Indian Journal of Fibre & Textile Research
Vol. 41, September 2016, pp. 338-343

Short Communications

Fabric pilling– Objective measurement system

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Received 10 October 2014; revised received and accepted 30 March 2015

An objective method of measuring pilling profile of fabric has been proposed using an inexpensive newly developed instrumentation. This measurement has been validated by direct measurement of pills using stereo microscope, as suggested by correlation analysis carried out between two sets of data. Results indicate that the objective assessment of pilled fabric could reliably be done by this machine, which can support subjective assessment done by the experts in grading of fabric.

Keywords: Fabric pilling, Fabric fluffiness, Fabric grading, Objective assessment, Pilling profile

Pilling is one of the most common types of fabric surface defect, which causes serious problem to textile industry.Pilling drastically changes the appearance of the fabric, thereby compromising its acceptance for the apparel, home furnishing and other textiles. One has to understand what is pilling to quantify this fabric surface defect objectively.

The pilling of textile fabrics refers an appearance caused by bunches or balls of tangled fibres held to the surface of fabric by one or more fibres. Pilling is an effect of wear and tear that considerably spoils the original appearance of a fabric. Pill generation begins with a migration of fibres to the external part of yarns, so that fluffiness emerges on the web surface. Due to friction, this fluffiness gets entangled and forms somewhat spherical mass called pill. It remains suspended from the web by long fibres – called anchor fibres – still embedded in the yarn and therefore fabric. Because of wear some pills fall off, causing the additional effect of loss of material[1].

Pilling in the fabric can also be generated by artificial means, which can simulate actual wear over the long period. Pilling can be created by subjecting fabric samples to artificial abrasion in different apparatuses and machines like Martindale abrasion machine, tumble machine.

Assessment of pilling from the point of view of grading of textiles is critically important to textile industry. Present day’s popular practice in the textile industry is visual inspection of the pilled surface of the fabric by experts and /or comparing it with photographic standards which are prescribed and supplied by various standardisation agencies like ASTM, BIS, BS, etc. The grading of pilled surface is done on this basis by experts for the evaluation of the pilling. But this practice is very much subjective and depends on the personal expertise in the field. This practicemay generate different grades for the same sample. It also depends upon the expert’s availability and number of experts involved in subjective evaluation.

In the last two decades, sensing the problem of subjective evaluation, researchers have tried to evolve objective assessment methodologies so as to eliminate subjective biases in the assessment of the pilled status of the fabric. Various non-contact methods were used to obtain pilling information from the surface of pilled fabric using digital imaging and analysis worked out so as to extract pilling information[1-9].

The present work involves the development of inexpensive objective pill-grading system using commercially available cheap flat-bed scanner, personal computer and supporting electronics. Tested fabric specimen is mounted on the rubber cylinder which is fixed to the shaft of rotational motor. This part of the pill-machine is developed by the present researchers[10]. This cylinder is just above the glass surface of the flatbed scanner such that the fabric does not touch the glass (Fig. 1). The scanning is carried out in such a manner that the movement of scanner sensor is synchronised with the rotational and translational motion of the fabric cylinder. The scan so obtained is as good as it appears that the fabric is laid flat on the scanner glass. This non-contact aspect of the system helps in reliable objective assessment of the pilling of the pilled fabric surface, as it does not disturb the pill distribution.

Primary aim of the present instrument is to record the pilling information from the pilled surface of the fabric without disturbing surface profile of pills on

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fabric. Complete profile of the pilled surface can be obtained in single cycle of the scanner operation and in a short time interval, without using complicated, and dedicated apparatus set-up.

Experimental

Instrumentation

Figure 1 gives system block diagram of the instrument fabricated. It consists of:

(i) Personal computer—used to obtain scanned image of fabric sample.

(ii) Flatbed scanner

(iii) Pill-cylinder and motor arrangement — pill cylinder for mounting fabric sample and two motors for moving pill cylinder along the linear track and rotating it about the axis, coinciding with cylinder's axis.

(iv) Controller electronics— for sensing movement of light-head of scanner and controlling movement of motors accordingly.

Sample Preparation

Fabric samples were subjected to abrasion using standard procedure and machines. This is done, so that natural wear and tear of the fabric can be artificially simulated when fabric is subjected to machine abrasion. Following two types of pill testers based on tumbling of the specimen were used:

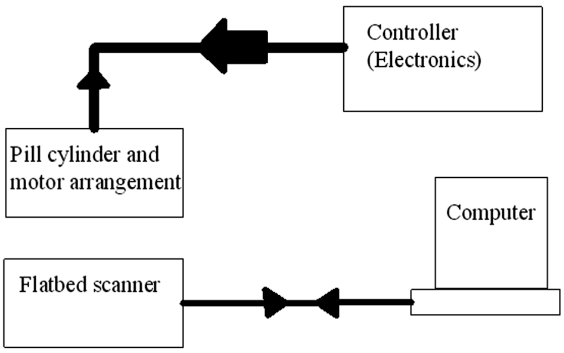

Fig. 1—System block diagram of new instrument

(i) Random tumble pilling tester – In order to form pills that resemble pills formed in wear (in appearance and structure), small amounts of short length grey cotton fibre are added to each chamber with specimen.

(ii) ICI pilling box tester – A piece of fabric is sewn in place firmly around a rubber tube. These tubes are placed inside pilling boxes. These boxes have inner lining of standard abrasive material. Pilling boxes are then rotated at 60 rotations/min for 5 h.

In the present study, ICI pilling box tumbling method (ii) was used to generate pills on the specimen fabric. Fabric was cut into square size pieces as per the standard[11] and mounted one each on pill-cylinder. Such four pill cylinders were then kept in the two boxes of pill tumble machine.These boxes are lined (pasted) inside by special liner material which aids in abrasion of the fabric when it comes in contact with it. This tumble machine was set for 18,000 tumbling rotations. Due to tumbling inside the boxes, surfaces of the fabric sample mounted on pill-cylinder get rubbed against the rough surface of the liner. The rubbing action between two surfaces causes fibres from some part of fabric surface to get broken. These broken fibres get entangled, developing into an oval or spherical ball like structure. These balls are the pills developed on the surface.

Physical properties of woven and knitted fabrics are given in Table 1. Tested fabric mounted on rubber cylinder is mounted on shaft of the motor. With a railing arrangement, the cylinder is made to rotate and move parallel to the scanner glass. This motion is synchronised with the movement of the scanner sensing device/ light-head by using electronic sensors. Scan of the fabric surface is recorded by the computer linked with scanner. Sample scan of a fabric looks like that as shown in Fig. 2.

Table 1—Physical parameters of woven and knitted fabrics

Property	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Threads/ length					
Ends or courses /cm	24	36.6	37	24	8.7
Picks or wales /cm	22	28.7	31.9	15.7	4.7
Yarn count (tex)					
Ends or courses /cm	20.4	10.5	12.8	16.4	73.8
Picks or wales /cm	20.4	12.8	13.4	16.4	73.8
GSM	213	77	96	16.4	73.8

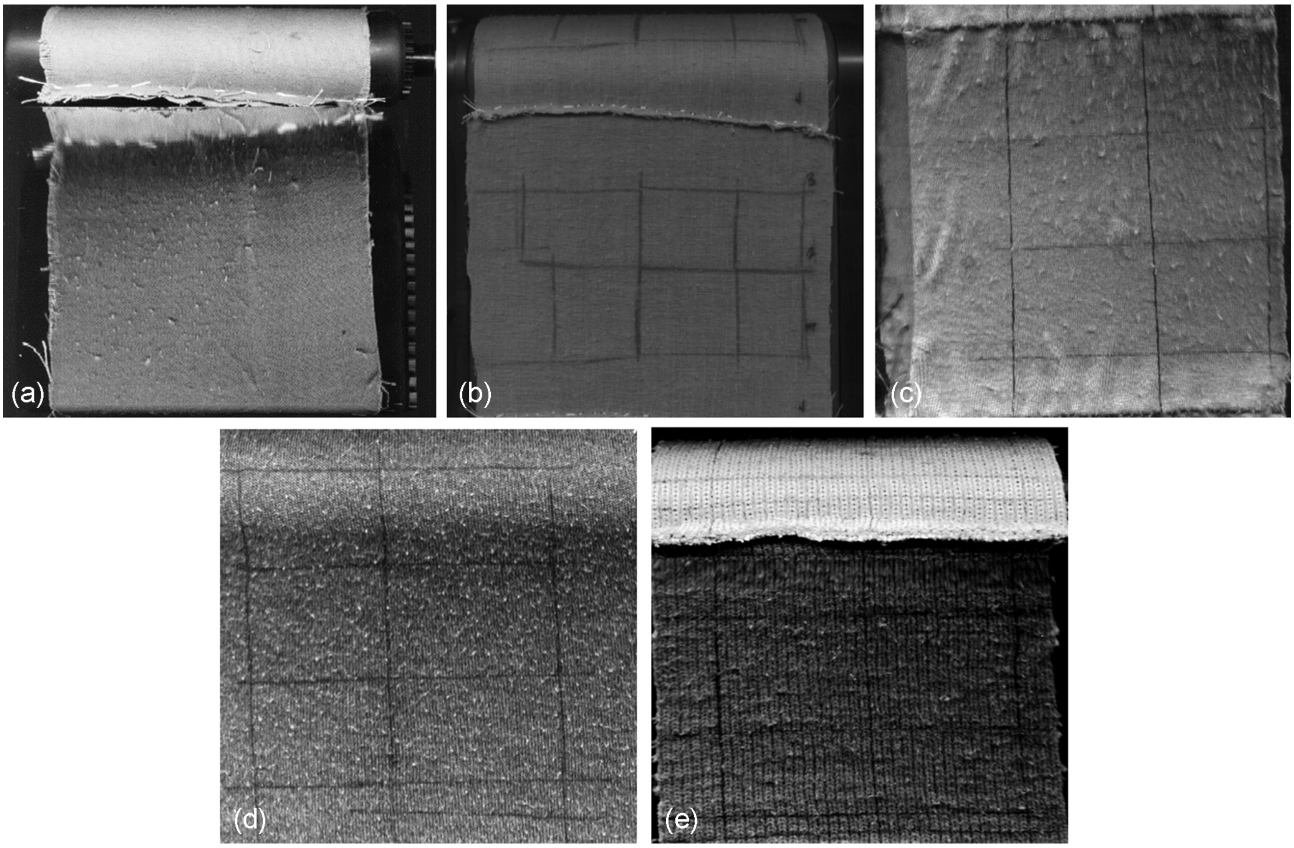

Fig. 2—Digital images of fabrics with pilled surface acquired using new instrument (a) Sample 1, (b) Sample 2, (c) Sample 3, (d) Sample 4, and (e) Sample 5

Results and Discussion

The work has been carried out in two parts.In the first part, Scanning of the Surface profile of the pilled fabric specimen is carried out using flatbed scanner operated from computer and controller electronics of the machine. It's a non-contact capture of the pilled surface of the fabric specimen which preserves the status of the fabric surface after tumbling. Such unspoiled and untouched surface profile scan,clearly present most of the details of pilled surface.Here researchers have employed frequency domain analysis technique in the study of pilled fabric images, which helps in identifying /detecting localised features in an image.

A pilled fabric image embeds varied types of information such as regular base structure or weave pattern of the fabric, fabric surface unevenness, defects such as pills,background illumination present at the time of capturing image. This information exists in the image frequency domain at different frequency bands which can be deciphered by using wavelet analysis. Wavelet transforms and analysis are based on small waves called wavelets, of varying frequency and limited duration, wherein appropriate wavelet is used to decompose image into sub images. Each such sub image brings out specific information about the fabric surface as stated above.

Here tool used for the wavelet/frequency domain analysis is discrete wavelet transform,which decomposes an image at one scale into one low frequency approximate sub-image and three high frequency detail sub-images at that decomposition scale, corresponding to horizontal (D_h), diagonal (D_d) and vertical (D_v) detail coefficients , oriented at angles of 0°, ±45° and 90° respectively. At each scale of wavelet analysis, the new approximation of the original image is developed by performing the decomposition process on the current approximation of the image. The pilled fabric image is decomposed using haar-wavelet, and reconstructed at different scales by simply retaining the Scale $j(S_j)$ detail coefficient, and setting the other scale ($S_1, S_2, \ldots, S_{j-1}, S_{j+1}, \ldots, S_J$, where J is the total number of decomposition scales) detail coefficients to zero.

Appropriate scale was chosen so that the reconstructed image derived from wavelet analysis does have distinct and prominent pill-profile with minimum appearance of underlying fabric structure orfuzz appearance[12,13]. The reconstructed image is analysed using program-code written in Matlab software, taking advantage of various functions available in image processing toolbox, to derive useful pilling features such as number of pills,pill area, and pill perimeter.

In second part of the work, direct measurement of the prominent pills was undertaken to authenticate/validate the measurement of the pilling features done in the first part. Direct measurement was done using Motic stereo microscope with mounted moticam digital camera 2300 with ½" CMOS imaging chip having live resolution of maximum 2048 × 1536 pixels. It is provided with USB 2.0 as data link to the personal computer. To observe images, Motic Images Plus 2.0 software is provided by the manufacturer. Stereo microscope with digital camera was first calibrated using the standard procedure and calibration slide provided by the manufacturer, for the measurement purpose. Calibration was done for ×1,×2,×3 and ×4 magnification, which enabled measurement of few properties of the prominent pills like area, major axis-length, minor axis length, perimeter. Measurements could be done in micrometre. Figure 3 shows photographs of the tested fabrics as taken by Motic stereo microscope.

For direct viewing of the pills,the pill cylinder with mounted fabric sample was placed in holder. It has facility to slide along the length and width when kept under the objective of the microscope. Systematic sliding ensures sequential capturing of images, leading to total coverage of the fabric sample mounted on the pill-cylinder. As the pills' appearance is very clear, it helps in identifying them individually and labelling. This is laborious and time consuming part compared to direct measurement done on the machine.

After both measurements, correlation analysis was carried out between two sets of measurements. Correlation coefficient was determined using Karl Pearson' method[14]. Following five samples are selected for this validation exercise:

(i) Sample 1—Brown fabric has 81 data pairs [Fig. 4(a)].

(ii) Sample 2—Pillow cover cloth has 49 data pairs [Fig.4(b)]

(iii) Sample 3—Polyester-Viscose has 64 data pairs [Fig.4(c)]

(iv) Sample 4—Hosiery (Black-knitted) has 100 data pairs [Fig.4(d)]

(v) Sample 5—Wool (White-knitted) has 106 data pairs [Fig. 4(e)]

Pilling assessment of fabrics was carried out in identical manner on all fabric samples, using the

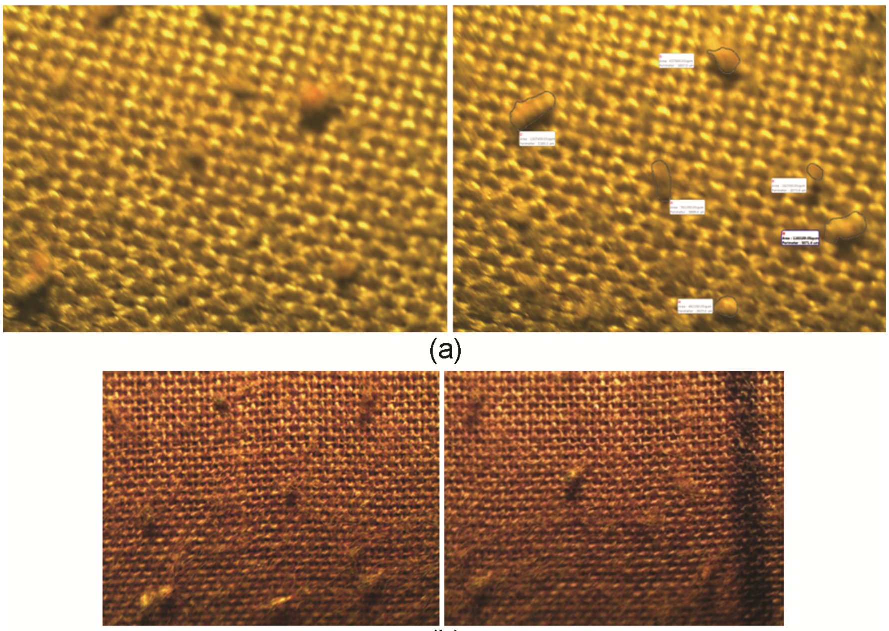

Fig. 3—Motic pictures of pilled surfaces of (a) Sample 1, and (b) Sample 2

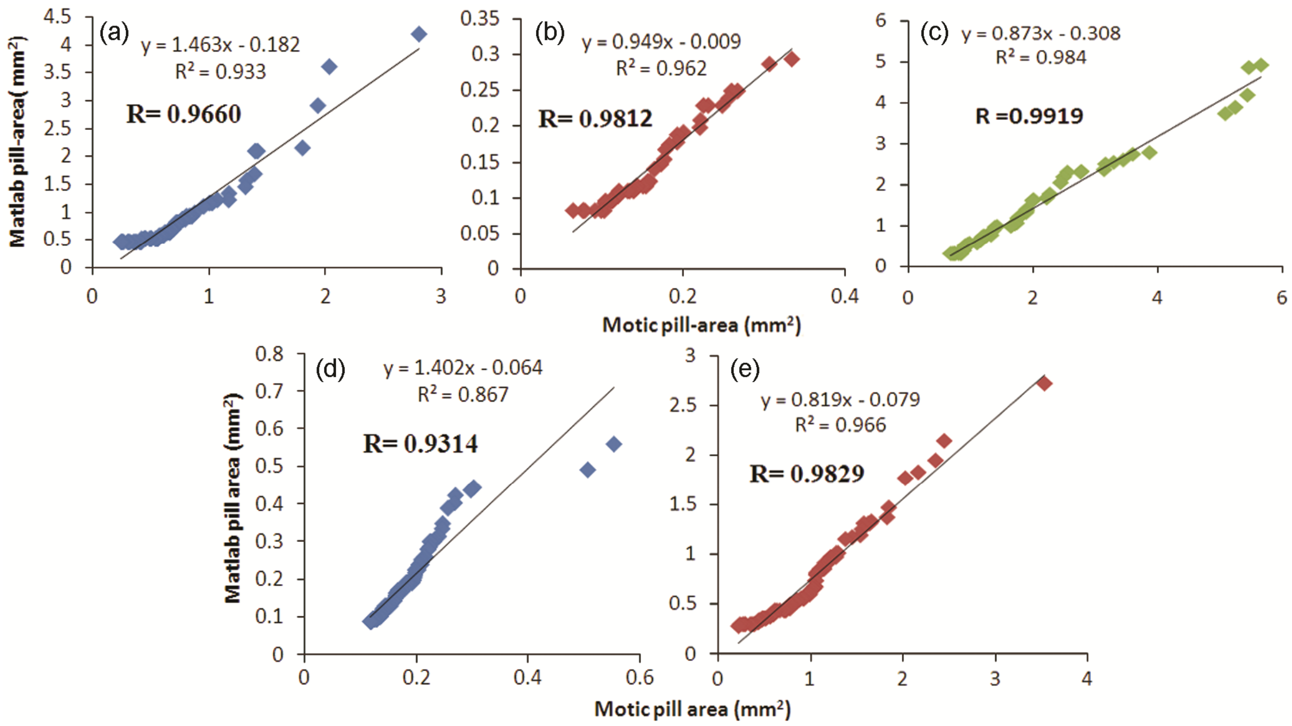

Fig. 4—Correlation graphes for (a) Sample 1 (81 pairs), (b) Sample 2 (49 pairs), (c) Sample 3 (64 pairs), (d) Sample 4 (100 pairs), and (e) Sample 5 (106 pairs)

procedure laid out in the description and on the machine developed by the researchers.

For correlation analysis, Moticstereo microscope area measurements are taken on the x axis, while Matlab area measurements are taken on the y axis. Figure 4(a) shows the relationship for Sample 1. High correlation coefficient of 0.9660 shows that these measurements can be linearly related.

Sample 2 was divided into six rectangular parts as can be seen in pilling profile-scan [Fig. 2(b)] taken on the newly developed machine as shown below:

A	B	C
D	E	F

Out of these six parts, part "E" was selected for comparative measurement of pilling by the two systems. Figure 4(b) shows linear relationship between the two measurements with correlation coefficient of 0.9812.

Other fabric Samples (3 – 5) were sub divided for the purpose of convenience, into six rectangular parts marked as given, one part is selected for further measurement and analysis:

A	B
C	D
E	F

For Samples 3 and 4, part "F" from pilling profile scan [Figs 2(c) & (d)] was selected for comparative measurement by pilling the two systems. Figures 4(c) and (d) show linear relationship between the two measurements with correlation coefficients of 0.9919 and 0.9314 respectively. For Sample 5, from pilling profile-scan [Fig. 2(e)], part 'C' is selected for comparative measurement. Figure 4(e) shows linear relationship between the two measurements with correlation coefficient of 0.9829. All the correlations are statistically significant.

These strong positive correlations between two sets of measurements for five widely different samples indicate that matlab code assessment using the newly fabricated device can be used as a quicker method for objective evaluation of pilling of fabrics.

Measurement of the pills using the stereo microscope and the proposed machine show high correlation. It certainly brings out the utility and usefulness of this technique. It can be used in further investigation of pilling phenomenon associated with wide variety of fabrics. Objective assessment of the pilling of the fabrics done with this proposed machine can be used as a supportive method along with subjective method of visual observation (rating by experts). With further investigation and study, this method could become independent objective assessment method of pilling potential of the fabric.

Acknowledgement

Authors are thankful to Head of Microbiology Department, Ramnaran Ruia Collage, for providing permission to use motic sterio microscope. Thanks are also due to Mr Panwar, Mr Banergee and Mr More of Yarn Testing Section of CIRCOT for helping in measurement.

References

1 Abril H C, Millán M S, Torres Y & Navarro R, *Opt Eng*, 37(11) (1998)2937.
2 Tao S X, *Text Res J,* 70(12) (2000)1076.
3 Kang T J, Cho D H & Kim S M, *Text Res J,* 74(11) (2004)1013.
4 Chen X & Huang X B, *Text Res J,* 74(11) (2004)977.
5 Kim S C & Kang T J, *Proceedings,* (*IEEE*) *Conferenceon Instrumentation and Measurement Technology,* Vol.1 (IEEE) 2005, 628.
6 Behera B K & Madan Mohan T E, *Int J Clothing Sci Techol,* 17(2005) 279.
7 Cherkassky A & Weinberg A, *Text Res J,* 80 (2010), 226.
8 Mendes A, Fiadeiro P T, Pereira M J T & Dual R A L M, *Text Res J,* 80(2010) 1201.
9 Xu B, Yu W &Wang R W, *Text Res J,* 81(2011) 2168.
10 Nachane R P & Mayekar V M, *Indian Pat* Application No. 362/MUM/2013.
11 *Indian Standards Specifications* IS: 10971 (Bureau of Indian Standards, New Delhi), 2006.
12 MATLAB Image Processing toolbox, Version 7.6.0.324 (R2008a), Wavelet toolbox, Version V4.2, (R2008a), (The MathWorks Inc.), 2008.
13 Zhang J, Palmer S & Wang X, *Text Res J,* 77 (2007) 871.
14 Kothari C R, *Quantitative Technique*s (Vikas Publishing House Pv tLtd, New Delhi), 1984, 231.