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An experimental study on the effect of pile length on the abrasion resistance of chenille fabric

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Abstract: In this experimental study, the effects of pile length on abrasion resistance of chenille fabrics were investigated. In order to monitor the effect of pile length, we produced chenille yarn samples with different pile lengths of 0.7, 0.8, 1, 1.2 mm and wove them into upholstery fabric. Then, the fabric samples were subjected to the Martindale abrasion test for 20 000 rubbing motions. The specimens were also examined using a micro-projection device and data were evaluated using statistical methods. The results indicate that pile length is certainly an effective factor for the mass loss of chenille yarns. The mass loss rate (%) tends to increase as pile length increases. The lowest total mass loss rate (%) clearly occurred for the samples with 0.7 mm pile length as shortest. The removed pile fibers are not only pulled out from between lock yarns but are also broken.

Key words: Chenille yarn, chenille fabric, abrasion resistance, pile length pile yarn, lock yarn.

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INTRODUCTION

Recently, there has been a significant increase in competition in the textile and clothing sectors all over the world. So, it is necessary that products with high added-value need to have knowledge, technology, creativity and quality in order to get advantage in high competition (Vision, 2003). For this aim, fancy yarns are an alternative. Chenille yarn, which is a fancy yarn, has been developing in the market for the last fifteen years and nowadays is popular. It is currently finding many different uses such as outerwear, home textiles, car interiors, and ornamentations. Especially, it is used widely for upholstery fabric production.

Fancy yarns have many advantages in producing attractive fashion products and creating new brands (Özcan and Özipek, 1997). Chenille yarn, which has a significant place in fancy yarns, is a fuzzy, soft, bulky and original yarn. It has a beautiful pile surface – with a velvet-like and changeable brightness depending on the light ways.

Chenille yarns, which are produced by using a special chenille machine, have two components. The first is a couple of core (lock) yarns twisted together in the center along all the length, providing strength to the resulting yarn and gripping the other components, called the pile yarns that protrude transversely all around the core yarns (Tung and Whitehead, 1997). Because the pile fibers lean to one side and because of the helical structure of the yarn, there is a beautiful wavy appearance and changeable brightness on the surface of the woven fabric. The lock yarns grip the pile yarns (or fibers), which protrude transversely, held stable by means of twisting. The factor preventing the pile fibers being removed is mechanical friction forces between the lock and pile yarns (Tung and Whitehead, 1997).

Generally, 4 lock yarns and 2 pile yarns are fed to every production unit from a creel in the chenille machine and two chenille yarns are delivered in every unit. The pair of pile yarns are twisted together by means of a head and are wound around a metal body, called a calliper or gauge, located vertically. Thus, there become many consecutive pile yarn rings downwards on the calliper body. The pile rings going down are cut by a circular blade into two equal parts. The parts are joined in chenille yarns derived in the production unit (Fig. 1).

The chenille yarns formed are delivered from take-up and companion rollers at a production rate. As soon as they are delivered, the chenille yarns are twisted and wrapped as bobbins in a traditional ring-twisting take-up mechanism.

The twist level of chenille yarn affects the properties of the chenille yarn, so it must be carefully determined. The width of the calliper body (neck) determines the

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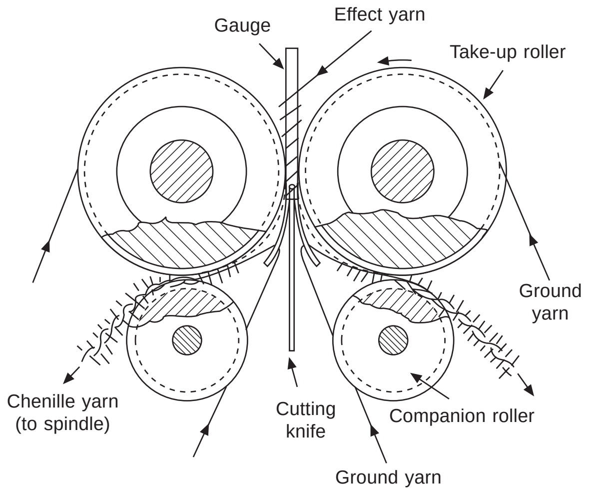

Figure 1 Chenille yarn formation in a production unit of chenille machine (Longma, 2004).

length of the pile yarns and the diameter of the chenille yarn. Therefore, a calliper with different gauges is used according to the length of pile yarn required. The count of chenille yarn is determined by the count of the lock and pile yarns, the number of them, twist, pile density and length.

Chenille yarn has some disadvantages such as being delicate against machine washing and tumble drying and having low abrasion-resistance. Especially, the low abrasion resistance against rubbing and friction is a most important problem for upholstery fabrics. Because chenille yarn is a combined yarn, its properties are influenced by many factors. These factors are the count of the yarn, the properties of the lock and pile yarns, twist level of the chenille yarn, pile length, fiber types, and so on.

It has been claimed that pile length is a major factor on the abrasion resistance of chenille yarns and fabrics (Tung and Whitehead, 1997; Kaloğlu and Demir, 2001; Ülkü *et al.*, 2003) Kaloğlu and Demir put forward that fiber types, twist, and pile length are effective on the abrasion resistance of chenille fabric and there was more pile loss for a fabric with viscose fibers than one with polyacrilic and cotton fibers (Kaloğlu and Demir, 2001). Ülkü *et al.* (2003) put forward that twist level, weaving construction and pile length are effective factors on the abrasion resistance of chenille fabric, and the average mass (pile) loss weight tends to decrease as twist level increases for all weaving constructions. They performed 10 000 double rubs as the maximum level and put forward that when twist level goes up, the lock yarns grip the pile yarns better. Thus, higher twist levels prevent pile yarns from snagging and pulling out. They mentioned that mass loss decreases as pile length increases and that the shorter pile yarns may be pulled out easier than longer pile yarns. Nergis and Candan (2003) studied the properties of plain knitted fabrics from chenille yarns. They concluded that mass loss rate tends to increase for dry relaxed knitting fabrics as pile length increases and that the count of component yarns decreases after 2000 rubs. However, they observed that there is no tendency of this for other samples such as washed and tumble dried, washed and flat dried, and dry cleaned.

It is known that the abrasion resistance of upholstery fabrics in the market may be more than 10 000 double rubs. Furthermore, it is believed that the results should be evaluated according to mass loss rate (%). Therefore, a new study on this subject has been performed.

In this study, we investigated the effect of pile length on the abrasion resistance of chenille fabric. Firstly, chenille yarn samples which had four different pile length levels were produced and woven into an upholstery fabric, and then these chenille fabric samples were subjected to the Martindale abrasion test. The results have been evaluated according to mass loss rate (%) and mass loss quantity (g). Statistical methods have been used to analyze the data in the study. It is concluded that mass loss rate (%) tends to increase as pile length increases for the chenille fabric samples. In addition to this, the reason of mass loss is not only the pile yarns being pulled out completely but also to their being broken.

MATERIALS AND METHOD

Chenille yarn samples were produced at different levels of pile length in order to examine the effect of pile length on abrasion resistance of chenille fabric. Then these samples were subjected to the Martindale abrasion test. Because it is widely used in upholstery fabrics, polyacrylic *Dralon* fiber was selected as the raw material. All blends consisted of 100% polyacrylic *Dralon* fibers having the same properties. Fineness and length of fibers were respectively 1.3 dtex and 38 mm.

The yarn samples were produced on a *Giesse, type AC 91/E*, 1997 chenille machine. The head speed was adjusted at different levels in order to ensure a yarn count of Nm 4. The average head speed was 11 800 rpm and the average production rate was 8 m/min. The twist level was 860 tpm.

The climate conditions in the chenille yarn production were 45% relative humidity and 29 °C temperature. The yarn samples were produced, rewound and passed through an electronic clearer. The pile missing defects (≥ 1 mm) and the thick sections (≥ 50 %) were cleared. After rewinding, the chenille yarn samples were fixed under saturated steam at 65 °C for 15 minutes. Later, the chenille yarn samples were dyed in the form of skeins. The technical data of the yarns before weaving are given in Table 1.

The dyed chenille yarn samples were woven as upholstery chenille fabric on a rapier weaving loom fitted with a jacquard. After weaving, the fabric samples were fixed under dry steam at 90 –100 °C for 6–7 seconds. The weaving construction of the chenille fabric is given in Fig. 2. This construction was particularly chosen to ensure the largest friction area between the chenille fabric specimen and the abradent fabric. 150 denier textured semi-dull polyester filament yarn with 300 tpm was used

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Table 1 **Technical data of chenille yarn samples before weaving**

Pile length (mm)	Yarn count		Twist		Tensile		Extension	
	Nm	CV%	tpm	CV%	cN	CV%	%	CV%
0.7	3.627	2.240	966.250	2.196	985	6.84	37.44	6.29
0.8	3.585	1.123	958.500	2.297	955	8.52	36.72	6.27
1	3.686	1.129	913.750	3.063	956	7.92	36.76	6.99
1.2	3.703	1.376	958.400	2.437	984	5.28	40.41	5.65

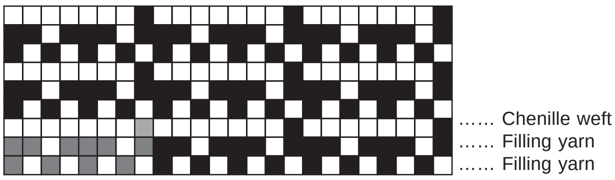

Figure 2 Weaving construction of chenille fabric.

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as the warp yarn and Ne 10/1 cotton spun yarn with 210 tpm was used as the weft yarn of the woven upholstery fabric samples. In weaving, two filling yarns and one chenille yarn were inserted consecutively. The warp density was 66 ends/cm; the weft density was 19 ends/cm in the gray fabric and 21 ends/cm in the final fabric. The average weight of the final chenille fabric samples was 431.4 g/m^2.

The chenille fabric samples were subjected to an abrasion test using the Martindale abrasion tester according to TS EN ISO 12947-3 standard procedure.

When the samples had been conditioned in the laboratory under standard climate conditions (20 ± 2 °C temperature and 65 ± 2 % relative humidity) for 24 hours, a pre-test was performed and it was found that mass loss in specimens began at 5000 double rubs. Thus, the following series of rubbing motions was selected and the 20 000 level was added to the series in order to get more accurate results. The series consisted of 1000, 2500, 5000, 7500, 10 000, 15 000, and 20 000 double rubs.

Six specimens were taken from each chenille fabric sample. When the specimens were cut from the fabric samples, attention was paid not to match the specimen place on the same warp and weft. For upholstery fabric, a weight of 12 kpa (795 ± 7 g) is applied on the abrasion device according to the standard. Since the fabric weight was under 500 g/m^2, a disc of polyurethane foam was placed between the specimen and the metal face. All specimens were weighed at every rubbing motion level using a scale with 0.001 g sensitivity. Since the weight of the specimens before test may be different, the mass loss rate (%) was used for statistical analysis and comparing, in order to evaluate the data objectively. During the test, all specimens were weighed at every rubbing motion level and noted. Then, cumulative mass loss rates (%), cumulative mass loss quantities (g), and specific cumulative mass loss rates (%) at every rubbing motion level were calculated and shown in graphics. One-way analyses of variance were performed on the data and the sample means were compared with each other. The results were evaluated using significant tests at 0.05 level and a multi-comparison test called LSD was performed. All the statistical analysis was performed on a computer using the SPSS (Statistical Package of Social Science) packet program.

RESULTS AND DISCUSSION

As mentioned earlier, chenille yarn samples were produced at four levels of pile length, namely 0.7, 0.8, 1 and 1.2 mm. It is clear that after 20 000 double rubs there were still many pile fibers not removed on the specimens with 0.7 mm pile length but there were almost no fibres on the others.

It was shown that the lowest cumulative mass loss rate (%) occurred for the samples with 0.7 mm pile length and the highest cumulative mass loss quantity (g) occurred for samples with 0.8 mm pile length, but the others are similar, as seen in Figures 3 and 4. It seemed that there was a conflict between the facts in Fig. 3 and the facts in Fig. 4. In this case, it was decided that the cumulative mass loss rate (%) data were more reliable than others for objective evaluation, considering that the weight of specimens at the beginning were different. Therefore, the cumulative mass loss rate (%) data were used in the statistical analysis.

Figure 5 shows the specific mass loss rates (%) at every level of rubbing for different pile lengths. As seen, the mass loss rate (%) increases in range of 15 000–20 000 rubs for 0.7 mm pile length but increases a little or decreases for others. Here, it is indicated that there are still many

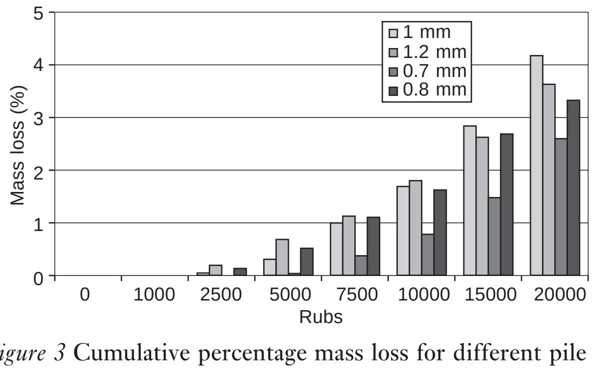

Figure 3 Cumulative percentage mass loss for different pile lengths.

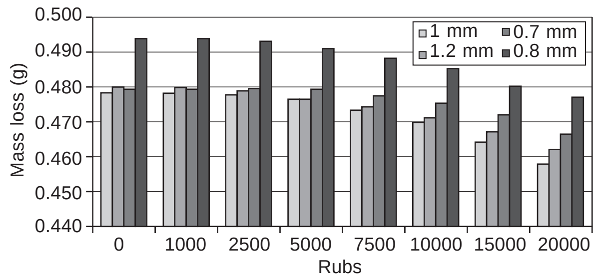

Figure 4 Cumulative mass loss quantities for different pile lengths.

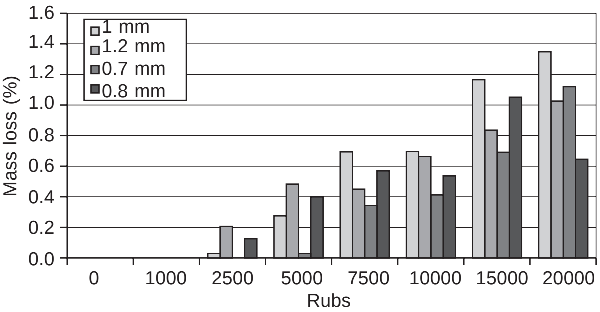

Figure 5 Specific mass loss percentage at every level of rubbing for different pile lengths.

pile fibers to be removed on the sample with 0.7 mm pile length at the end of the test.

The longer pile fibres lead to an enlarged contact area between abradent fabric and specimen surface. Thus, the friction forces increase and become more effective in causing pile fibers to be removed from the fabric body. In addition to this, pile fibers are not only removed from the fabric due to overcoming friction forces between lock yarns and pile yarns, but are also being broken. Since it is almost impossible for the pile fibers to be curled and forced to be broken for the shorter pile lengths, the mass loss decreases as pile length decreases.

One-way analysis of variance was performed on the data in order to find out if there was any significant effect of different pile lengths on the mass loss for the chenille fabric samples. In the analysis, the sample means were compared and the data referring to the samples are given in Table 2.

The result of the analysis of variance is that there was a significant difference between the means of samples with different pile lengths at 0.05 level ($p = 0.00 < 0.05$). Therefore, it is clear that pile length is an effective factor on mass loss. A graph which was drawn with the means of mass loss rates (%) is given in Fig. 6. In this graph, it seems that the lowest mass loss (%) occurred for the sample with 0.7 mm pile length. Here, the mass loss tended to increase as the pile length increased until 1 mm, but later decreased slowly. According to the results of the LSD test, given in Table 3, the level of 0.7 mm pile length is significantly different from other levels at 0.05 level.

How the mass loss occurred was also examined, in order to comment clearly on the results. Therefore, the specimens were examined by using micro projection device. After some double rubs, it seems that some of pile fibers were still gripped by lock yarns, some of the pile fibers had been removed from surface and the lengths of pile fibers were different. In addition to these examinations, some of the yarns were removed from abraded specimens and examined. It was observed that the pile fibers on the top

Table 2 **Means of total percentage mass loss for the samples with different pile length**

	Means of total mass loss (%)			
Specimen	Pile length (mm)			
number	0.7	0.8	1	1.2
1	2.263	3.838	3.805	4.274
2	2.840	4.032	4.073	3.427
3	2.731	2.424	4.384	3.498
4	2.972	3.245	4.124	3.313
5	2.521	3.484	4.139	3.086
6	2.326	3.030	4.574	4.348
Mean	2.579	3.342	4.183	3.658

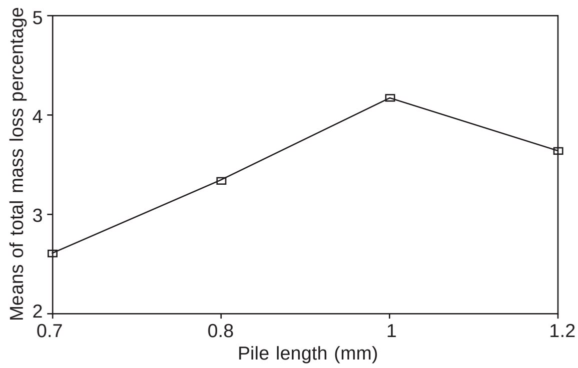

Figure 6 Means of total percentage mass loss for the samples with different pile length.

Table 3 **Results of multi-comparison LSD test**

(I) Pile length (mm)	(J) Pile length (mm)	Mean difference (I–J)	Sig.
0.7	0.8	–7333.333*	0.009
	1	–1574.333*	0.000
	1.2	–1048.833*	0.000
0.8	0.7	733.333*	0.009
	1	–841.000*	0.003
	1.2	–315.500	0.226
1	0.7	1574.333*	0.000
	0.8	841.000*	0.003
	1.2	525.000	0.051
1.2	0.7	1048.8333*	0.000
	0.8	315.5000	0.226
	1	–525.5000	0.051

*. The mean difference is significant at the 0.05 level.

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surface of fabric that was subjected to rubbing motions were removed completely, but the pile fibers on the bottom surface of the fabric, which were not subjected to rubbing motions, were not removed. So, it is clear that the pile fibers on the top surface of chenille fabric are removed not only by slipping off but also by being broken, and the pile fibers on the bottom surface of chenille fabric are still retained mostly because of being gripped by lock yarn.

Some more tests were performed to prove this claim. In these tests the tendency of acrylic fibers to be broken and curl was investigated. Firstly, acrylic fibers were curled as a loop and put between two glass surfaces. When the fibers were subjected to a low tension, they were broken easily. There was the same result for all replications. Secondly, a few acrylic fibers were subjected to one or two rubbing motions between two abradent fabrics in the Martindale abrasion device and examined by means of the micro projection device. It is seemed that some of fibers were curled as loops and bent sharply. In this case, it is possible that the longer pile fibers on chenille fabric may be curled during rubbing motions and broken more easily than shorter pile fibers.

CONCLUSIONS

In this study, the effect of the pile length factor on abrasion resistance of chenille fabrics was investigated. After 20 000 double rubs, it seems that total mass loss rate (%) tends to increase as the pile length increases. The lowest total mass loss rate (%) clearly occurred for the samples with 0.7 mm pile length.

We have also observed that the pile fibers of the chenille yarn were removed not only by completely slipping off but also by being broken. In this case, the properties of the pile fiber type are as important as the friction forces between pile yarns and lock yarns for abrasion resistance of chenille yarns.

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