

## Study on Pilling Test of Cashmere Knitted Fabrics

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**Abstract:** The pilling properties of the cashmere knitted fabrics were tested and analyzed by using Pilling Box, Random Tumbling Pilling Tester, and Martindale Tester. Based on the test results and the actual wear, the pilling test method that was more suitable for cashmere knitted fabric was stipulated and the factors influencing this method were analyzed.

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### 1. Introduction

Fabric pilling test methods include Pilling Box, Random Tumbling Pilling Tester (RTPT) and Martindale Tester. In RTPT, samples tumble in a cork-lined cylinder cavity in which a steel impeller is mounted. The samples are rubbed with each other and with the inner wall of the chamber. The motion of specimen is random. Moreover, the samples could be fixed at the back of the impeller occasionally because the steel impeller collides with specimen directly. Thus, the repeatability of the test results could not be assured. In Martindale Tester, a circular sample is mounted on the instrument and the face of the sample is rubbed against the face of the same samples. The rubbing motion is a lissagous figure. In Pilling Box, samples are mounted on polyurethane(PU) tubes and tumbled in cork-lined cubical wooden boxes that rotate its axle in Pilling Box. In this method, the samples move under the condition of no pressure. The specimen is to conduct mutual transient touching and the rubbing for the samples is random. The research on the pilling of woven fabric has some reports [1-3]. Cooke and Goksory [2] compared the results of the Pilling Box, Martindale Tester, and Accelerator Tester and reported that the Martindale and Accelerator gave reliable results, while the results of ICI's Pilling Box might be misleading. Similarly, Cooke [1] indicated in his earlier work that the ICI's Pilling Box Tester should be avoided, particularly for testing fabrics containing fibers that fatigue rapidly with normal use. Ozer Goktepe [3] tested three different pilling testers, Martindale, ICI's Pilling Box, and pilling drum, using fabric samples to investigate the sensitivity of different testers to various

fabric parameters, and found that different testers might give different pilling results for the some fabric. Martindale Tester gave worse pilling grades than the Pilling Box and Pilling Drum. However, research on the pilling of cashmere knitted fabric has not been reported. This work is to examine the more suitable pilling test technology for cashmere knitted fabric by using a Pilling Box, a Random Tumbling Pilling Tester and Martindale Tester.

### 2. Experimental

The samples were produced by Inner Mongolia Erdos Cashmere Group of China, and the experiment was done at Erdos. All samples were cashmere woolen knitted fabrics with plain stitch. The specifications of cashmere knitted fabric were shown in Table 1. The pill formation and wear-off rates were determined using ICI's Pilling Box, Random Tumbling Pilling Tester, and Martindale Tester, respectively. Fiber diameter was tested using USTER OFD100. The pill on the samples was observed using Motic Digital Microscope. The pilling standards used for rating the fabrics had the following scales: 5=no pills, 4=slight pilling, 3=moderate pilling, 2=severe pilling, 1=very severe pilling.

### 3. Results and discussion

To study a suitable pilling test method, the comparison between the test conditions and the actual wear should be carried out.

**Table 1** Specification of samples<sup>a</sup>.

Sample	Mean Fiber Diameter, $\mu\text{m}$	Mean Fiber Length, mm	Fiber Length <12.5mm, %	Yarn count, tex	Yarn twist, T/10cm	No. of threads per inch
C3165	15.42	32.34	32.36	55.56×2	21.0	8
C2768	15.37	31.46	29.50	55.56×2	21.1	8
C5119	15.38	32.50	24.50	38.46×2	26.5	10.5
W6220	15.19	35.27	30.60	38.46×2	26.2	10.8-10.9
W0022	15.37	35.40	21.70	31.25×2	31.6	12.9-13
W2441	15.39	37.40	25.90	31.25×2	31.8	12.9-13
W4387	—	—	—	38.46×2	24.4	—

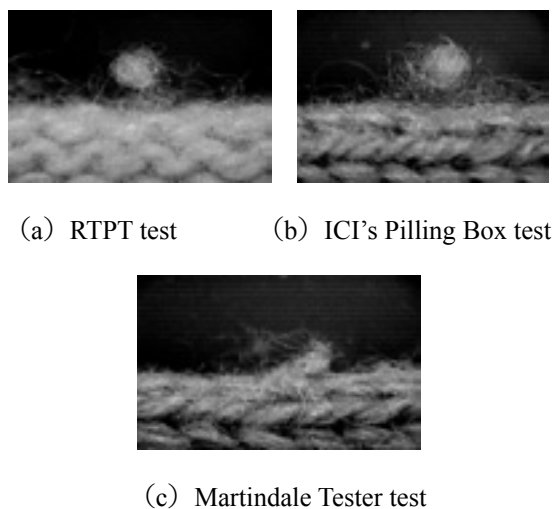
<sup>a</sup>) Sample W4387 had a blend ratio of wool/cashmere(30:70%), and other samples were pure cashmere.

### 3.1 The comparison among the test methods

#### 3.1.1 Pill structure

Cashmere knitwear is rubbed with the various parts of the out wears in actual wear. The pills formed in actual wear have the loose ball-like shape, and are attached to the knitwear surface by anchoring fibers.

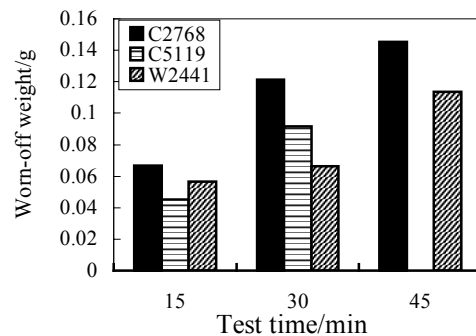
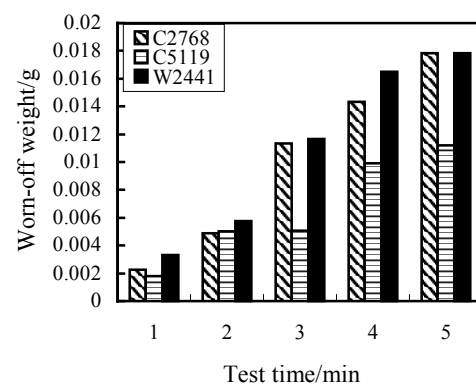
Fig.1 shows the pill structures. It was observed that the pills on fabric for RTPT and Pilling box were more similar to the pills shape for the actual wear. However, the fibers in the pills formed in Martindale Tester test were entangled tightly, and the fibers were elongated into a long shape, not a ball. Thus, the pills formed with Martindale Tester are much different from those in actual wear. Therefore, Martindale is not suitable for the pilling test of cashmere knitted fabric.

**Fig. 1** Pill on the samples.

#### 3.1.2 The comparison of worn-off pills and fuzz

As compared with ICI's Pilling Box, the results show that there are more worn-off pills and fuzz in the case of RTPT for samples C2768, C5119 and W2441

(see Figs.2 and 3). The worn-off pills and fuzz by RTPT for 15min is about 3-4 times of those by Pilling Box for 5 hours. According to actual wear, worn-off pills and fuzz by RTPT were too much.

**Fig. 2** Worn-off weight by RTPT.**Fig. 3** Worn-off weight by ICI's Pilling Box.

Figs.4 and 5 show the mean fiber diameter of worn-off pills and fuzz by RTPT and Pilling Box, respectively. It is observed that mean fiber diameter of worn-off pills and fuzz is smaller than that of blending materials.

#### 3.1.3 Comparison of pill ratings

Figs. 6 and 7 show the pill ratings for the samples

C2768, C5119, and W2441 after RTPT and ICI's Pilling Box tests, respectively. It is observed that the pill ratings decrease with increasing test time by both RTPT and ICI's Pilling Box. Moreover, the pill ratings of the three samples by RTPT are lower than that by ICI's Pilling Box. The pill ratings of the samples are about 1-2 after 30min by RTPT. That is because the force acting on the samples is greater.

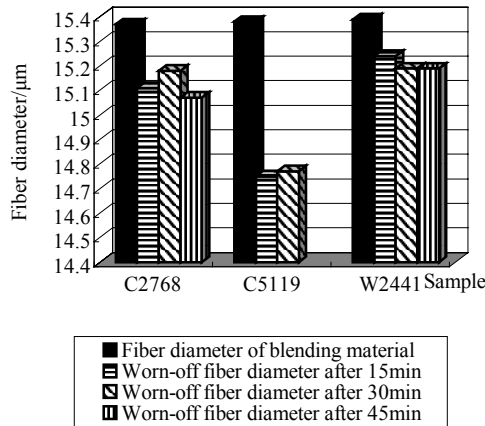


Fig. 4 Worn-off fibers diameter by RTPT.

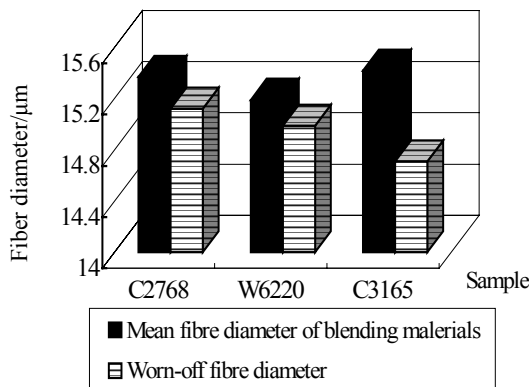


Fig. 5 Worn-off fibers diameter by ICI's Pilling Box.

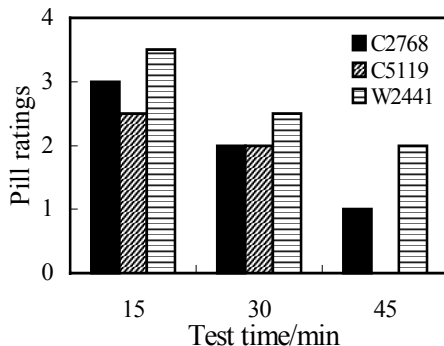


Fig. 6 Pill ratings by RTPT.

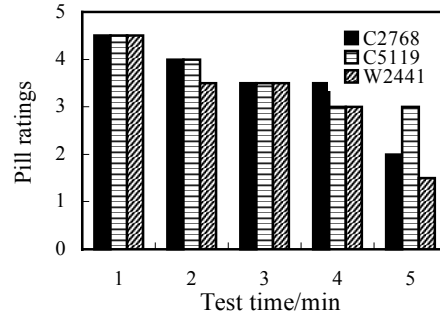


Fig. 7 Pill ratings by ICI's Pilling Box.

Thus, through comparison of tests by RTPT, Martindale Tester, and ICI's Pilling Box, it is concluded that ICI's Pilling Box is suitable for pilling test of cashmere knitwear.

### 3.2 Factors influencing pill ratings by ICI's Pilling Box

#### 3.2.1 Effect of PU tub hardness

Generally, the rubbing between the PU tub and cork-liner is different when the tubs hardness varies. The pill ratings were tested using three kinds of PU tub hardness. Tub A is comparatively soft; Tub B, moderately hard; Tub C, comparatively hard. The experiment was done in three types of pilling box. Table 2 shows the pilling box types used for the test.

Table 2 Pilling Box types.

Pilling Box	Types	Producer	Using time
1	YG1351	Wen Zhou, China	New
2	SDL M227	SDL, UK	2 months
3	P-3	Toyobo, Japan	2 years

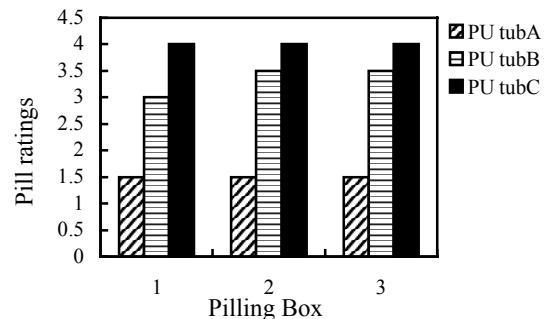


Fig. 8 Effect of PU tub hardness on pill ratings.

The results are shown in Fig. 8. It is observed that pill ratings increase with increasing PU tub hardness for the three pilling boxes. Because high PU tub hardness

will decrease rubbing time between tub and tub, along with tub and cork-liner, which may lead to low pill ratings.

### 3.2.2 Effect of PU tub number

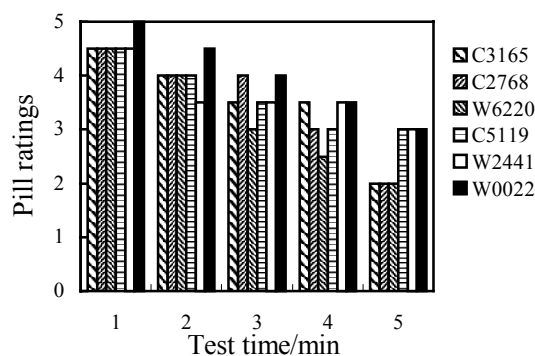
Besides the rubbing between tubs and cork-line, there is also friction between tub and tub in one box. The test results for the number of PU tub in one box influencing pill ratings are listed in Table 3. For one tub in one box, rubbing occurred only between tubs and cork-line, so the pill ratings increase. When the number of tubs in one box increases, the pill ratings decrease because the rubbing action increases.

**Table 3** Effect of number of tubs on pill ratings.

Sample	C3165			W6220		
No. of tub	1	2	4	1	2	4
Pill ratings	5	4.5	4	5	4.5	4

### 3.2.3 Effect of test time

The pill ratings and the worn off pills and fuzz under different test time are shown in Figs.9 and 10, respectively. From the figures, it is observed that the pill ratings decrease but the worn off pills and fuzz up increase, with increasing test time. The pills on fabrics and the worn-off pills and fuzz increased with increasing test time.



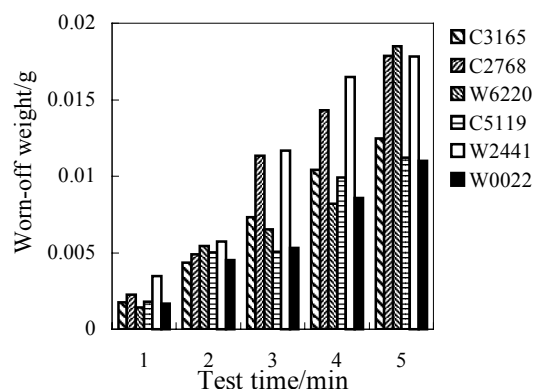
**Fig. 9** Effect of test time on pill rating.

The pill structures under different test time are shown in Fig.11. It is observed that fibers in the pills are entangled more tightly with increasing test time, because rubbing time increases. And, all pills on fabric have a ball shape.

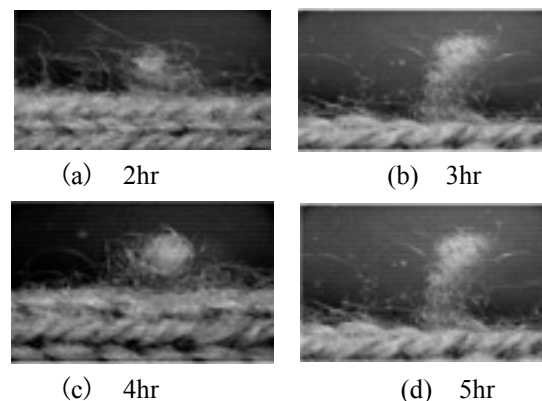
### 3.2.4 Effect of pilling box speed

There are different rubbings when pilling box has various rotational speeds. The rubbing time between tubs and cork-liner increases with decreasing pilling box

speed. For 7200rounds by pilling box, the pill ratings in 30rpm are lower than those in 60rpm(see Table 4). Moreover, the pill shape changes from spheres to entangled long fibers with increasing time (see Fig.12).



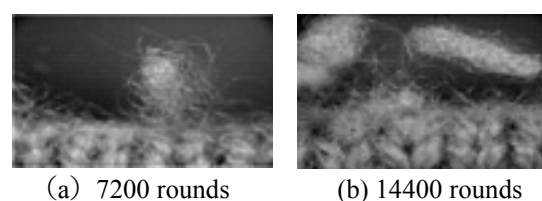
**Fig. 10** Effect of test time on worn-off weight.



**Fig. 11** Pill structure for different test time.

**Table 4** Effect of pilling box speed on pill ratings.

Sample	7200rounds		14400rounds	
	30rpm	60rpm	30rpm	60rpm
C3165	1.5	4	1	3.5
W6220	2	4	1	3



**Fig. 12** Pill structure for different rounds.

## 4. Conclusions

The samples of cashmere knitwear have serious

wear by Martindale and RTPT test. Thus, Martindale Tester and RTPT are not suitable for pilling test of cashmere knitted goods. The hardness of PU tubs, the number of PU tub in one box, speed of pilling box, time of test influence pill ratings. Pill ratings increase and worn-off pills and fuzz decrease with increasing PU tub hardness and with decreasing PU tub number, pilling box speed, and test time. Mean fiber diameter of worn-off pills and fuzz is smaller than that of blending material. The pill ratings decrease but the worn-off pills and fuzz increase with an increase of time of test throughout the period of evaluation.

### Acknowledgement

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### References

1. W. D. Cooke, *J. Textile Inst.*, **74**, 101 (1983).
2. W. D. Cooke and M. Goksoy, *Melliand Textilber. Eng. Ed.*, **69**, 250(E134) (1998).
3. O. Goktepe, *Textile Res. J.*, **77**, 625 (2002).