The Evaluation of Mechanical and Thermal Property of Women's Hosiery and Aesthetic Impression

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Abstract: To wear comfortable stockings and make legs look beautiful are the attractive subjects for women of all ages. With the exception of summer season, almost all women wear hosiery: panty hoses, tights, knee-length socks and socks. In general, knitted fabric of hosiery has the advantage of being highly efficient at both stretching highly and fitting. In this study, a variety of women's hosiery ate examined for their performance both under no deformation and deformed condition during wearing. One of purposes of this study is to compare the performance of various hosieries objectively. The other of purposes is to estimate the change of the performance by wearing deformation for each sort of hosiery. Deformation is observed in wearing test and given an account of stretch ratio values for wale and course directions. Compression property is measured first. Standard thickness, compression work and resilience values are recorded from the pressure-thickness relation curves. And air resistance and thermal conductance are measured by KES- AP1 and KES- THERMO- LABO II fabric testing instruments, respectively. In addition, sensory tests are carried out to examine affective disposition of women who choose stockings to acquire better aesthetic and comfort. Tests are held with several items, for example, tactile impressions of softness, thickness and smoothness, and visual impressions of transparency and degree of compression. In the tests questionnaires are used and judges are young women.

Keywords: hosiery, compression property, air resistance, thermal conductance.

1. INTRODUCTION

Clothing style to wear skirts is reported to begin in the tumulus period in Japan. Skirts have become the important item and at the same they has specialized men and women's wears. Skirts design has changed in times, and women have paid the attention to foot fashion. As Japan's textile industry developed in modern times, length of skirts has changed in the times. For foot wears, epoch making shall be the development of the hosiery which was actualized by the invention of a circular knitting machine. In previous studies many scholars studied the quality of durability (Aly

and Stanley, 1973) (Gibson, 1973) (Sasaki, Toyoma, Kato and Tanaka, 1977). Since mass production, bulk buying and mass consumption, days has come the quality evaluation research becomes active. Although hosieries tend to be recognized as expendable objects, the high quality which let legs to show beautiful and slim is keen required among women. Papers on the relation of feeling to wear and deformation during wearing and tensile properties of typical hosieries have been reported (Fujimoto, Sukigara and Niwa, 1989) (Sukigara, Fujimoto and Niwa, 1990).

In this study, various mechanical properties are measured using KES-FB (Kawabata Evaluation System for Fabrics) system. Air Resistance is measured for all the samples. From the results, categorized typical hosiery groups such as tights, knee length socks and panty hoses are evaluated and compared for their properties. The sensory test is also carried out on the other hand. Subjects judge seven samples of panty hosieries on foot torsos.

2. SURVEY OF ACTUAL STATE TO WEAR HOSIERY

In order to get the knowledge and requirements of consumers, questionnaire investigation was carried out as follows:

Term: the end of November to the beginning of December, 2013

Subjects: 94 universities students, 20-22 years old

Investigation method: Using a questionnaire, Respondents fill out evaluation forms which Include seven items on purposes to wear hosiery, wearing frequency, time and seasons, favorite combination of bottoms and hosiery, value of buying hosiery, other requirements. After collected questionnaire sheets, answers on items were amounted and discussed.

3. EXPERIMENTAL

3.1. Hosiery Samples

Table 1: Samples basic properties

No	Hosiery	Group	Fiber contents	Courses / cm	Wales / cm	Thickness ,m	Weight, mg / cm^2	B.D, gf / cm^3
1	Knee/ high length-socks	H	cotton / acrylic	11.25	10.25	0.0026	38.53	0.148
2			wool	10	8.25	0.0033	40.05	0.122
3	Tights	T	nylon / polyurethane	16.75	17	0.0013	15.60	0.124
4			nylon / polyurethane	15.5	17.75	0.0013	15.67	0.118
5			nylon	23.75	17.75	0.0008	10.54	0.136
6			nylon	25.5	21	0.0008	9.82	0.116
7			wool	16	10.75	0.0020	29.22	0.148
8			nylon	15.75	12.25	0.0017	26.88	0.158
9	Panty hoses	P	nylon / polyurethane	14	19.75	0.0003	3.23	0.108
10			nylon / polyurethane	18.75	19.5	0.0003	3.51	0.111
11			nylon / polyurethane	11	17	0.0003	3.16	0.095
12			nylon	18.75	19.5	0.0003	2.14	0.063
13			nylon / polyurethane	85.25	56.75	0.0005	11.94	0.244
14			nylon / polyurethane	12.75	17.5	0.0003	3.41	0.110
15			nylon / polyurethane	21.75	16	0.0003	1.96	0.058
16			nylon / polyurethane	38	42.25	0.0004	6.73	0.168
17			nylon / polyurethane	16	20.75	0.0003	3.02	0.092
18			nylon	30.5	25.25	0.0005	2.59	0.057
19			nylon / silk / polyurethan	15	20.75	0.0003	3.47	0.118
20			nylon / silk / polyurethan	21	17.25	0.0003	4.87	0.156

After researching the hosieries sold on the market, 20 typical hosieries were prepared. Basic properties of samples for this study are shown in Table 1. Samples are classified into three groups that are knee/over-knee length socks, tights and panty hoses.

3.2. Wearing test to measure extension during wearing

In order to know the stretch ratio when the subject wear a hosiery, the distances of marks, which are marked in both of wale and course directions, are measured before and after putting on samples. Those samples before and after stretched by wearer were provided to the measurement of air resistance and thermal property.

3.3. Measurement of structural properties and mechanical properties

Compression property was measured by KES-FB3 fabric testing apparatuses respectively. Thickness at the compression stress of 0,5gf/cm^2 was derived from the compression stress-thickness curve measured under the condition at the maximum compression stress of 50gf/cm^2.

3.4. Measurement of air resistance and Thermal conductance

Air resistance was measured by KES-AP1 apparatus under one cycle process of the charge-discharge of constant air flow amount through sample sides.

For the measurement of thermal property, rectangle of specimen were taken from samples of each group and conditioned in the laboratory. Thermal conductance and insulation ability are measured by d KES-Thermo-labo II fabric testing instrument which applies the method of two plates of different temperatures under steady state condition. Heat flux from heat source to heat sink was measured.

Those experimental measurement were carried out in the laboratory controlled at the standard condition of 20 ± 2 ℃ and 65 ± 5 % R.H. .

4. SENSORY TESTS BY TOUCH AND VISION TABLE

Semantic differential method is applied in the sensory tests, using selected words list which includes the ten most important words for the vision tests and the six most important words for the touch tests. The sensory tests were carried out for seven kinds of characteristic hoses which were displayed as shown in Figure 1. The “feel “of the hosiery’s wear – both positive and negative adjectives were elicited. The pairs of bipolar words were prepared and arranged into a grid where each trait was put on the between the extreme values of its poles and could be estimated on a five point scale. The ten pairs in the vision tests were “wishing to wear everyday/not” “ wishing to wear sometimes/not” “ transparent/not transparent” “look beautiful/not” “look slim/not slim” “comfortable/not comfortable” “durable/not durable” “thick/thin” ” warm/cold” “preferable/not preferable”. The six pairs of words for touch tests are “wishing to wear everyday/not” “smooth/rough” “comfortable/not comfortable” “thick/thin” ” warm/cold” “preferable/not preferable”.

Samples were rated with consumer respondents by touch and vision. The results were examined in relation to the samples properties measured in the experiment.

Figure 1: A part of displayed samples in the sensory test

5. RESULTS AND DISCUSSION

5.1. Purposes to wear hosiery

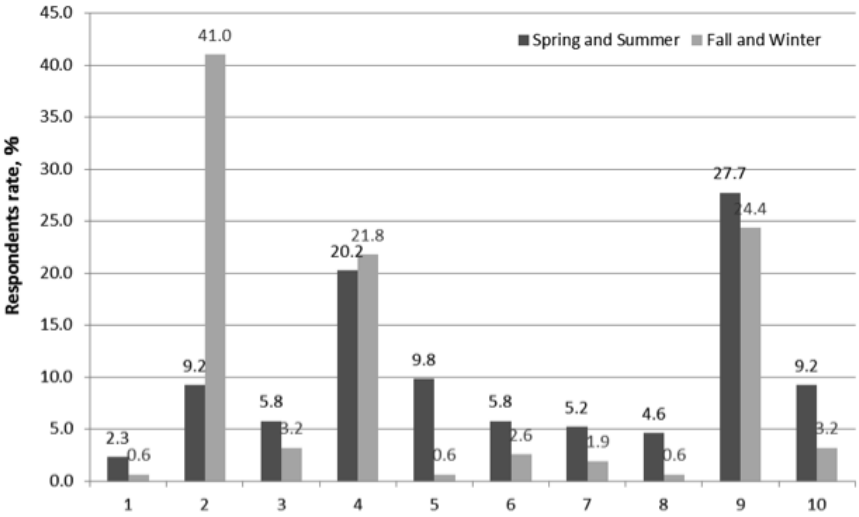

Figure 2: Purposes to wear panty hoses and comparison of them between ‘‘spring and summer ’’ and ‘‘fall and winter ’’

1: To be cool 2: To be warm 3: Keep foot clean 4: Neat appearance 5: UV cut 6: Prevent blister 7: Prevent welling 8: Prevent fatigued 9: To show legs beautiful 10: The others

Figure 2 shows the result of a survey on “purposes to wear hosiery”. In order of higher respondent’s rate to wear panty hoses, “to show legs beautiful” and “for neat appearance” are ranked. To wear “to be warm” is required markedly in fall and winter seasons.

5.2. Results of measurement of structural properties and mechanical properties

Thickness and bulk density are plotted in Figure 3. Samples in H group are thick at around 3 mm. Tights samples of T group have a range of thickness at 0.8 - 0.13 mm. For samples of panty hoses, P group, thickness shows thinner than 0.3 mm, but bulk density has a wide range from 0.06 - 0.25.

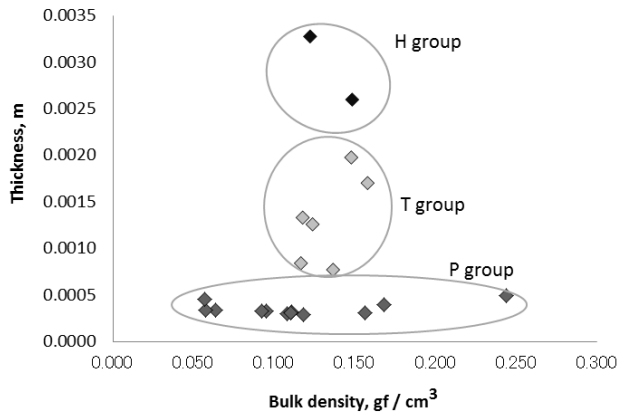

Figure 3: Relationship between Thickness and the bulk density

5.3. Air Resistance and thermal property

The relationship between the specific air resistance and the bulk density is shown in Figure 4.The specific air resistance increases with the increase of the density. The H group samples exhibits larger air resistance than other samples of T and P groups. The air resistance of yarn assemblies increases as the diameter of consistent yarn increases.

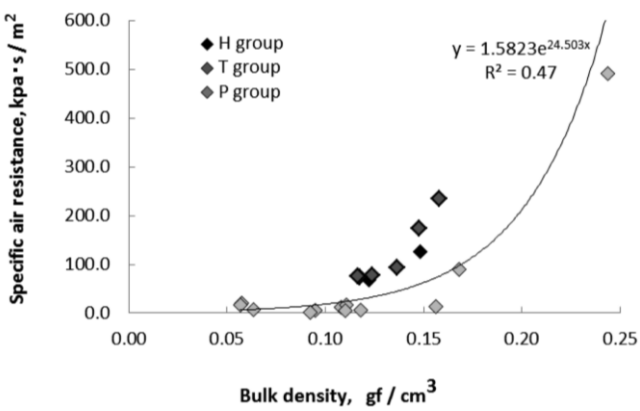

Figure 4: Relationship between the specific air resistance and bulk density

For thermal property, the effective thermal conductance of samples was measured. To calculate the thermal conductance, values were divided by the standard thickness of each sample. The effective thermal conductance of samples of H group is 20 - 30 W· $m^{-2}K^{-1}$; T group is 40 - 70 W· $m^{-2}K^{-1}$; P group is 80 - 120 W· $m^{-2}K^{-1.}$. The effective thermal conductance panty hoses has a wide range depending to the consistent yarn thickness, however, which is thinner than other two groups samples. Then thermal insulation ability is one fourth or one fifth.

When hosiery is strained by wearing, the knitted fabrics are extended and change the properties.

We measured extension rates during wearing. Stretch ratio of area for calves of high length hosiery was around 1.5 and that of other type hosieries and tights showed 2.0 - 2.5 ratios. By the deformation of area of sample during wearing, thickness decreased by 30 %. The decrease of thickness bought the reduction of air resistance and insulation.

5.4. Sensorial estimation of panty hoses

We selected samples of P group, the sensory estimation on aesthetic and favor impression. The feeling to the touch are summarized by calculation of ranking score by respondents for "wishing to wear everyday/not" "smooth/rough" "comfortable/not comfortable" " "thick/thin" " warm/cold" "preferable/not preferable" in Figure 5.

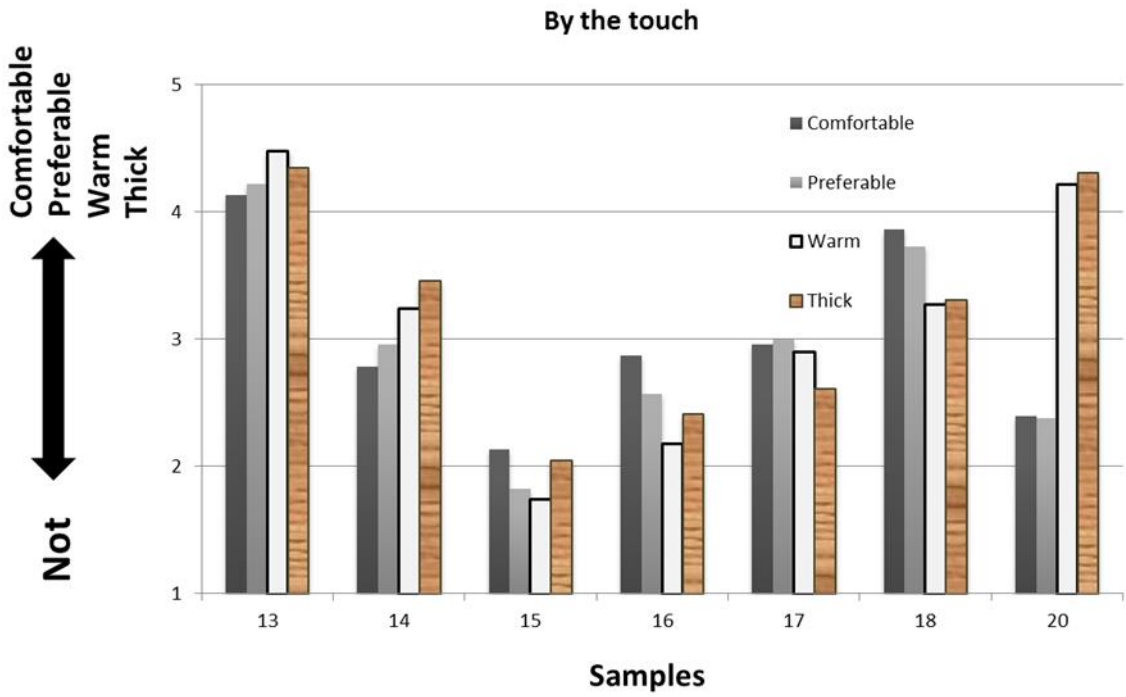

Figure 5: Results of sensory touch test for panty hoses

The vertical axis shows the five steps differential scales and chart graphs are the mean values of each feel rating. It is obvious that thick feeling links warm feeling as shown for samples with no. 13, no. 18 and no. 20. Comparing them, the sample no.13 which is most dense stitches, was recognized as to be preferable and comfortable. The sample no. 18 follows. The sample no. 20 with sparser stitch than no. 13 was judged as to be not preferable and not comfortable.

It was found that visual feeling becomes better as the area stitch density is sparser and for the dense sample could be said oppositely felt comfortable, preferable to the touch.

6. CONCLUSIONS

Although hosieries tend to be recognized as expendable objects, the high quality which let foot to show beautiful and slim is keen required among women. Sensory tests are carried out to examine affective disposition of women who choose stockings to acquire better aesthetic and comfort. This time, Sensory test's Samples were rated with consumer respondents by vision and touch. The results were examined in relation to the samples properties measured in the experiment

Consumers tend to make decisions about purchasing hosieries on the basis of appearance on showcases. In this study, however, there were great differences in some items between results of the vision tests and that of the touch tests. This suggests that comprehensive selection including considerations of tactile sensation is needed to heighten utility.

As a result of the touch test and measurements of panty hoses samples, bulk density of materials strongly affected overall preference. Specifically, higher bulk density made consumers more comfortable.

Sensory tests of this study carried out in cold districts in winter. Therefore, it is assumed that samples looking thick and warm tend to be preferred. In addition to tests in this paper, detailed tests with consideration of seasons and areas are required.

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BIOGRAPHY

Naoko Nakayama is a senior student of Hokkaido University of Education in Japan and majoring in clothing material science and Kansei engineering. She has studied on the evaluation of mechanical and thermal property of various fibrous materials for two years. She has a tea ceremony qualification.

Dr. Takako Fujimoto belonged to 1) Niigata University (1977-1981), and then has belonged to 2) Hokkaido University of Education (1992- at present) and has been professor since 1992. She has been i) Head, Japan Section of The Textile Institute of UK (2005-), ii) a member of council of TI, iii) a council member of Japan Research Association for Textile End-uses, iv) a visiting professor, University of University of New South Wales, Australia (1996.9-1997.3). Her major research areas in scientific achievement are a) theory of heat transfer of fibrous materials, b) mechanical properties and handle estimation of clothing fabrics, c) objective evaluation of clothing materials, d) durability of clothing materials. The number of her published original books is 5, of her published original papers and articles are around 130. She received three prizes and awards related to the above scientific achievements.