

Blending Effect on the Mechanical and Hand Properties of Wool/Acrylic Blend Knits

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Abstract

Mechanical properties and hand evaluation of wool/acrylic(W/A) blend knits were conducted before and after repeated washing to get the optimum W/A blending ratio, which could help achieve the optimum mechanical and hand properties of the knits. The five test fabrics using the yarns with different W/A blending ratios(%), 100/0, 70/30, 50/50, 30/70, 0/100, were knitted. The fabrics were washed by a rotating drum type washing machine. Then, objective mechanical and hand properties were evaluated by KES-FB, Kawabata evaluation system for fabric. The results are as follows: there was no change in the hand value of the knitted fabric with the W/A-blended yarn caused by the change in the blending ratio before washing. After washing, however, the increase of acrylic's blending rate caused the bending property to decrease proportionally, while the friction coefficient of the surface property increased. Furthermore, the study showed that W/A 50/50 possesses the most superior tensile property and shearing property, which could attain the optimum blending ratio. Similar results in hand value were derived in all the samples. After washing, however, the increase in acrylic's blending rate caused a proportional decrease in KOSHI and an increase in FUKURAMI. In addition, W/A 50/50 gained the biggest NUMERI value, again corresponding to the optimum blending ratio. Similar results in total hand value were derived in all the samples before washing. After washing, though, all the total hand values decreased, and, as the wool fabric's blending rate increased, the total hand values proportionally decreased further.

Key words : hand value, total hand value, blend, KOSHI, FUKURAMI, NUMERI.

1. Introduction

Wool is an ideal apparel material widely used for high-quality wear. However, washing under agitation, friction and pressure in the presence of heat and moisture, felt shrinkage makes the

care of wool products more difficult.¹⁾ Many researches have been conducted to address shrinkage due to scales on wool fiber. Such researches can be categorized into two main approaches: non-shrink treatment with woolen fiber²⁻⁶⁾ and blending with other fibers.⁷⁾ Though fiber is used in knitted fabric, wool cannot be easily

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¹ Norman Hollen, Jane Saddler, Anna L. Lanford, and Sara J. Kadolph, *Textiles*, 6th ed. (NY: Macmillan Publishing Co., 1988), 44-56.

² Myung-Ja Park, and Soo-Kyoung Kwak, "Shrinkproof Effect and Property of Shrinkproof-Finished Wool Knit," *The International Journal of Costume Culture* 7, no. 2 (2004): 103-111.

used in low priced products due to its cost and difficulty in management. Thus, generally, the acrylic staple fiber, which has a similar appearance and has the characteristics of wool, is mixed in various degrees with wool.

The acrylic staple fiber, used for mixed spinning with wool, is smooth, warm, lighter than wool, washable and possesses good characteristics after wash and wear unlike wool. Frequent physical friction, however, can cause pills, and when the weather is dry, it is also likely to create static electricity. Once wool is mixed with acrylic, the advantage and the disadvantage of using both fibers are neutralized. Compared to 100% wool, this type of mixed fiber is frequently used in knitted fabric for sweaters or underwear in the winter season, in various price ranges and performances for manufacturers and consumers.⁸⁾

Studies regarding wool-blending show that the focus has been mainly on wool, wool/PET mixed fabrics, or knitted fabrics. Studies on wool/acrylics(W/A) mixed yarn have been done by several researchers: Inok Park (1999) showed that when the fabric was repeatedly washed, durable press property, thickness, volume, and flexibility,

among other mechanical properties, showed little change until the fifth washing. After repeated washing, the fabric's mechanical properties drastically changed.⁹⁾ Also she compared the changes in form during the wet and dry cleaning of W/A 15/85 and W/A 53/47 knitted fabrics. She presented that as the frequency of the washing increased, the rate of shrinkage also gradually increased. Her study also showed that the higher the blending rate of wool, the higher the rate of shrinkage.

Although there have been various types of researches on W/A blending, which is widely used as an alternative to wool for knitted fabric, comprehensive studies on the various mechanical properties of knit fabrics due to the blending ratio of the W/A mixed yarn currently sold, and hand evaluations after washing, are still lacking. Some researches have been made on the hand evaluation of knitted fabrics. Inok Park¹⁰⁾ observed, after the wet and dry cleaning of W/A 15/85 and W/A 53/47 knitted fabrics, that the Total Hand Evaluation (T.H.V.) of the W/A 53/47 knitted fabric decreased slightly after wet cleaning. Jeongah Ju and Hyoseon Ryu(2004)¹¹⁾, Hye-Jin Cho *et al.*(2004)¹²⁾ studied subjective and

³ H. Ito, and Y. Muraoka, "Shrink-Resistant Properties and Surface Characteristics of Wool Fibers Treated with Multifunctional Epoxides," *Text. Res. J.* 68, no. 4 (1994): 440-444.

⁴ K. J. Dodd, C. M. Carr, and K. Byrne, "An Investigation into the Application of a UV-Curable Silicone for the Shrinkproofing of Wool Fabric," *J. Text. Inst.* 84, no. 4 (1993): 619-630.

⁵ K. J. Dodd, C. M. Carr, and K. Byrne, "Ultraviolet Radiation Curing Treatments for Shrink-Resistant Wool Fabric," *Text. Res. J.* 68 (1999): 10-16.

⁶ K. R. F. Cockett, and D. M. Lewis, "Shrink Resist Finishing of Wool Knits," *Textile Chemist and Colorist* 10, no. 11 (1978): 33-35.

⁷ Myung-Ja Park, Youn-Hee Lee, and Soo Kyoung Kwak, "Shrink-Resist Effects and Properties of the Knitted Fabrics from Wool/Acrylic Fiber Blends," *The Research Journal of the Costume Culture* 12, no. 6, (2004): 945-952.

⁸ Norman Hollen, Jane Saddler, Anna L. Lanford, and Sara J. Kadolph, *Op. cit.*

⁹ Inok Park, "Stability Changes of Wool/Acrylic Weft Knits by Laundering," (MS Thesis, Sook Myung University, 1999).

¹⁰ Inok Park, *Op. cit.*

¹¹ Jeongah Ju, and Hyoseon Ryu, "Effect of Weft Knit Structural Characteristics on the Subjective Texture and Sensibility," *Journal of the Korean Society of Clothing and Textiles* 28, no. 11 (2004): 1516-1523.

¹² Hye-Jin Cho, Won-Ja Lee, Young-Ju Kim, and Jung-Kwon Suh, "Effect of Knit Structure on the Hand Properties of Weft Knitted Fabrics-Focusing on Objective Hand Evaluation-," *Journal of the Korean Society of Clothing and Textiles* 28, no. 8 (2004): 1153-1164.

objective texture and sensibility of weft knits depending on knit structural characteristics, which showed that hand evaluation is also greatly affected by the structure of the knitted fabric and the knitting conditions. As such, researches on the mechanical properties of wool-processed fabric, fabric mixed with wool and other fibers, and wool knitted fabric, and subjective or objective hand evaluations, have been actively conducted. Until now, however, few studies have been done on hand evaluations before and after washing knitted fabrics according to the blending ratio of the W/A blended yarn. Therefore, this study attempted to show the effect of W/A blending on mechanical and hand properties before and after washing, and to obtain the optimum blending ratio of W/A-blended yarn, which has superior mechanical and textural properties, while retaining the advantageous qualities of wool. It is believed that the results of this study will be a big help to customers who wish to protect their wool knitted clothing, and will offer manufacturers of wool knitted fabrics the optimum production conditions that can help them come up with the best mechanical and textural properties for their products. The results of the study are also expected to pave the way for many more knitted products through the blending of raw materials.

II. Experimental

1. Materials

1) Yarns

White and scoured wool 100%(2/48's), acrylic 100%(2/50's), wool/acrylic-blended, W/A 70/30, 50/50, 30/70 (2/50's), yarns were used for the manufacturing of test knitted fabrics. The characteristics of the five species of yarns are summarized in <Table 1>.

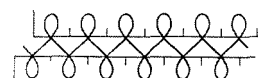
2) Preparation of the Test Fabrics

The test fabrics were knitted by a weft knitting machine (SHIMASEIKI SES124 S) with 48 inch width, 12 gages, and all needle knitting structure (0×0 rib stitch), presented in <Fig. 1>, under the same knitting conditions with loop 5.4 mm long and degree of knit density.

2. Treatment and Evaluation Methods

1) Washing Method

The specimens were prepared in size of 50×50cm and the evaluation was performed by the washing method (KS C 9608). The washer, which is the rotating drum-type washing machine (TROM WD-R100C, LG Electronics) was under the same washing conditions of general cloths. The washing was carried out for 40 minutes at 30℃ temperature with commercial all-purpose detergent with a regular washing course. The time spent for washing, rinse, and spin-drying was an hour and 20 minutes. Five times of washing cycles were carried out.



<Fig. 1> Structure of All Needle Knitting.

<Table 1> Characteristics of the Wool/Acrylic Blend Yarns

No.	Sample Code	Blending Ratio		Thickness of Yarn	Characteristics
		Wool(%)	Acrylic(%)		
1	W100	100	0	2/48's	22μ Wool Top
2	70/30	70	30	2/50's	3 ^D Regular Antipilling 22μ Wool Top
3	50/50	50	50	2/50's	3 ^D Regular Antipilling 22μ Wool Top
4	30/70	30	70	2/50's	3 ^D Regular Antipilling 22μ Wool Top
5	A100	0	100	2/50's	3 ^D Regular Antipilling

2) Hand Properties

Samples were prepared into 20×20cm. Objective hand properties were determined through KES-FB(Kawabata Evaluation System for Fabric, Kato Tech. Co. Ltd) based on the methods proposed by Hand Evaluation and Standardization Committee(HESC) in Japan. Mechanical properties of 6 characteristics(tensile, bending, shearing, compression, surface, and thickness & weight) and 16 items were measured at 65% RH and 20℃ in the controlled room. The primary hand values were calculated from the equation of KN-402-KT to obtain KOSHI(stiffness), NUMERI(smoothness), FUKURAMI(fullness and softness). Total hand values were calculated from the equation of KN-301-WINTER.

III. Results and Discussion

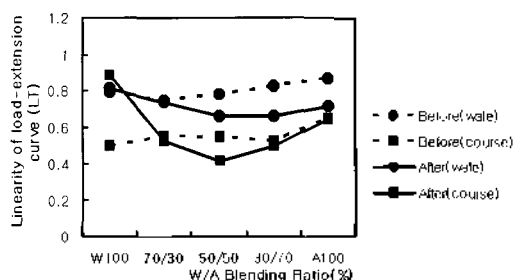
1. Mechanical Properties of W/A Knits

1) Tensile Properties

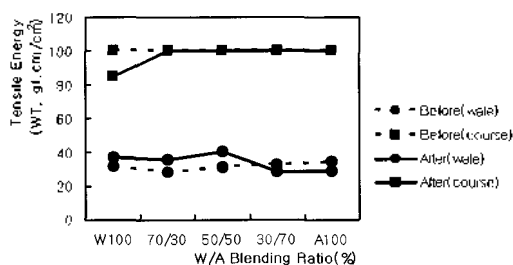
Before washing, the tensile property did not show any difference in the linearity of load extension (LT) and tensile energy (WT) as the blending rate of wool decreased, presented in <Fig. 2>(a),(b). Tensile resilience, however, decreased proportionally, proving that the wool fiber greatly affected resilience, shown in <Fig. 2>(c). After washing, though, the tensile property of all blended yarns and the A100 before washing was either retained or decreased slightly, except for the W100 knitted fabric, whose tensile property drastically increased due to pilling and shrinkage; its tensile property increased, and its drape property and sense of wear improved.

2) Bending Properties

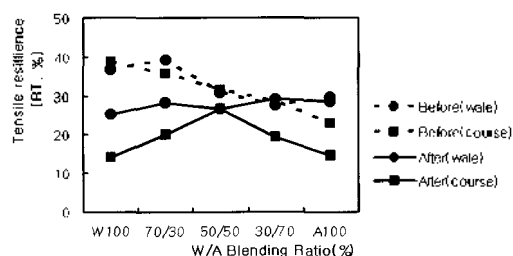
As the bending property decreased, the ability to form curves improved, presented in <Fig. 3>(a). In the case of the course direction before washing, the wool fabric with a 70% bending ratio, or higher, showed high bending rigidity (B), while the wool fabric with a 50%-or-below bending rate decreased in bending rigidity, or



(a) Linearity of Load-Extension Curve(LT)



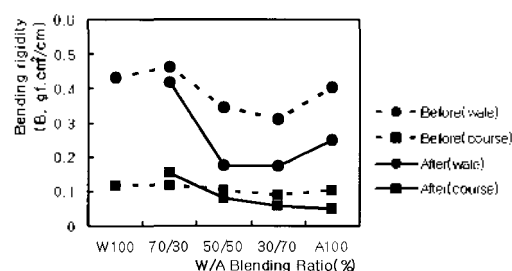
(b) Tensile Energy(WT)



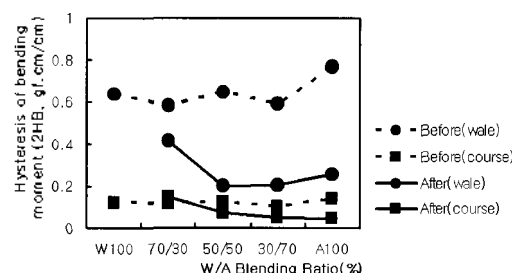
(c) Tensile Resilience(RT)

<Fig. 2> Tensile Property of the W/A Blend Knits.

became more flexible. After washing, the bending rigidity of the blended yarns and the A100 knitted fabric decreased, while that of the W100 increased, although it was impossible to determine its exact measurement because its thickness surpassed the measurement limit. A hysteresis of the bending moment (2HB) due to the blending rate of the wool fabric showed similar results. After washing, however, shown in <Fig. 3>(b), the result was similar to that of the bending rigidity above, and the wool fabric with a 50%-or-below bending rate showed a considerable decrease in the hysteresis of the bending moment, resulting in an increase in flexibility.



(a) Bending Rigidity(B)

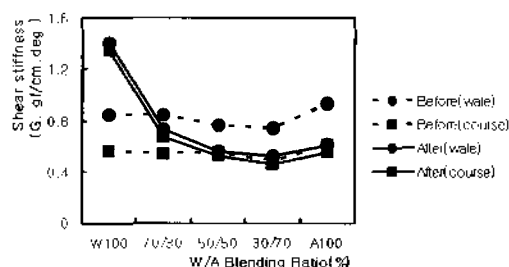


(b) Hysteresis of Bending Moment(2HB)

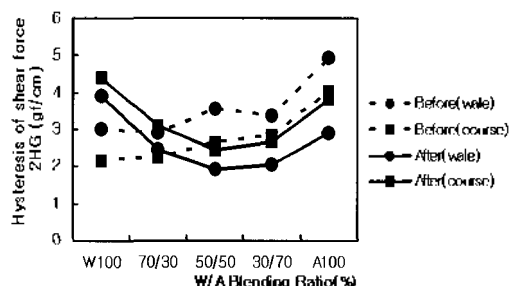
〈Fig. 3〉 Bending Property of the W/A Blend Knits.

3) Shearing Properties

Shearing property, presented in 〈Fig. 4〉, together with bending property, affects drape property, which makes the fabric fit well into the human body, and allows easy movement. It is one of the most important elements that can dictate outer appearance, form, and wear. As the number of shearing stiffness (G) decreases, it becomes easier for the fiber to be deformed. Both directions of the fabric showed a fixed value, regardless of the type and blending ratio of yarns. The yarn's blending ratio did not affect the fabric's shearing property. After washing, however, the fabric was considerably affected by the type and blending ratio of the yarns. The W100 knitted fabric showed the most drastic change. As the blending rate of the wool decreased, the shearing property also gradually decreased. Compared to that of W100, the shearing property of A100 was very small. The value of the hysteresis of the shear force (2HG) was the least in W100, and the largest in A100, before washing. After washing, however, based



(a) Shear Stiffness(G)



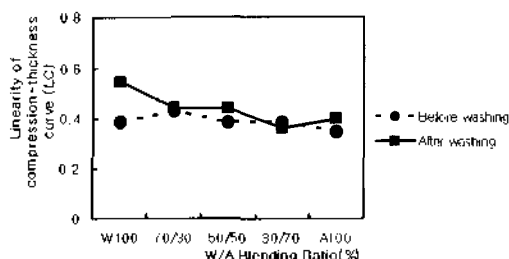
(b) Hysteresis of Shear Force(2HG)

〈Fig. 4〉 Shear Property of the W/A Blend Knits.

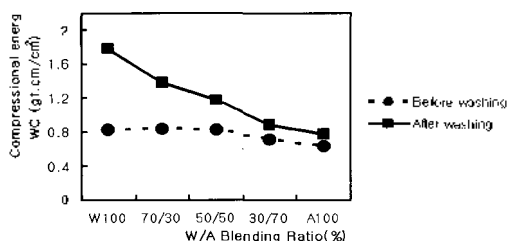
on the value of W/A 50/50, which was the least, the hysteresis of the blending yarns' shear force increased as the acrylic and wool blending ratios increased. As a result, the curve of the graph showed a mirror image of the left and right parts of the graph. Therefore, the result showed that modification of form was easiest when the blending ratio was W/A 50/50.

4) Compressional Property

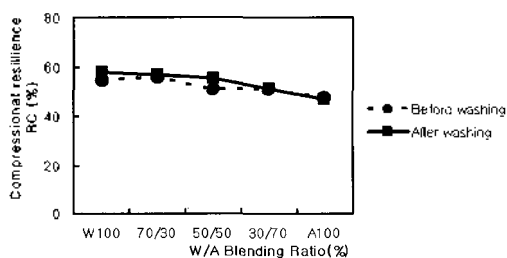
Compressional property is a property related to volume, fineness, opulence, and thickness of fabrics. Shown in 〈Fig. 5〉(a),(b),(c), before washing, an increase in acrylic's blending rate appeared to force the compressional property to somewhat decrease. After washing, however, as the wool's blending rate increased, the linearity of the compression thickness (LC) and the compressed energy (WC) both increased, which meant that the wool was hard to compress because of the high resistance to the initial compression. In particular, the compressional property seemed to be linearly proportional to the blending rate, revealing that the content of the



(a) Linearity of Compression-thickness Curve(LC)



(b) Compressional Energy(WC)



(c) Compressional Resilience(RC)

〈Fig. 5〉 Compression Property of the W/A Blend Knits.

wool had a dominant effect on the compressed property.

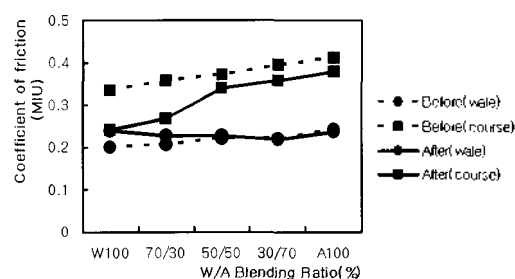
5) Surface Properties

Related to smoothness of fabrics, together with the basic mechanical characteristics of fabrics, surface property is a characteristic that greatly influences the value of the hand. In general, a decrease in the characteristic values of the surface means an increase in surface property, as surface property causes the sliding of the surface. Shown in 〈Fig. 6〉(a),(b),(c), after washing, nevertheless, an increase in wool's blending rate made the surface smoother, resulting in a decrease

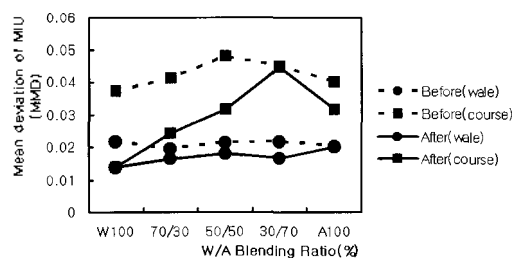
in the average friction coefficient, the average deviation of the friction coefficient, and the value of the surface roughness. It is believed that this is because the bends of the surface of knitted fabrics are hidden, and the knitting structure becomes obscure due to the pilling of wool. A100, which does not pill, showed no differences after washing, and the surface property was almost the same before and after washing.

6) Thickness and Weight

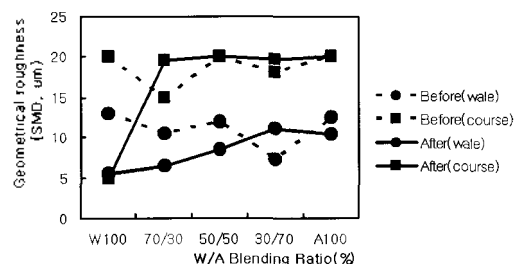
A change in thickness and weight appeared to show similar results before and after washing.



(a) Coefficient of Friction(MIU)



(b) Mean Deviation of MIU(MMD)



(c) Geometrical Roughness(SMD)

〈Fig. 6〉 Surface Property of the W/A Blend Knits.

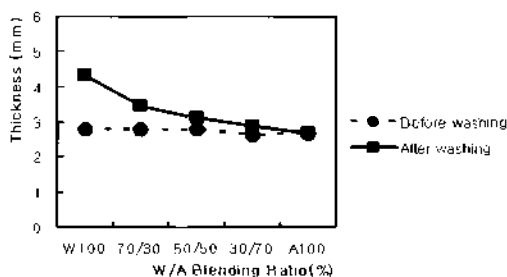
Presented in <Fig. 7>(a),(b), before washing, the thickness and weight showed almost similar values, regardless of the type of fiber or the blending rate. After washing, an increase in wool's blending rate caused the fabric to become thicker and heavier. This seems to be attributable to pilling, due to scaling activities caused by the pilling of wool after washing.

2. Hand Evaluation of W/A Knits

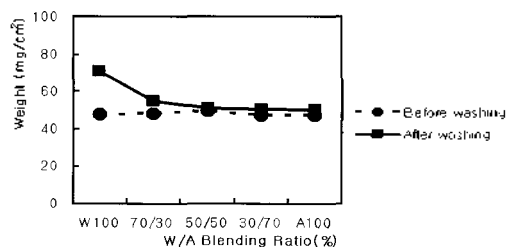
1) Hand Value

Presented in <Fig. 8>(a), KOSHI(stiffness) had low values, between 2~4 in all samples, showing general flexibility. This is believed to be due to the flexible characteristics of knitted fabrics. The wool fabric's blending rate increased after washing, and the value of KOSHI proportionally increased, but only slightly. This may be because the pilling of wool increases the value of KOSHI.

Presented in <Fig. 8>(b), the value of NUMERI(smoothness) before washing was 3~5 in all samples, relatively higher than that of KOSHI, and the values seemed to increase. W/A 50/50

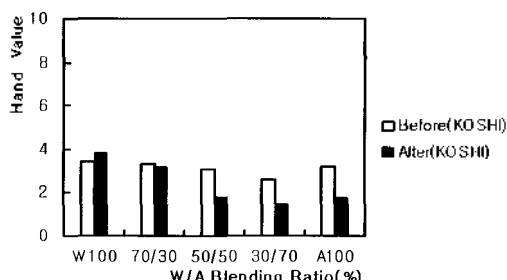


(a) Thickness(T)

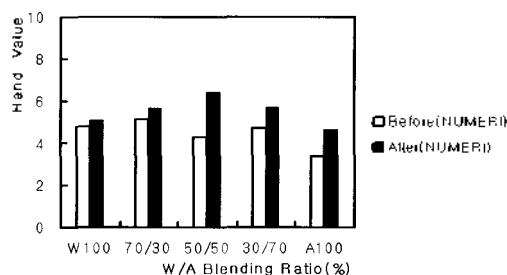


(b) Weight(W)

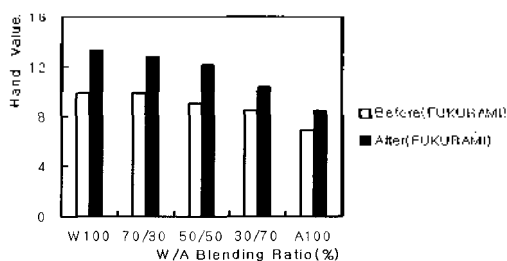
<Fig. 7> Thickness & Weight of the W/A Blend Knits.



(a) KOSHI(stiffness)



(b) NUMERI(smoothness)

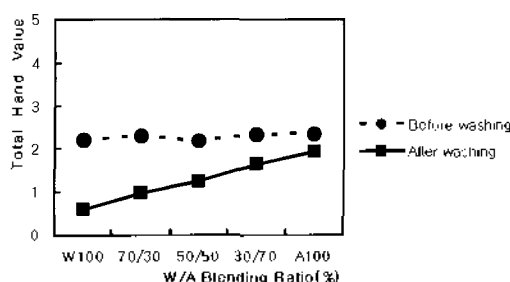


(c) FUKURAMI(fullness and softness)

<Fig. 8> Hand Value of the W/A Blend Knits.

showed the largest value, confirming that it was the smoothest and softest, and that it had the most flexible blending ratio, among various types of blended yarns.

Presented in <Fig. 8>(c), the value of FUKURAMI(fullness and softness) is about 10 in scope, which is the largest value in terms of hand evaluation. As wool's blending rate decreased, the value of FUKURAMI seemed to decrease as well, resulting in a gradual decrease in volume. This shows that FUKURAMI possessed similar tendencies in terms of changes in compressed property, thickness, and weight, proving that it would be affected by these properties.



〈Fig. 9〉 Total Hand Value of the W/A Blend Knits.

Evaluation: 0(very poor) - 5(excellent).

2) Total Hand Value

Total hand value shows a comprehensive result of all the dynamic characteristics and the hand value. Shown in 〈Fig. 9〉, it is within 1~5 grades. It is understood that the bigger the total hand value, the better the hand value will be. All five knitted fabrics resulted in the value of about 2 or so, showing that there is no relation between the total hand value and the types and blending ratio of fibers. After washing, however, all the values decreased. As the value of the wool fabric's blending rate decreased, the value seemed to increase consistently. Therefore, it is understood that knitted fabrics that have higher blending rates have poorer total hand values after washing.

IV. Conclusion

After producing knitted fabric samples using W/A-blended yarns, mechanical properties and hand evaluation were conducted before and after repeated washing to get the optimum W/A blending ratio, which could help achieve the optimum mechanical and hand properties of the knits. The results of the experiment and analysis are as follows: There was no change in the hand value of the knitted fabric with the W/A-blended yarn caused by the change in the blending ratio before washing. After washing, however, the increase of acrylic's blending rate caused the bending property to decrease proportionally, while the friction coefficient of the

surface property increased. Furthermore, the study showed that W/A 50/50 possesses the most superior tensile property and shearing property, which could attain the optimum blending ratio. Similar results in hand value were derived in all the samples. After washing, however, the increase in acrylic's blending rate caused a proportional decrease in KOSHI and an increase in FUKURAMI. In addition, W/A 50/50 gained the biggest NUMERI value, again corresponding to the optimum blending ratio. Similar results in total hand value were derived in all the samples before washing. After washing, though, all the total hand values decreased, and, as the wool fabric's blending rate increased, the total hand values proportionally decreased further.

References

- Cho, H., W. Lee, Y. Kim, and J. Suh. 2004. "Effect of Knit Structure on the Hand Properties of Weft Knitted Fabrics -Focusing on Objective Hand Evaluation-." *Journal of the Korean Society of Clothing and Textiles* 28.
- Cockett, K. R. F., and D. M. Lewis. 1978. "Shrink Resist Finishing of Wool Knits." *Textile Chemist and Colorist* 10.
- Dodd, K. J., C. M. Carr, and K. Byrne. 1993. "An Investigation into the Application of a UV-Curable Silicone for the Shrinkproofing of Wool Fabric." *J. Text. Inst.* 84.
- Dodd, K. J., C. M. Carr, and K. Byrne. 1999. "Ultraviolet Radiation Curing Treatments for Shrink-Resistant Wool Fabric." *Textile Research Journal* 68.
- Hollen, N., J. Saddler, A. L. Lanford, and S. J. Kadoh. 1988. *Textiles*, 6th ed., New York: Macmillan Publishing Co.
- Ito, H., and Y. Muraoka. 1994. "Shrink-Resistant Properties and Surface Characteristics of Wool Fibers Treated with Multifunctional Epoxides." *Textile Research J.* 68.
- Ju, J., and H. S. Ryu. 2004. "Effect of Weft Knit Structural Characteristics on the Subjective Texture and Sensibility." *Journal of the Korean Society of Clothing and Textiles* 28.

- Park, M.-J., and S.-K. Kwak. 2004. "Shrinkproof Effect and Property of Shrinkproof-Finished Wool Knit." *The International Journal of Costume Culture* 7.
- Park, M.-J., Y. H. Lee, and S.-K. Kwak. 2004. "Shrink-Resist Effects and Properties of the Knitted Fabrics from Wool/Acrylic Fiber Blends." *The Research Journal of the Costume Culture* 12.
- Park, I. 1999. "Stability Changes of Wool/Acrylic Weft Knits by Laundering." Master's Thesis, Sook Myung University.