# The Effect of Salt-Shrinkage on the Silk Union Fabrics by Continuous Treatment System

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## ABSTRACT

The continuous treatment system of salt-shrinkage and their use to improve stretch and crease resistance by silk union fabrics. Calciumnitrate (specific gravity 1.43) were produced on silk union fabrics. The fabric stretch to the ASTM D3107-07(2008) test over five repetitions was determined. When applied to silk/cotton and silk/wool union fabrics by a continuous treatment procedure, in the presence of sodium nitrate, all of these fabrics gave excellent stretch and crease resistance properties, although the times required varied. The continuous treatment procedure required to achieve stretch and crease resistance, about 3 to 5 minute**s.**

**Keywords**: Silk, Salt Shrinkage, $Ca(NO_3)_2$, Union Cloth, Crease-resistance, Stretch

## INTRODUCTION

The silk products, fashion is excellent basically, when it is a chemical process for functionalizing shape stability, such as chemical fiber, various difficult to impart a different functionality from the prior art, silk it is necessary to minimize the characteristics of the compromise.

The fiber exhibits not only excellent affinity for dyes, but also the sense of vitality which is not readily felt in other fibers since it belongs to the animal fibers. Silk fiber, however, has demerits as follows: low dimensional stability, to damages by acid and alkali, yellow discoloration due to ultraviolet rays, and discolorations due to salts including perspiration have been presented.

Novel finishing methods have been developed continuously in order to create the high sensibility out of silk fibers. Salt shrinkage finishing has a long history of utilizing the property of contraction caused by inorganic salts. Most of the accompanying changes by the shrinkage finishing procedures are the increase of shrinkage rate, the decrease of tenacity and Young's modulus, the increase of elongation, and the increase of resilience of elasticity (Lee et. al., 1997).

The method for dimensional stability of silk products, salt-shrinkage process, and the like, these processes are, for using inorganic salts of excessive : Material of the processors used, temperature difference of processing in-flight up



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and down due to the high percentage, inorganic salts, which are absorbed in the fiber because there are many, the difficulty of maintaining the concentration, short processing time, etc. The product was released risk of damage of the fibers than by such as high, there was little (Lee et. al., 1998).

As a solution to these problems, continuous and how to process material of the material in strong inorganic salt is required. The material of the processing machine can be made to order if there is a variety of materials, even the solution in a number of ways, the other conditions will be maintained to the form stability of the silk products but it vary according to the degree of shrinkage it is necessary to work looking for conditions. In this study, investigated the effect on the stretch effect, dimensional stability, and wrinkle resistance by salt-shrinkage process in order to improve the easy care of the union of silk, and of a continuous process for mass production was considering the application little (Choi et al., 2009).

# EXPERIMENTALS

## Specimens and chemicals

### Fabric Specimens

Use jacquard and dobby, by using silk warp, using silk, cotton, wool, nylon and the weft were woven as described in Table 1. The specimens for the salt shrinkage finishing were cut to the size of 36x44in.

### Reagents

Calcium Nitrate ($Ca(NO_3)_2 \cdot 4H_2O$) was used for the salt shrinkage finishing. The reagent was dissolved in the deionized water to reach the specific gravity of 1.35, 1.38, 1.41, 1.43 and 1.45. The test used SP-20 (Hea-sung chemical, Korea) as a dispersing agent for the removal of unreacted inorganic salt.

Table 1 Characteristics of the fabrics specimen

| Sample No. | Fabric weave | Fabric composition | density (Ends/in) | weight(g) |
|---|---|---|---|---|
| DS-1 | plain | silk 100% | 132×120 | 55 |
| DS-2 | plain | silk 100% | 132×120 | 55 |
| DS-3 | 1/4twill | warp : silk 100%<br>weft : silk 30%<br>wool 70% | 264×130 | 200 |
| DS-4 | plain | warp : silk 100%<br>weft : silk 20%<br>wool 80% | 132×76 | 80 |
| DS-5 | satin | warp : silk 100%<br>weft : silk 26%<br>wool 74% | 264×105 | 280 |
| DS-6 | satin | warp : silk 100%<br>weft : silk 60%<br>cotton :40% | 264×100 | 123 |
| DS-7 | plain | silk 100% | 264×100 | 110 |
| DS-8 | 1/4twill | warp : silk 100%<br>weft : silk 40%<br>rayon 60% | 132×120 | 177 |
| DS-9 | satin | warp : silk 100%<br>weft : silk 60%<br>cotton 40% | 264×120 | 140 |
| DS-10 | 2/2plain | warp : silk 100%<br>weft : silk 35%<br>cotton 65% | 264×120 | 130 |

## Experimental methods

**Effect of specific gravity change on the salt shrinkage**
In the case of 1.35 ~ 1.45 of $Ca(NO_3)_2$ in specific gravity, fabric specimens were treated for 3min, while maintaining treatment temperature of 80℃. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

**Effect of temperature change on the salt shrinkage**
The effect of temperature on the salt shrinkage was investigated using a $Ca(NO_3)_2$ solution in 1.43 specific gravity with temperature 70, 75, 80, 85 and 90℃. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

**Effect of time change on the salt shrinkage**
The effect of time on the salt shrinkage was investigated using a $Ca(NO_3)_2$ solution in 1.43 specific gravity with time 1, 2, 3, 4 and 5min, while maintaining treatment temperature of 80℃. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

**Pilot test**
The field test was proceeded time change on the salt-shrinkage was the optimum condition for the laboratory based on the fabric is woven. Pilot test conditions were tested 1, 3, 5 min each specific gravity 1.43, at 80 ± 2 ℃ temperature. After removal of inorganic salts unreacted with a dispersing agent, and washed with water. After the treatment, specimens were dried under room temperature.

## Measurement and Analysis

**Stretch effects**
Stretch effects of the fabric specimens was tested by the method of D3107-07 (2008) ASTM.

Fabric Stretch 10s after Tension, % = $100 \times (A\text{-}O_1)/O_1$
※$O_1$ : original gage length
A : read the fabric stretch

**Measurement of shrinkage by washing**
Shrinkage by washing of the fabric specimens was tested by the method KS K ISO 7771

Shrinkage ratio, % = $(L_0 - L)/L_0 \times 100$
$L_0$ : original fabric length
L : After treatment fabric length

**Measurement of washing fastness**
A washing fastness was tested by the method KS K ISO 105-c1.

**Measurement of crease recovery**
A crease recovery was tested by the method KS K 0550.

# RESULT AND CONSIDERATION

## Effects of salt-shrinkage of silk fabric

**Effect of specific gravity change on the salt shrinkage**
Figure 1 show the results of the treatment under the condition maintaining 3 minutes and temperature of 80℃. As shown in Figure 1, the silk fabric was shrunk with specific gravity. The reaction hardly occurred at a specific gravity 1.41 or more began to increase with specific gravity. It is found that the effect of salt shrinkage is extremely sensitive to the specific gravity. Treatment of specific gravity in 1.45 reduced the original down to almost half the

size.Shrinkage of about 10% is generated lengthwise. In terms of fabric's convention, area reduction down to half the size after finishing is a very high shrinkage rate. It seems to be an highly excessive treatment condition.When we reviewed the 1.43 treatment results, the shrinkage ratio are not so high as we had expected. From this fact, it seems that the shrinkage is almost completed between the specific gravity in 1.43~1.45 in the case of 80℃ treatment.

**Effect of temperature change on the salt shrinkage**

Figure 2 show the results of the treatment under the condition maintaining specific gravity 1.43 and 3 minutes. As shown in Figure 2, the silk fabric was shrunk with temperature. It is found that the effect of salt shrinkage is extremely sensitive to the temperature. When we reviewed the 80 and 90℃ treatment results, the shrinkage ratio are not so high as we had expected. From this fact, it seems that the shrinkage is almost completed between the temperature 80~85℃ initial period in the case of specific gravity 1.43 and 3 minutes.

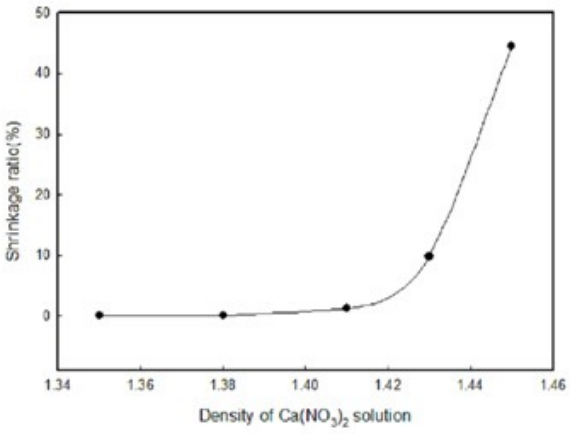


Figure 1. Shrinkage ratio with Density of $Ca(NO_3)_2$ solution

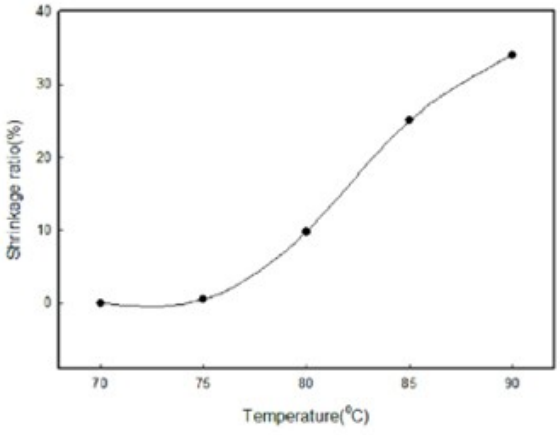


Figure 2. Shrinkage ratio with temperature

**Effect of time change on the salt shrinkage**

Figure 3 show the results of the treatment under the condition maintaining specific gravity 1.43 and temperature 80℃. As shown in Figure 3, the silk fabric was shrank with treatment time. It is found that the effect of salt shrinkage is extremely sensitive to the time. From this fact, it seems that the shrinkage is almost completed between the time 3~5 minutes initial period in the case of 80℃.

## Effects of salt-shrinkage of silk union fabric

The salt-shrinkage field tests of union silk, use a cloth that they offered to the table 1, were studied around the factors that affect the easy care. The main factors of salt-shrinkage finishing evaluated the effect of processing time on stretch effects, shrink, wrinkle resistance and fastness to washing of silk union. The processing conditions of silk I tested 1, 3, 5 min each specific is the optimum condition of silk cloth gravity1.43, at 80 ± 2 ℃. The salt-shrinkage processing union of silk there is a sense of distance cloth after processing slip of silk the surface was very hard when dry. This phenomenon appears to be dried is in a state that is not completely removed by the washing step is an inorganic salt of unreacted. If the removal of the salts of unreacted not fully phenomenon that the reaction proceeds continuously during drying of silk union the fabric may be damaged also occurs when the amount of inorganic salt unreacted large, dough phenomenon break in tense also occurs. Therefore, to remove the unreacted salts silk of union were tested various washing preparation showed the best effect SP-20 chemical agent. Inorganic salt was sufficiently removed at a temperature of 50 ℃ or higher temperature the amount of the auxiliary agent used for washing was 20g / l.

**Stretch effects of silk fabric treated with salt shrinkage**

Figure 4 and Figure 5 show the stretch effects of silk fabrics and silk union treated with salt shrinkage and washing by SP-20. we did not take into account the shrinkage of the union in the stretch field test. In the final products



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there is no much sense form of the fabric first. The use of SP-20 was used to sufficiently removed quickly inorganic salts unreacted. As a result of the test union of silk when using wool, cotton by weft of silk union shrinkage does not occur almost had no stretch. Therefore, in the analysis of the stretch in the union of silk was evaluated on the basis of the warp is being considered to affect only the stretch silk salt shrinkage processing.

Figure 4 show the fabric stretch of silk fabrics treated with salt shrinkage after washing. When we first review of effect on times, regardless of shrinkage of fabrics. As shown in Figure 4, stretch ratio of silk fabrics was highly than using raw silk warp direction stretch was highly than weft direction. This is because the density of fabric in the warp direction is high shrinkage occurs more by salt shrinkage is raw silk. Figure 5 show the fabric stretch of silk unions treated with salt shrinkage after washing. Stretch ratio of silk fabrics was higher in density of warp is small we suggested shrinkage due to salt shrinkage is because so much happened density is small this.

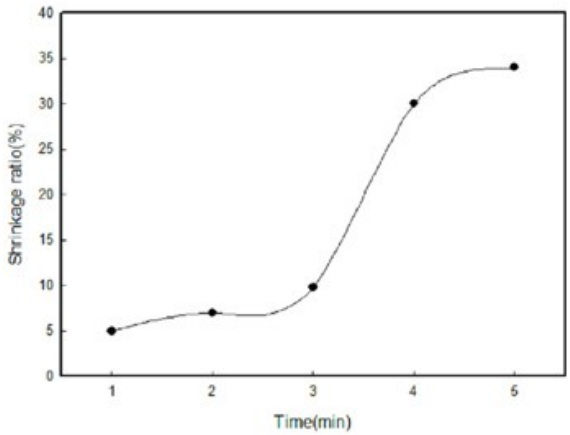


Figure 3. Shrinkage ratio with time

**Crease Recovery**

Figure 6 and Figure 7 show the crease recovery of silk fabrics and silk union treated with salt shrinkage and washing by SP-20. As shown in Figure 6, crease recovery of silk fabrics with raw silk, since the processing time is longer, the direction of the warp direction is showed a tendency to increase the crease of the raw silk, but weft direction was rather decreased. We considered to have occurred in the excessive shrinkage of the fabric.

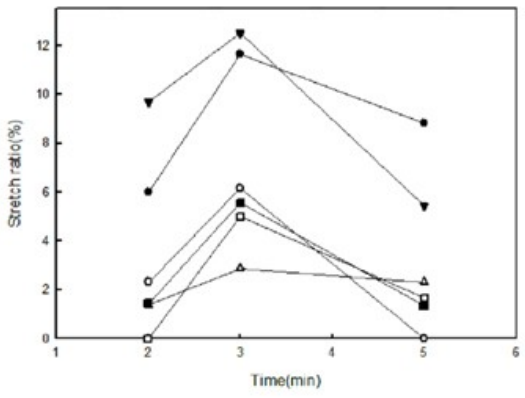


Figure 4. Fabric stretch of silk fabrics with salt shrinkage
(○ : sample 1, △: sample 2, □ : sample7, filled : warp, unfilled : weft)

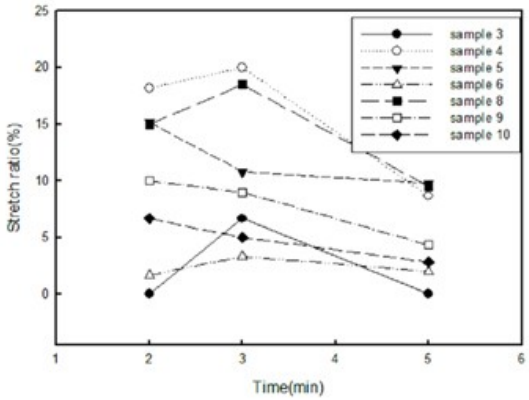


Figure 5. Fabric stretch of silk unions with salt shrinkage

Figure 7 show the fabric stretch of silk unions treated with salt shrinkage after washing. Crease recovery of the union was increased substantially by processing, but when other fiber and silk are mixed in the density of the silk by warp is high tend to decrease slightly crease degree revealed. Under the influence of raw silk wrinkle also slightly reduced in samples that have been mixed in the weft (sample 6, 8). The jacquard fabrics by using the degummed silk, crease recovery increased in mixed product (sample 9, 10).



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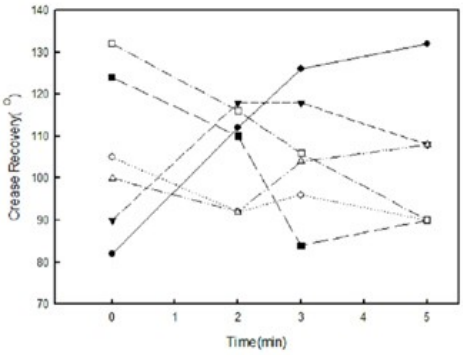


Figure 6. Crease recovery of silk fabrics with salt shrinkage
(○ : sample 1, △: sample 2, □ : sample7, filled : warp, unfilled : weft)

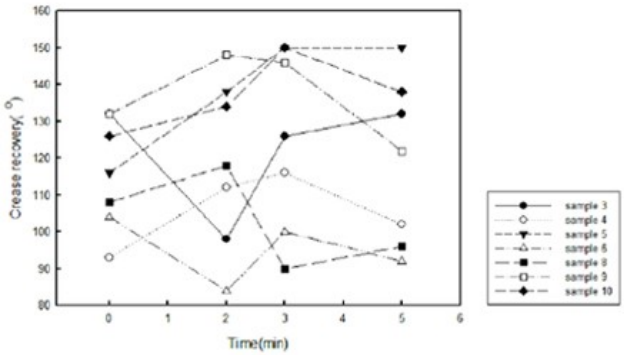


Figure 7. Crease recovery of silk union with salt shrinkage

**Shrinkage and washing fastness**

The samples that have been with salt shrinkage processed fabrics there was no change in dimension by the test. This appears to salt shrinkage condition has occurred in the conditions contraction stronger than washing field test conditions.

Table 2. Shrinkage of washing

| no. | | Time(min) | | |
|---|---|---|---|---|
| | | 2 | 3 | 5 |
| 1 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 2 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 3 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 4 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 5 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 6 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 7 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 8 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 9 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |
| 10 | wp | 0.00 | 0.00 | 0.00 |
| | wt | 0.00 | 0.00 | 0.00 |

Table 3. fastness of washing

| no. | | Time(min) | | |
|---|---|---|---|---|
| | | 2분 | 3분 | 5분 |
| 1 | color change | 4 | 4 | 4 |
| | staining | 4-5 | 4-5 | 4-5 |
| 2 | color change | 4 | 4 | 4 |
| | staining | 4-5 | 4-5 | 4-5 |
| 3 | color change | - | - | - |
| | staining | - | - | - |
| 4 | color change | 4 | 4 | 4 |
| | staining | 4-5 | 4-5 | 4-5 |
| 5 | color change | - | - | - |
| | staining | - | - | - |
| 6 | color change | - | - | - |
| | staining | - | - | - |
| 7 | color change | - | - | - |
| | staining | - | - | - |
| 8 | color change | - | - | - |
| | staining | - | - | - |
| 9 | color change | 4 | 4 | 4 |
| | staining | 4-5 | 4-5 | 4-5 |
| 10 | color change | 4 | 4 | 4 |
| | staining | 4-5 | 4-5 | 4-5 |

※ - : Notation is a white product.

It is predicted, not the fabric shrinkage and removal of the inorganic salts goods loosening occurs, the experimental results relaxation actual not occur. Acid dyeing product of raw silk cloth was excellent washing fastness.

# CONCLUSIONS

By using a continuous processing apparatus for a scale up process development for the commercialization of salt shrinkage which remained experimentation various sample we have developed a process step of union silk and silk



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fabrics. We have investigated the effect on the physical properties for easy care for improvement through the field test.

In this study, various aspects properties of salt shrinkage phenomenon were reviewed by applying calcium Nitrate ($Ca(NO_3)_{2)}$ on silk union as object. Fabrics stretch change, Crease recovery and color fastness of washing were investigated around shrinkage of silk fabric and silk union according to the change of treatment conditions.
The experimental results are summarized below.
In the case of specific gravity 1.43 of $Ca(NO_3)_2$ solution, treatment temperature of 80℃, the salt shrinkage is almost completed within initial 3mins.

Crease recovery is a decline rather than as a change in physical properties due to processing of raw silk. We plan to use the silk thread to use a degummed silk as much as possible.

A stretch effect by imparting salt shrinkage, samples has received a lot of influence of density of fabrics and types of textile and silk percentage of the weft. In the case of the actual sample stretch appears high in satin weave on is loose.

Wash fastness of the fabric has been improved over previous salt shrinkage in 4~5grade, there is no change even shrinkage samples dimension stability was improved.

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