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Surface Friction Properties of Fabrics and Human Skin

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1. Introduction

We will select and decide to buy our clothes not only by looking at the design and colour of the clothes, but also by handling the cloth. And for the people which their skin has any trouble, the surface friction property of fabrics is important. It is known that the fabric handle judged by hand is affected by the mechanical properties, surface property and the thermal and water transfer properties of the fabrics. The objective evaluation equations are developed by Kawabata and Niwa [1].

Figure 1 shows the factors concerning for the performance of clothing. The factors of the properties of clothing are the structure of clothing and the properties of fabrics. And the factors of the properties of fabrics are the structure of the fabrics and the properties of yarn, and the factors of the properties of yarn are the structure of the yarns and the properties of fiber.

In the objective evaluation equations of hand value, especially, *NUMERI* and *FUKURAMI*, the effects of surface properties is so large. In this study, objectives are to be remarkable about three points. At first, the friction properties of fabrics which differ from the kinds of fiber, yarn counts, and yarn density, secondly, the friction properties of the human skin and next, the friction properties between human skin and the fabrics are experienced.

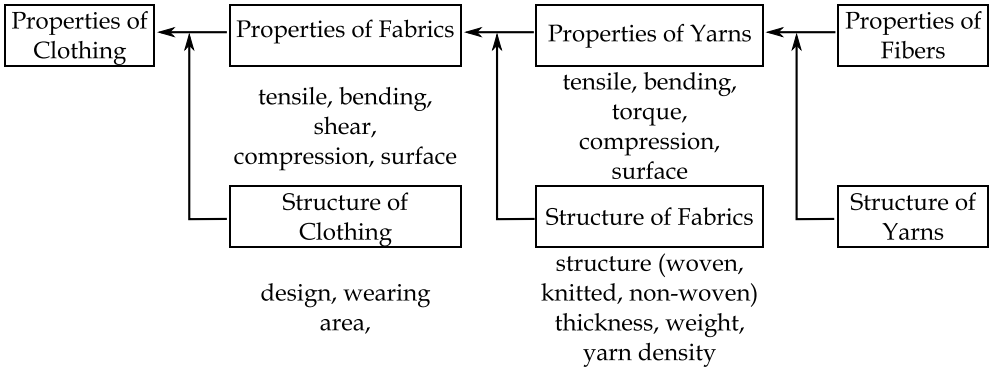


Fig. 1. The factors for properties of clothing

2. Experimental

2.1 Surface friction properties of fabrics

2.1.1 Measuring method

The surface friction properties of fabrics are measured by KES-SE surface friction tester as shown in Figure 2. Figure 3 shows the friction contactor. It consists of the twenty steel wires of which the diameter is 0.5 mm and the fingerprint is simulated. The contact area is 10mm x 10mm, and the contact load is 0.5N. The scan speed of the tester is 1 mm/sec. Measuring characteristics values are coefficients of the surface friction, *MIU* and the standard deviation of *MIU*, *MMD*. This tester is used in all experiments.

Fig. 2. KES-SE surface friction tester

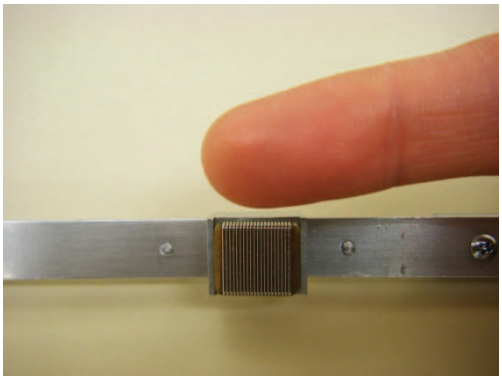


Fig. 3. Friction contactor

2.1.2 Samples

The properties of the fabrics are affected by the yarn properties and the structure of the fabrics. And the yarn properties are affected by the properties of fibers and the structure of the yarns. In these experiments, the samples are composed of different fibers as shown in Table 1. Another samples are shown in Table 2. Yarn counts of these samples are same, but yarn density is different in these groups.

symbol	Fiber		Yarn	Yarn counts tex(=×10^{-5}N/m)	
			structure	warp	weft
SC	Natural	cotton	staple	14.8	14.8
SL	fiber	linen	staple	7.4	7.4
SW		wool	staple	14.1	12.3
SS		silk	staple	8.4	8.4
FN	Synethetic	nylon	filament	7.8	7.8
FP	fiber	polyester	filament	5.6	8.3
SA		acrylic	staple	11.4	11.4

Table 1. Samples for fabric consisted of various fibers

symbol	Fiber	Yarn counts	Yarn density	
		tex(=×10^{-5}N/m)	ends/cm	picks/cm
C1	cotton	14.8	43.0	30.4
C2	(staple)	14.8	34.6	30.0
C3		14.8	43.0	20.2
C4		14.8	33.2	20.0
C5	cotton	7.4	47.0	39.0
C6	(staple)	7.4	46.2	30.0
C7		7.4	33.6	30.4
C8		7.4	45.8	20.4
P1	polyester	16.7	38.7	40.1
P2	(filament)	16.7	37.3	35.5
P3		16.7	36.3	31.7
P4		16.7	36.1	27.5

Table 2. Samples for fabric which are different density

2.2 Surface friction properties of human skin

Surface friction properties, *MIU* and *MMD* of human skin of twenty-six subjects in their twenties are measured by KES-SE. in Figure 2. Figure 4 shows the measurement of human skin and the figure 5 shows the example of the measurement result of the surface friction. And moisture regain of the skin also is measured as shown in figure 6.

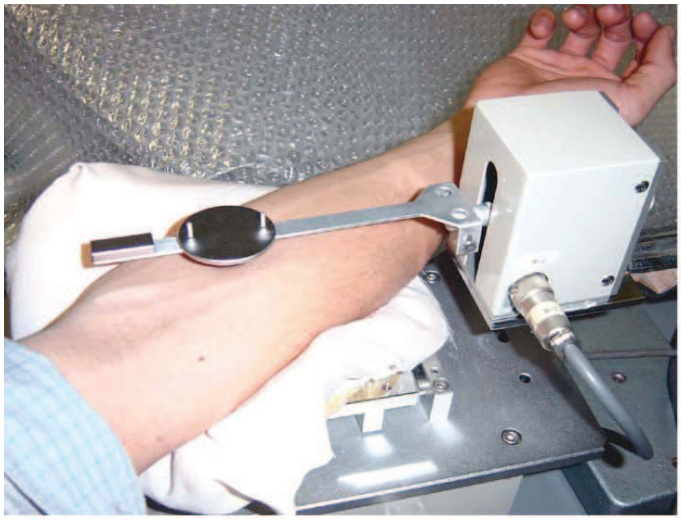


Fig. 4. Measurement of surface friction properties of human skin

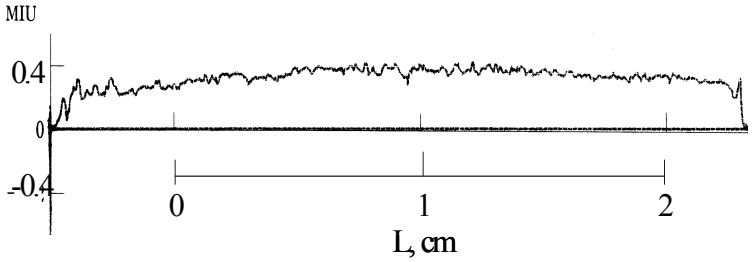


Fig. 5. The example of the measurement result of the surface friction

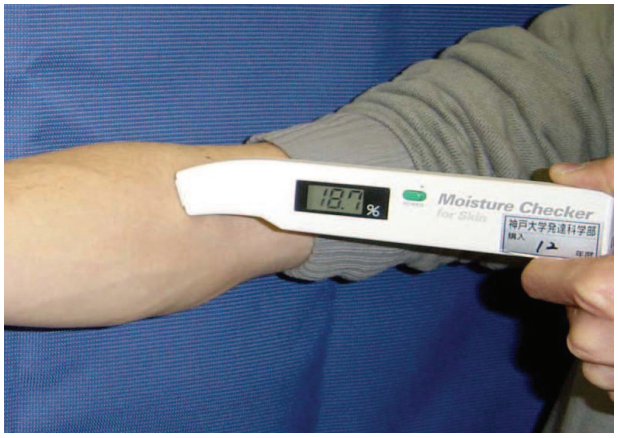


Fig. 6. The measurement of moisture regain of human skin

2.3 Friction properties between Human skin and fabric

Friction properties, that is, coefficients of the surface friction, *MIU* and the standard deviation, *MMD* of human skin of twenty-six subjects in their twenties are measured by KES-SE using contactor with fabrics between Human skin and fabric. Figure 7 shows the contactor.

The mounted fabrics are two knitted fabrics and two woven fabrics. The *MIU* and *MMD* of each fabric are shown in Table 3. *MIU*s of K2 and W2 are larger than K1 and W1, respectively.

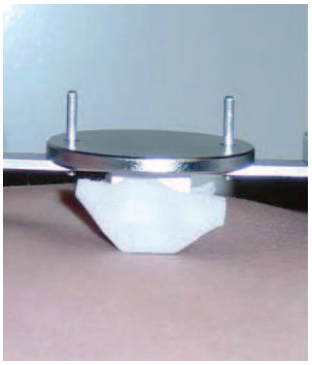


Fig. 7. Surface contactor mounted with fabric

sample	structure	fiber	*MIU*		*MMD*		thickness	weight
			Ave.	SD	Ave.	SD	mm	mg/cm²
K1	rib knitted	cotton 100%	0.163	0.016	0.0070	0.0016	0.78	21.6
K2	plain knitted	cotton 100%	0.273	0.037	0.0115	0.0015	2.41	32.0
W1	plain woven	cotton/PET 50/50%	0.131	0.002	0.0172	0.0051	0.34	11.0
W2	twill woven	cotton100%	0.227	0.007	0.0084	0.0012	1.49	21.3

Table 3. *MIU* and *MMD* of fabrics using friction experiments with human skin

3. Results and discussion

3.1 Surface friction properties of fabrics

Table 4 shows the *MIU* and *MMD* of specimen which is composed of different fiber. *MIU* of sample FN (nylon filament) shows the lowest value and the *MIU* and *MMD* of sample SW (wool staple) show the highest values. The tendency is that *MIU* and *MMD* of filament fiber are lower than staple fiber. But it's not remarkable.

The relationship between product of yarn density in the warp and weft direction and the *MIU* or *MMD* shows in Figure 8. In the case of staple yarn, the tendency is not remarkable, but it is remarkable that the higher density shows the higher *MIU* and *MMD* in the case of filament yarns.

symbol	*MIU*	*MMD*
	μm	μm
SC	0.161	0.0104
SL	0.127	0.0149
SW	0.169	0.0154
SS	0.141	0.0148
FN	0.102	0.0145
FP	0.130	0.0125
SA	0.205	0.0099

Table 4. *MIU* and *MMD* of specimen composed of different fiber

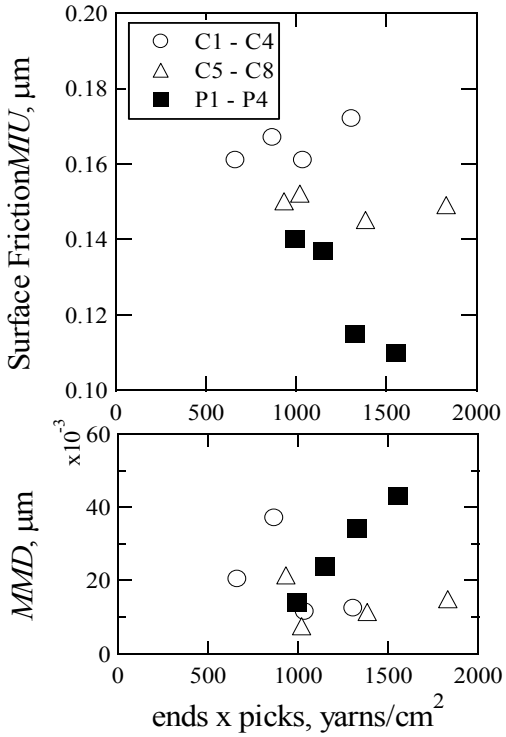


Fig. 8. The relationship between product of yarn density and *MIU* and *MMD*

3.2 Surface friction properties of human skin

Surface friction properties, that is, coefficients of the surface friction, *MIU* and the standard deviation, *MMD* of human skin of twenty-six subjects in their twenties are shown in Table 4. There is no difference between male and female, but there is large difference among individuals because of the large standard deviation.

Figure 9 shows the relationships between moisture regain and *MMD* of all subjects in 25 degree C and 65%RH. It does not show the remarkable tendency, but the it is consider that the larger moisture regain, the larger *MMD* it is.

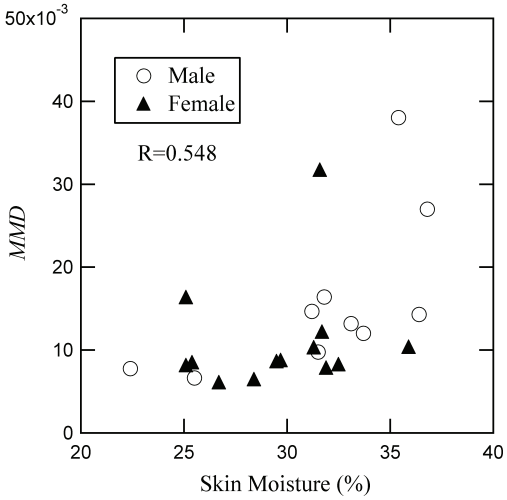


Fig. 9. The relationships between moisture regain and *MMD* of all subjects in 25 degree C and 65%RH

Figure 10 shows the examples of coefficients of surface friction of skin versus moisture regain of skin in the same person. The coefficients of surface friction have not only the large difference among individuals, but also the difference of moisture regain. Therefore, it is consider that there are the differences between season or rhythm of one day.

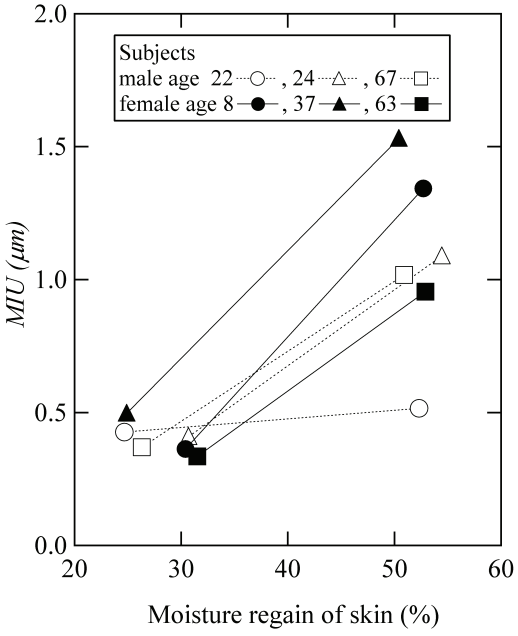


Fig. 10. The relationship between moisture regain and *MIU* of human skin

	number	*MIU*		*MMD*		Moisture regain, %	
		Ave.	SD	Ave.	SD	Ave.	SD
male	13	0.405	0.220	0.0193	0.0136	32.3	4.5
female	13	0.430	0.144	0.0111	0.0065	29.6	3.2
all	26	0.419	0.187	0.0148	0.0114	30.8	4.2

Table 4. *MIU*, *MMD* and moisture regain of human skin

3.3 Friction properties between Human skin and fabric

Figure 11 shows the examples of *MIU* which the change of *MIU* is the largest one of twenty-six subjects. From these results, it is concluded that the *MIU* between human skin and fabric does not relate to the *MIU* of fabric, but moisture regain of skin.

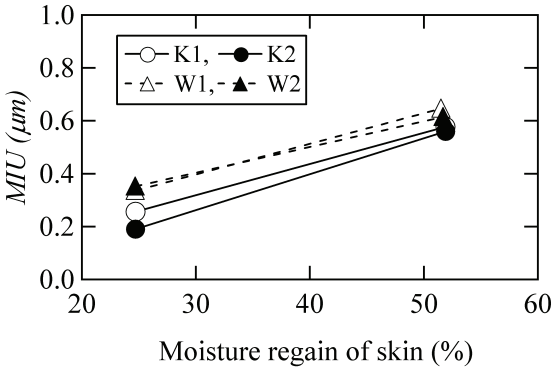


Fig. 11. The relationship between moisture regain and *MIU* of human skin/fabric

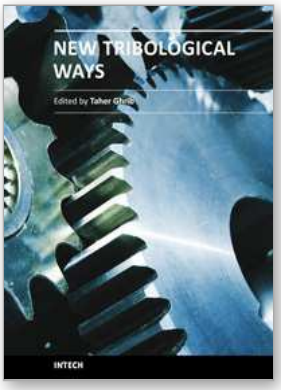
4. Conclusion

The hand of fabric used as clothing materials, the surface friction properties of skin and the friction between clothing materials and skin were measured. As the results, the tendency was that *MIU* and *MMD* of filament fiber were lower than staple fiber. And it was remarkable that the higher density showed the higher *MIU* and *MMD* in the case of filament yarns. Friction between human skin and fabrics were measured, and the effects of the moisture regain of human skin and the friction of fabrics were shown from the results. Our group will develop the new apparatus which the width of the part of contactor are wider one at present. On the basis of the results of this study, we would like to develop the apparatus which are close to human sense for friction properties.

5. References

[1] Sueo Kawabata, "*The standardization and analysis of hand evaluation (second edition)*", The Hand Evaluation and Standardization Committee and The Textile Machinery Society of Japan, 1980

[2] Harumi Morooka and Masako Niwa, *Jpn. Res. Assn. Text. End-uses,* Vol.29, No.11, 486-493, 1988



New Tribological Ways

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This book aims to recapitulate old information's available and brings new information's that are with the fashion research on an atomic and nanometric scale in various fields by introducing several mathematical models to measure some parameters characterizing metals like the hydrodynamic elasticity coefficient, hardness, lubricant viscosity, viscosity coefficient, tensile strength .... It uses new measurement techniques very developed and nondestructive. Its principal distinctions of the other books, that it brings practical manners to model and to optimize the cutting process using various parameters and different techniques, namely, using water of high-velocity stream, tool with different form and radius, the cutting temperature effect, that can be measured with sufficient accuracy not only at a research lab and also with a theoretical forecast. This book aspire to minimize and eliminate the losses resulting from surfaces friction and wear which leads to a greater machining efficiency and to a better execution, fewer breakdowns and a significant saving. A great part is devoted to lubrication, of which the goal is to find the famous techniques using solid and liquid lubricant films applied for giving super low friction coefficients and improving the lubricant properties on surfaces.

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