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A Study on the Structural and Tensile Properties according to Knitting Methods with Rib Stitch - Focused on Wool Yarn -

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Abstract

The purpose of this study is to characterize physical and tensile properties according to a knitting method as basic materials for solving the difficulties that occur due to the fact that the crosswise elongation is most different among knit stitch at the time of measuring elongation of knitwear. The sample used for this study was wool 100% and was knitted into two, that is, controlled loop length controlled to properties of structure and fixed loop length by using Shimaseiki SES-124S 12G computer automatic flat knitting machine with DSCS device. Also, the density of rib fabric was 12gauge and its quantity was a total of seven of 0×0, 1×1, 2×1, 2×2, 3×3, 4×4 and including plain fabric, and knitted 2 pieces of sample of 300 wale×400 course. In conclusion, rib stitch has the much higher stretch rate in the direction of the course than other stitches.

Key words : rib stitch, knitwear, structure, loop length, wool.

Ⅰ. Introduction

With increasing income level, the interest and demand of the consumers for knitwear continue to grow with increased desire for free activities and pleasantness.

To examine the characteristics of knitwear, it has merits of elongation, porosity, softness, soft hand, absorbency, keeping warm and demerits of lack of friction-proof nature, pilling nature and stability. Especially, the elements that affect the stability and silhouette of knitwear includes wale of knitwear, elongation in the course direction, change in fabric, gauge of knitted fabric, kinds of yarn, thickness and density of yarn, yarn count, tension at the time of knitting and processing methods of fabric. Therefore, in case of knitwear, it is needed to propose basic materials based on the inherent properties of knit structures which are different from woven fabrics.

Rib stitch among various knitted structures vary in its elongation from other knitted structures, so difficulties appear at the time of designing knitwear or in the process of producing knitwear. The elongation of rib stitch[1)] is as large as rubber-gum, so it is called "rubber knitting", also called "circular rib fabrics" though its origin is not known. This texture is made by front knit and back knit being knitted crosswise, with front needle and back needle being in the course direction and at the right angle or similar angle

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1) Hanyang Women's College Knit Research Institute, *Knit structure - warp · weft knitting-*.(2003), 108, 154-161.

thereto, and a crease is formed between front knit and back knit. This texture is usually used for hem or the body. For making hem, 1×1, 2×1 rib fabrics are mostly used, and for making the body, fabrics that form a crease of more than 3 needles are mostly used, but sometimes 2×2, 3×3 are also used. Because of continuity of front knit and back knit, front knit and back knit cling to themselves respectively, their sections look like the skin of a snake, which gives good elongation, so in case knitwear is knitted by using yarn of the same denier, needle score and density, the width of knitwear made of rib stitches is narrower than others. This is important features of rib fabrics.

Regarding change in rib fabrics, the changed fabrics such as 0×0, 1×1, 2×1, 2×2, 3×3, 4×4 can be obtained by the number of front knit and back knit in the course direction and in the order of front needle and back needle. It indicates various elongation according to texture.[2)]

Today, many studies on the physical properties of knitwear[3~6)] continue, but the study on rib stitch which is most used and whose elongation is peculiar is in short, and especially there is no study on wool.

Accordingly, the purpose of this study is to show physical and dynamical properties in accordance with respective knitting methods by knitting knitwear in 12 gauge out of rib stitches of 0×0 (all needle knitting), 1×1, 2×1, 2×2, 3×3, 4×4 in a 12 gauge with wool 100% as raw materials at the most serious rib stitches that is different from other structures.

This study is expected to present basic materials with contentment for satisfying a variety of demands from the customers through analyzing the characteristics of rib structures, which have gradually increasing importance in the knit industry.

Ⅱ. Study Methods and Process

1. Knitting Machine and Conditions

1) Knitting Machine

The knit structure for experiment of this study were knitted into two, that is, controlled loop length to properties of fabric and fixed loop length, by using Shimaseike SES-124S 12G computer automatic flat knitting machine with DSCS device.

2) Knitting Conditions

(1) DSCS (Digital Stitch Control System)

In case knitwear is made by using stitch data for a long period of time, the size of finished clothes may vary according to various conditions such as place where a machine was installed, materials and size of corn, DSCS(Digital Stitch Control System) keeps the quantity of knitting yarn fixed in the unit of 1 course, the unit of basic yarn and the unit of a suit of clothes by automatic control of stitch cam by setting the length of a loop, and so in the research loop length data was used instead of stitch data.

(2) Loop Length

As showed in 〈Fig. 1〉 and 〈Fig. 2〉 at the

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[2] S. A. Kim, "A Study on the Knit Pattern Considering the Characteristics of Rib Stitch", Master's Thesis, Graduate School of Hanyang University (2004).

[3] H. E. Kim, "Effect of Aftertreatments for Washing on Mechanical Properties of Knitted Fabrics", *J. Kor. Soc. Cloth. Ind.*, Vol. 3, No. 2, (2001), 174-179.

[4] S. W. Park, B. C. Kang, Y. G. Hwang, and J. S. An, "Studies on the Mechanical Properties and Hand of Double Knitted Fabrics", *Journal of the Korean Fiber Society*, Vol. 32, No. 9, (1995), 859-868.

[5] M. S. Choi, and S. Y. Kim, "Effect of Knitting Condition on the Deformation Behavior of the Weft-Knitted Fabrics", *J. Kor. Soc. Cloth. Ind.* Vol. 1, No. 3, (1999) 280-287.

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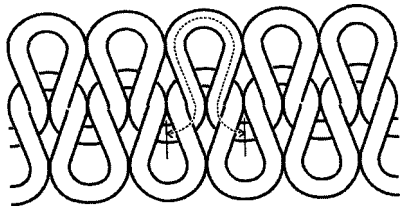
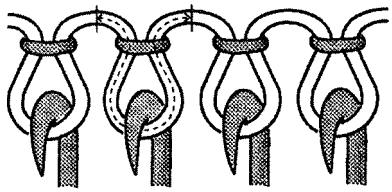


〈Fig. 1〉 Loop length.



〈Fig. 2〉 Single jersey knitting loop length.

time of knitting, the length of a loop was decided and input, and in case of rib fabrics, different from single jersey fabrics, the fabrics only one bed of which is used like plain fabrics, loop length according to setting of excess yarn connected to front and back bed was proposed as showed in 〈Fig. 3〉.

As to loop length, controlled loop length was decided after several times of experimental knitting, and 4×4 rib fabrics loop length, which is the largest value of rib stitches that can be knitted, was based on fixed loop length.

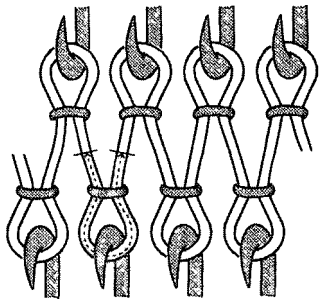
2. Knitting Yarn for Test and Knitting Structure

1) Knitting Yarn

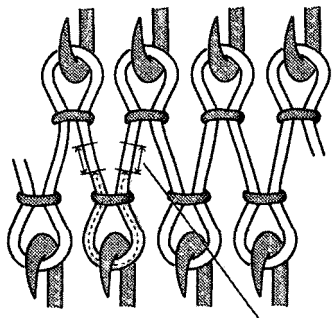
As knitting yarn, wool 100% whose elongation recovery is excellent was used and the knitting yarn of the same wool 100% (2/48's× 2) was used in order to remove possible change in elongation in knit specimens different fiber compositions.

2) Knitting Structure

Knit sample(specimen), on the basis of two basic stitch, that is, plain stitch and rib stitch, was knitted with knitting conditions varied accor-



(Setting including excess yarn)



(Setting not including excess yarn)

〈Fig. 3〉 Rib knitting loop length.

ding to study purpose. Rib stitch was composed of six fabrics of 0×0, 1×1, 2×1, 2×2, 3×3, 4×4 rib, and included a total of 7 stitches as showed in 〈Table 1〉, and respective two sheets of sample in the same 12G was knitted (300 wale × 400 course) by computer flat knitting machine.

Also, two samples were knitted for each stitch using DSCS system, and were labelled as Knit 1-1, 1-2, etc. as showed in 〈Table 1〉. Respective loop length and total quantity of used yarn according to loop length were proposed in 〈Table 2〉.

The size variation of the test fabric, when respective two sheets of sample were knitted (300 wale × 400course) by computer flat knitting machine, is shown in 〈Table 3〉.

3. Measurement Method of Physical Properties

Among 14 knitted samples shown in the 〈Table 1〉, elongation according to size, weight, thickness, density, and strength of 13 knit sample

〈**Table 1**〉 Characteristics of Sample Fabric

Sample	Knit 1-1,2	Knit 2-1,2	Knit 3-1,2	Knit 4-1,2	Knit 5-1,2	Knit 6-1,2	Knit 7-1,2
Fiber Content	Wool 100%	Wool 100%	Wool 100%	Wool 100%	Wool 100%	Wool 100%	Wool 100%
Count (No. of Blended Yarn)	2/48`×2	2/48`×2	2/48`×2	2/48`×2	2/48`×2	2/48`×2	2/48`×2
Structure	plain	0×0 rib	1×1 rib	2×1 rib	2×2 rib	3×3 rib	4×4 rib
Gauge	12G	12G	12G	12G	12G	12G	12G

〈**Table 2**〉 Knitting Structure and Yarn Quantity according to Loop Length

No. of sample	Structure	Loop length (mm)	Total yarn usage(m)	No. of sample	Structure	Loop length (mm)	Total yarn usage(m)
1-1	plain	6.4	772.75 769.00	1-2	plain	6.0	725.24 725.49
2-1	0×0 rib	5.0	1,390.51 1,389.42	2-2	0×0 rib	6.0	1,682.43 1,683.89
3-1	1×1 rib	4.8	666.12 666.07	3-2	1×1 rib	6.0	845.62 845.07
4-1	2×1 rib	5.6	971.73 970.81	4-2	2×1 rib	6.0	1,050.81 1,047.92
5-1	2×2 rib	5.4	704.27 704.77	5-2	2×2 rib	6.0	786.86 785.47
6-1	3×3 rib	5.7	726.13 726.13	6-2	3×3 rib	6.0	764.31 765.98
7-1	4×4 rib	6.0	753.09 754.19	7-2	4×4 rib	6.0	754.49 753.74

〈**Table 3**〉 Change in the Basic Size of Wool Knit Stitch (unit : cm)

No. of sample	Structure	Sample 1		Sample 2		No. of sample	Structure	Sample 1		Sample 2	
		Width	Length	Width	Length			Width	Length	Width	Length
1-1	plain	47.0	48.0	47.0	48.0	1-2	plain	43.8	45.0	43.8	44.8
2-1	0×0 rib	48.5	47.0	48.8	46.9	2-2	0×0 rib	58.2	59.0	58.2	59.0
3-1	1×1 rib	25.0	40.0	24.6	40.5	3-2	1×1 rib	30.1	54.6	30.0	54.3
4-1	2×1 rib	22.7	40.5	22.7	44.3	4-2	2×1 rib	25.5	51.8	25.8	51.5
5-1	2×2 rib	32.2	48.2	32.2	48.0	5-2	2×2 rib	38.4	53.0	34.3	53.5
6-1	3×3 rib	19.6	47.0	19.6	46.5	6-2	3×3 rib	20.4	50.3	20.2	50.4
7-1	4×4 rib	17.4	49.0	17.4	48.9	7-2	4×4 rib	16.8	49.0	16.8	49.0

whose knitting method is different, was measured by Korean Industry Standard(KS) as follows; grasped physical properties; and then indicated properties of rib stitch according to excess yarn from front and back bed.

1) Measurement of Width and Length (KS K 0505, KS K 0507)

After test sample was spread on flat land and removing clumsy tension under normal situation, the total width(cm) and length(cm) were measured at five different places, showing down to one decimal place.

2) Measurement of Weight (KS K 0514)

After leaving sample under normal conditions for at least 24 hours and the sample reaching moisture equilibrium status according to KS K 0901(Fiber test room standard conditions), with the load of 0.01g, weight was calculated in accordance with following formula.

$$\text{Weight per unit area } (g/m^2) = \frac{\text{Weight of test fabric (g)}}{\text{Area of test fabric } (cm^2)} \times 10000$$

3) Measurement of Thickness (KS K 0506)

Thickness was measured by removing a knot or creases on the surface of test piece, cutting test piece in a controlled size for thickness measurement, making the thickness of test piece thin to 0.025mm and by using dead-weight type thickness gauge more than 1/10 away from both sides of the textiles. We measured the thickness with at least more than five samples, averaging and indicating the measured value down to two decimal places.

4) Measurement of Density (KS K 0512)

After putting test fabric on a flat die and removing clumsy creases or tension, we counted the number of wales and courses in 5cm square area. We measured the density of at least five different points, and indicated the unit density of each knitwear down to one decimal place in number of loop per 5cm after averaging the measurement results.

5) Measurement of Strength and Elongation (KS K 0520)

We measured the length of test piece as 10 cm, the width of test piece as 5cm and tensile speed as 300mm/min by using Instron model 3345 made in U.S.A. After collecting respective 3 sheets of test piece in the wales and course direction, we averaged the measurement results and obtained strength and elongation.

Ⅲ. Results and Discussion

1. Structural Properties by Wool Knitting Structure

As to specimen, a total of 7 knitting structure according to knitting methods of two kinds of stitches were knitted in optimized and fixed loop length in accordance with properties of respective stitch. Accordingly, a total of 14 test pieces were knitted.

When fixed loop length was made consistently in the value(6.0mm) of loop length of 4×4 rib stitches, the result of examining the difference of specimen is shown as following 〈Table 4〉, 〈Table 5〉 and 〈Table 6〉.

1) Changes in Size by Stitches & Loop Length

Except plain stitch, when all rib stitches were knitted by fixed loop length in the quantity of used yarn, and in the direction of width and length, the size became large. That's because optimized loop length is shorter than fixed loop length. as fixed loop length was used, loop length became long, and then quantity of used yarn increased.

In the case of rib stitches in which the difference between optimized loop length and fixed loop length is large, size greatly changed, because as fixed loop length in yarn use quantity or size change is used, loop length became long and thus yarn use quantity increased, while in the case of 2×1, 3×3 rib stitches in which the difference between optimized loop length and

fixed loop length is small, the size did not change greatly. Like this, the more the difference between loop length, the more yarn use quantity increased and change in size increased.

In the case of plain stitch, optimized loop length became larger than fixed loop length in the total yarn use quantity or size, which is probably caused by the fact that, differently from rib stitches, the loop length of fixed loop length is shorter than that of optimized loop length.

Especially, to examine the change according to width in rib stitches, it turned out that the width of 0×0 rib stitch was the widest and the width of 3×3, 4×4 rib stitches were the narrowest, which was because in case of 3×3 and 4×4 rib stitch different from other fabrics, the number of the needles in knitted fabrics was decreased. For example, when viewed on the basis of front bed, 300 needles in case of 0×0 rib stitch and 150 needles in case of 1×1 rib stitch participate in knitted structures. Also, between creases, if the distance of front knit after front knit and back knit became longer, respective front and back knits tended to stick to themselves like curling up. This is considered to affect an amount of alteration in size.

The results of size change as showed in 〈Table 4〉 is average value obtained by knitting(300 wale × 400 course) two samples out of 7 stitches in the same 12G which was indicated down two decimal places.

2) Changes in Weight and Thickness by Structure & Loop Length

The change in weight and thickness by stitch is as shown in 〈Table 5〉. In case fixed loop length is used, yarn use quantity and change in size was great, but weight increased more when all rib stitches were knitted in optimized loop length except for plain stitch, which was pro-

〈Table 4〉 Width & Length by Structure & Loop Length

Test piece No.	Appearance evaluation / Structure	Loop length (mm)	Total yarn use quantity (m)	Width (cm)	Length (cm)
1-1	plain	6.4	770.5	47.0	48.0
2-1	0×0 rib	5.0	1,389.9	48.7	46.9
3-1	1×1 rib	4.8	666.1	24.8	40.3
4-1	2×1 rib	5.6	971.2	22.7	42.4
5-1	2×2 rib	5.4	704.5	32.2	48.1
6-1	303 rib	5.7	726.1	19.6	46.8
7-1	4×4 rib	6.0	753.6	17.4	48.9
1-2	plain	6.0	725.8	43.8	44.9
2-2	0×0 rib	6.0	1,683.1	58.2	59.0
3-2	1×1 rib	6.0	845.4	30.1	54.5
4-2	2×1 rib	6.0	1,049.4	25.7	52.7
5-2	2×2 rib	6.0	786.4	34.4	53.3
6-2	3×3 rib	6.0	765.2	20.3	50.4
7-2	4×4 rib	6.0	754.2	16.8	49.0

〈**Table 5**〉 Weight and Thickness by Structure and Loop Length

Test piece No.	Structure (optimized loop length)	Weight (g/m^2)	Thickness (mm)	Test piece No.	Structure (Fixed loop length)	Weight (g/m^2)	Thickness (mm)
1-1	plain	329.0	1.36	1-2	plain	350.0	1.40
1-1	0×0 rib	555.9	2.15	2-2	0×0 rib	453.9	2.33
1-1	1×1 rib	583.6	2.10	3-2	1×1 rib	491.8	2.52
1-1	2×1 rib	583.4	2.55	4-2	2×1 rib	535.6	2.57
1-1	2×2 rib	665.2	2.69	5-2	2×2 rib	558.0	2.67
1-1	3×3 rib	701.3	3.24	6-2	3×3 rib	653.4	3.28
1-1	4×4 rib	794.4	3.73	7-2	4×4 rib	794.4	3.73

bably because optimized loop length is shorter in loop length than fixed loop length so wale and course become larger. However, in case of thickness, it turned out to be thicker when rib stitch were knitted in fixed loop length, and in case of 1×1 rib, it showed the largest difference.

In case of plain stitch, the length of fixed loop length became shorter than that of controlled loop length, so both weight and thickness increased, which seems to be properties according to single stitch, different from rib stitch.

In case of structural weight and thickness, 4×4 rib stitch recorded the most value. As shown change in size according to loop length, front knit and back knit, respectively, stuck to themselves by continuity of front and back knit. As a result, the elongation became the largest and thus the weight or thickness per unit area became the largest as well.

2. Changes in Density by Structure & Loop Length

The respective density in the course and wale direction is shown in 〈Table 6〉. As showed in size change, it is considered that in case knit stitch was knitted in fixed loop length, the length of controlled loop length and fixed loop length became longer and thus wale and course within 5cm became shorter, so density also became small.

〈**Table 6**〉 Change in Density per Stitch of Wool Knitting Structure (unit : wale and course/5cm)

Test fabric No.	Fabric (Optimized loop length)	Density		Test fabric No.	Fabric (Fixed loop length)	Density	
		Course	Wale			Course	Wale
1-1	plain	42.2	32.4	1-2	plain	44.6	35.6
2-1	0×0 rib	43.2	30.8	2-2	0×0 rib	34.2	25.4
3-1	1×1 rib	50.2	31.2	3-2	1×1 rib	36.8	24.6
4-1	2×1 rib	42.2	31.2	4-2	2×1 rib	38.2	28.6
5-1	2×2 rib	45.2	33.2	5-2	2×2 rib	38.6	30.2
6-1	3×3 rib	44.2	38.2	6-2	3×3 rib	40.2	38.2
7-1	4×4 rib	42.2	43.6	7-2	4×4 rib	42.2	43.6

3. Changes in Tenacity and Elongation by Structure & Loop Length

Changes in tenacity and elongation according to difference in respect to loop lengths in course and wale direction are indicated in 〈Table 7〉.

It was generally revealed that tenacity was 4~5 times larger in wale direction than in course direction, and elongation was 4~5 times larger in course direction than in wale direction. Change according to loop length was almost same in both controlled loop length and fixed loop length, and both tenacity and elongation were larger in rib stitch than in plain stitch.

To examine change per rib stitch, in case of 1×1, 2×2, 3×3, 4×4 rib, both tenacity and elongation of controlled loop length and fixed loop length increased in wale and course direction, which seems to be caused by the fact that as the number of ribs increase under the condition of 1/2 pitch in which front and back beds face each other, tenacity and elongation increase, that is, as showed in size change according to loop length, because front knits and back knits stick to themselves by continuity of front knits and back knits, elongation becomes the largest and thus the percentage to increased length also increased. Also, in case of 0×0, 2×1 rib, both tenacity and elongation were low, but the difference in case of elongation in the course direction was high, which seems to be caused by the fact that in case of 0×0 rib stitch, excess yarn is stretched from both sides, so the force is balanced, while in case of 2×1, one side is all needle knitting and the other is separate in front stitch and back stitch, so the force is unbalanced and thus tenacity appeared differently.

〈Table 7〉 Tenacity and Elongation by Structure & Loop Length

Division	Direction		Course		Wale	
	Test fabric No.	Tensile properties / Fabric	Tenacity (gf)	Elongation (%)	Tenacity (gf)	Elongation (%)
Optimized loop length	1-1	plain	24.32	234.50	34.38	96.75
	2-1	0×0 rib	23.54	415.25	76.18	109.00
	3-1	1×1 rib	29.15	411.75	66.47	131.00
	4-1	2×1 rib	21.37	458.50	74.21	110.25
	5-1	2×2 rib	22.58	467.00	76.05	124.75
	6-1	3×3 rib	22.62	570.25	88.12	129.25
	7-1	4×4 rib	20.62	621.00	93.98	131.75
Fixed loop length	1-2	plain	24.86	221.00	29.18	83.00
	2-2	0×0 rib	16.93	442.75	61.60	116.75
	3-2	1×1 rib	20.27	463.01	53.33	107.50
	4-2	2×1 rib	17.91	411.50	64.46	102.00
	5-2	2×2 rib	19.40	473.75	69.52	121.25
	6-2	3×3 rib	19.73	556.00	91.00	134.50
	7-2	4×4 rib	20.62	621.00	93.97	131.75

Ⅳ. Summary and Conclusion

As a result of this study, we came to the following conclusion.

1. The value of yarn use quantity, width and lengthwise size were high when knit stitch were knitted in fixed loop length, which seems to be caused by that loop length became large when knit stitch were knitted in fixed loop length because the length of controlled loop length is shorter than that of fixed one, so the difference appeared in change in yarn use quantity or size. In case of 3×3 and 4×4 rib stitch, different from other fabrics, change in size was large, which seems to be caused by the fact that such change is proportional to the number the needles of front and back beds that participate in knitted fabrics.
2. Weight and thickness increased more when knit stitch was knitted in controlled loop length, which seems to be caused by the fact that controlled loop length is smaller than fixed loop length. But it was revealed that the thickness was usually larger when knit stitch was knitted in fixed loop length.

In case of plain stitch, weight or thickness increased because the length of fixed loop length was shorter than that of controlled loop length. This seemed to be caused by properties according to same density as rib stitch.

3. When knitted in fixed loop length, density appeared small in change per rib stitch. As knitted in fixed loop length, being different from the event knit stitch, the length of loop length become long, and so density was small. Accordingly, the properties of rib stitch seems to emerge well as knitted in controlled loop length in comparison with the case when knitted in fixed loop length.
4. It was usually revealed that strength was 4~5 times larger in wale direction than in course direction and elongation was 4~5 times larger in course direction than in wale direction. As to change per stitch, rib stitch was larger both in strength and elongation than plan stitch.

To examine change of rib stitch, as the number of rib increased, both the tenacity and elongation increased in controlled loop length and fixed loop length in both of the wale and course direction. If loop length became small according to division of loop length, the stitch became small and the yarn was likely to be cut.

That was because extra amount of yarn in front of and back beds was constant and thus the stitch become small.

This phenomenon appeared differently according to difference of length. 0×0 rib stitches balanced the force between front and back stitches whereas in case of 2×1, one side was all needle knitting and the other was divided into front stitch and back stitch, respectively. Due to that, by imbalance of the force, strength appeared to be differently.

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