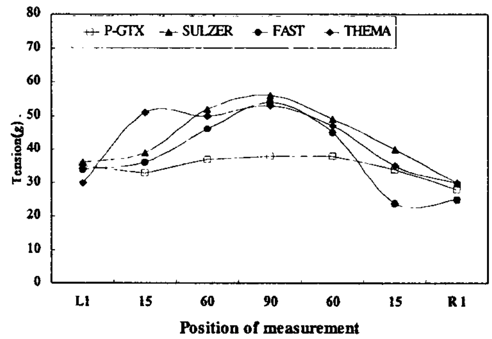


Fig. 8. Warp tension variation along fabric width of various looms.

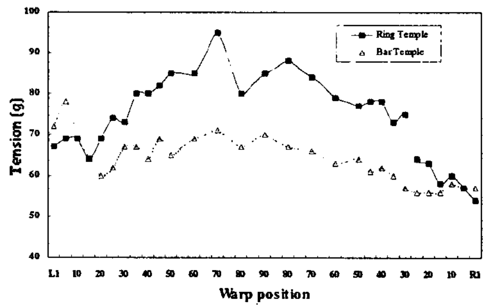


Fig. 9. Detail warp yarn tension along fabric width.

As shown in Fig.9, it is shown that warp yarn tension variation between left and right sides of fabric is very high, and the tension of right side of fabric is lower than that of left side of fabric.

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.

According to the result of Fig. 9, it seems that color difference between right and left sides of fabric can be diminished by reducing warp yarn tension variation between right and left sides of fabric using bar temple.

These tension variations may be originated from warping tension variation for sectional warping.

For confirming warping tension variation for sectional warping, warping tension was measured on the each band on the sectional warping machine, UK 305S.

Table 7 shows warping tension on the sectional warping machine.

Table 7. Warping tension on the sectional warping machine

Band No.	Measured point	Tension (gr)		
		Max.	Min.	Avg.
1	—	61	0	18
4	25m	43	2	16
5	130m	50	2	17
6	25~400m	49	0	13
	400~680m	53	0	16
11	50m	45	1	18
12	50m	43	1	18
13	50m	39	4	17
14	50m	36	3	17
15	Cone change			

As shown in Table 7, warping tension variation was from 0 gr to 60 gr, as can see in 6th band, warping tension is increased with increase of yarn layer on the warp drum and yarn speed. Warping tension difference between 1st band and last band was very large, warping tension was decreased with increase of band from 1st to last band.

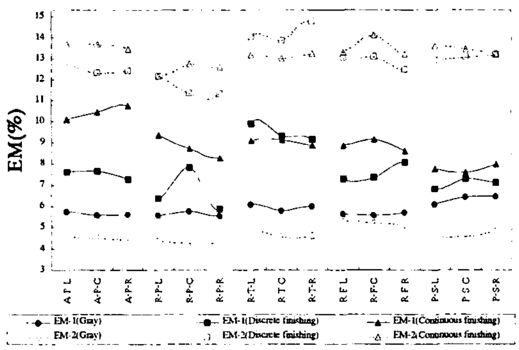
This phenomena is related with ballooning tension from cone i.e. unwinding tension from full cone at 1st band is larger than that from thin cone at the last band.

This is future topic for reducing warping tension variation among bands and weaving tension variation between right and left sides of fabric.

3.5 The mechanical properties of finished fabrics woven by various looms

3.5.1 Fabric extensibility

For surveying the effects of the looms and finishing process to the fabric extensibility, tensile properties of gray and finished fabric were measured using KES-FB1 system. For five kinds of looms, gray fabrics of left, center and right sides on the fabric were used as a specimens and gray fabric was 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, the other way was discrete processing with five kinds of grayfabrics.



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

Fig. 10. Fabric extensibility with various looms. (EM-1 : Warp, EM-2 : Weft)

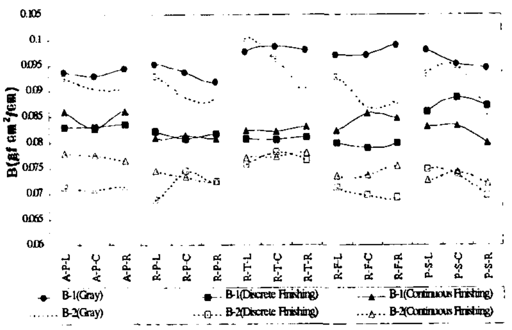


Fig. 11. Bending property of gray and finished fabrics woven by various looms.

Fig.10 shows fabric extensibility with various looms.

As shown in Fig.10, for the warp extensibility of gray fabric, projectile(Sulzer) and rapier(THEMA) show high values, then these looms show high warp yarn tension and low shed amount for weaving as shown in Fig. 7. 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 finishing process. As shown in Fig.10, 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 (—■—).

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.

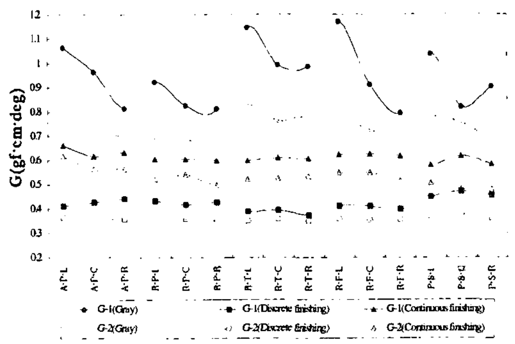


Fig. 12. Shear rigidities of gray and finished fabrics with various looms.

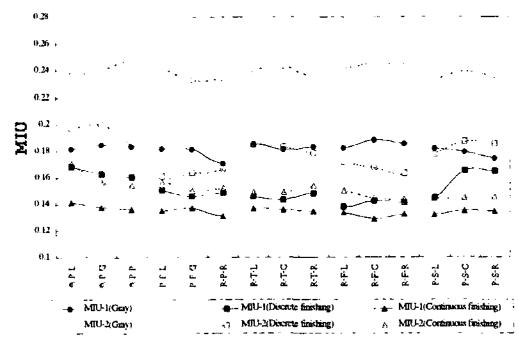


Fig. 13. Coefficient of friction of gray and finished fabrics.

3.5.2 Fabric bending property

Fig.11 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 were shown low warp yarn tension as shown in Fig.7, shows low values compared with other rapier looms(THEMA, FAST) and projectile(Sulzer).

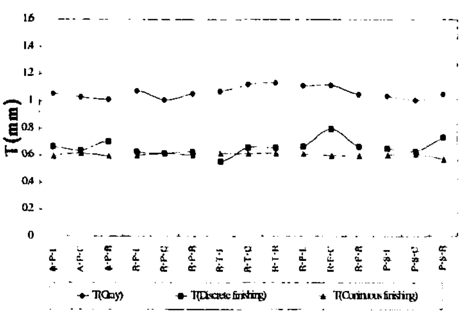


Fig. 14. The fabric thickness according to the various looms.

After gray fabrics were finished, the effects of high tension for weaving 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 for weaving as shown in Fig.8.

For the rapier(FAST) and projectile(Sulzer) looms, the bending rigidities on the center of the finished fabrics shows the highest values comparing to the right and left sides on the fabrics, which is originated from high tension for weaving. And it is shown that there was no variation of the bending rigidity on the finished fabric between continuous and discrete 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. 11.

3.5.3 Fabric shear property

Fig. 12 shows shear rigidities of gray and finished fabrics with various looms.

Shear modulus of gray fabrics as the same of bending rigidity shows the variation according to the weaving looms as shown in Fig. 12, i.e., High weaving tension makes shear modulus of gray fabric high, i.e., shear modulus of gray fabric(—●—)woven by Picanol(air-jet and rapier), which shows low warp tension during weaving, is lower than those of gray fabric woven by other rapier looms(Thema, FAST)and projectile Sulzer) as shown in Fig. 12. But these variation disappears after finishing, then shear modulus of finished fabric between continuous (—▲—) and discrete(—■—) finishing shows 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.

3.5.4 Fabric surface property

Fig. 13 shows coefficient of friction of gray and finished fabrics with various looms.

As shown in Fig. 13, the variation of the coefficient of friction (MIU) of gray fabrics (—●—)according to the various looms is 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 is also less than that between right and left sides on the fabrics. But the variation of finished fabric by discrete finishing method(—■—) is increased with various looms and right, center and left sides on the fabric.

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

3.5.5 Fabric thickness

Fig. 14 shows the fabric thickness according to the various looms.

As shown in Fig. 14, the variation of the fabric thickness after continuous finishing(—▲—) does not show anymore among various looms and right, center and left sides on the same fabric.

But for the discrete finishing(—■—), these variation is shown among looms and according to the position on the fabric.

This shows that finishing process is more important than weaving tension for the control of even fabric thickness.

3. CONCLUSION

Linear relationship between warp yarn tension and shed amount of loom was shown, then there was no relation between warp yarn tension and warp yarn break. Warp yarn tension variation between edge sides of fabric and center of fabric is about 20 gf, 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 shows big difference, the variation of warp extensibility among various looms by continuous finishing is smaller than that of discrete finishing.

Warp bending rigidity of gray fabric woven under low warp yarn tension shows low values, after finished, the effects of high warp yarn tension for weaving remained for the case of continuous finishing, The bending rigidity on the center of the finished fabrics shows the highest values comparing to the right and left sides on the fabrics, which is originated from high tension for weaving.

Shear modulus of gray fabrics shows 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 disappears after finishing, this demonstrates the importance of finishing process to the fabric shear property. Fabric surface property is almost same as the fabric shear property.

And finishing process is more important than weaving tension for the control of even fabric thickness.

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