Evaluation of fabric hand by extraction method

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A simple nozzle extraction method for measuring objectively the fabric handle has been used. This method is based on the use of a simple attachment fitted to a tensile testing machine and measures the force generated while extracting a circular fabric specimen through a nozzle. Different testing variables, like presence of supporting plate, extraction speed and shape of the specimen, have significant effect on peak extraction force, whereas the number of pass does not have any specific effect on the extraction behaviour of fabric. Chemical finishing results in reduction in extraction force and at the same time the traverse-at-peak extraction force also reduces with the chemical finish.

Keywords: Cotton, Extraction speed, Fabric hand, Peak extraction force, Polyester, Traverse-at-peak force, Viscose

1 Introduction
Handle is one of the most widely used fabric attributes followed by both industry and the consumer in determining the acceptability of goods for their end-use. It also influences consumers' preferences and their perception of the usefulness of the product. Looking at the importance of this property, there have been continuous efforts to quantify the fabric hand objectively. At present, there are few instruments available for evaluating fabric handle objectively and the Kawabata evaluation system for fabrics (KESF) is the most sophisticated among them. The main disadvantages of this instrument are high cost, complexity and time-consuming procedure that restrict its industrial applications, especially for small-scale apparel and textile manufacturers, processors and merchandisers.

Attempts have been made to overcome these limitations of complicated measurement and to develop a simple, inexpensive and reliable objective method to screen differences in fabric handle. Researchers have investigated simpler extraction measurement techniques. In these methods, the force generated while withdrawing a fabric specimen through a ring or nozzle was measured. The extraction force generated due to the combined deformations of fabric sample related to the bending, shear, tensile, compression and friction. The test apparatus consisted of an attachment fitted into a tensile testing machine. Measurements of this withdrawal force proved reliable in detecting changes in fabric handle. The earlier studies on fabric hand by extraction method concentrated on correlating either the withdrawal (or extraction) force with KESF measurements or the withdrawal force with hand related surface and physical properties. The fabric surface and physical properties are not the only parameters on which the extraction force depends. The variables during testing, like speed of extraction, repetition of extraction, presence of supporting plate of sample, shape of sample, may also have some effect on extraction force. No information is available on these aspects.

In the present work, the effect of different testing variables, like speed of extraction, shape of the samples during extraction and presence of supporting plate of sample, on the extraction behaviour of cotton and blended fabrics has been studied. The effect of chemical finishes on extraction behaviour has also been reported.
2 Materials and Methods

2.1 Materials

The measurement of handle is important for apparel fabrics and the most popular blend used for apparel is 100% cotton and polyester/viscose (P/V). So, in the present study, two fabrics, one each of 100% cotton and P/V blend (apparel grade), of reputed Indian brand were obtained from the market. The details of fabric constructional parameters and physical properties are given in Table 1. To observe the effect of chemical finish on fabric hand, three unfinished fabrics were selected for the chemical treatment. All the fabrics were conditioned in a standard atmosphere of 27 ± 2°C and 65 ± 2% RH for 24 h before testing.

2.2 Measurement of Extraction Force

In the present study, the method developed by Grover et al. is used. The measurement attachment (Fig.1) is mounted in SDL tensile tester. A circular fabric specimen, 250 mm in diameter and held by a pin, is drawn through a cylindrical nozzle of highly polished steel (20 mm diameter and 20 mm height). The fabric sample should be free from wrinkles and crease. As the top jaw with which the connecting pin is attached moves upward, it extracts the circular fabric specimens through the nozzle. The force required to extract the fabric specimens through the nozzle changes as more and more of the specimen is introduced into the nozzle. The fabric specimen gets folded, sheared, rubbed, compressed and bent during extraction. The extraction force can be recorded by the instrument. A typical force-displacement curve is shown in Fig. 2. The fabric handle behaviour is defined by the two parameters: (i) peak extraction force, and (ii) traverse-at-peak extraction force. Traverse-at-peak extraction force is the movement of cross-head from where the fabric sample starts exerting resistance to extraction till the force reaches to its maximum. Both these parameters can be obtained from force-displacement curves. Higher peak extraction force indicates stiffer fabric and higher traverse-at-peak extraction force indicates smoother fabric surface. The extraction force is the combination of fabric resistance to bending, compression, shear, extension and sliding. The effect of presence of supporting plate, extraction speed, shape of specimen and number of pass on peak extraction force and traverse-at-peak force is shown in Tables 2 and 3. All the fabrics were tested with face side up.

When a circular fabric sample is extracted through a nozzle, it takes any random shape, depending on its physical and structural behaviour. To eliminate the
randomness in taking shape, a circular supporting chrome-polished plate with 150 mm diameter has been introduced 40 mm below the nozzle. The fabric samples were extracted with and without the supporting plate at a speed of 100 mm/min with random shape of specimen to observe the effect of presence of supporting plate. The speed of extraction was changed from 50 mm/min to 400 mm/min to study the effect of extraction speed. The study was conducted without supporting plate and with random shape of specimen.

When the circular fabric specimen, held by a pin, is extracted through the nozzle, it takes any random shape. The randomness of the shape can also be controlled, to some extent, by extracting the specimen in folded condition. In the present study, the effect of fabric fold was studied by extracting the fabrics in folded condition, i.e. one and two folds, at a speed of 100 mm/min and without any supporting plate. The effect of repeated pass on extraction behaviour has also been studied. The same specimen was extracted repeatedly for two, three and four passes. The study on the effect of chemical finish was also carried out on three fabrics with three different types of chemical and two levels of finish concentration (Table 4). In these studies, the speed was kept at 100 mm/min, no supporting plate was used and the shape of the sample was random.

### 3 Results and Discussion

Different testing parameters and their effect on the extraction behaviour of fabrics are discussed in the following sections:

#### 3.1 Presence of Supporting Plate

It is evident from Table 2 that the presence of supporting plate has very significant effect on the extraction behaviour of the fabrics. The fabric samples when tested without supporting plate show a drastic reduction in the extraction force. This may be due to the presence of supporting plate which exerts an extra drag force on the fabric. This extra drag force...
is due to the interaction between supporting plate and backside of the fabrics. Traverse-at-peak force becomes lower when the specimen is extracted with supporting plate. The extra drag force exerted by the supporting plate acts on the fabric specimen till the fabric is in touch with the supporting plate and this results in the force development more quickly.

3.2 Extraction Speed

Table 2 also shows that as the extraction speed increases the peak extraction force increases for all the samples. The traverse-at-peak force shows a decreasing trend with the increase in speed. The reason may be that at slower speed the fabric samples get sufficient time to orient the folds in the favourable direction, i.e. the direction of folds where least force is required to bend the fabric. Also at slower extraction speed, the process of orientation and re-orientation of folds continues for a longer duration before reaching the peak force. A prominent stick-slip nature of the load-displacement curve near the peak extraction force is visible in case of slower extraction speed, which indicates the dominancy of fabric sample to nozzle surface friction at slower speed. At higher speed, on the other hand, the fabric bending and shearing forces dominate where prominent stick-slip nature is not visible.

3.3 Shape of the Samples

Table 3 shows that for lighter fabrics (C₁ and S₁), as the fabrics are folded prior to extraction, the extraction force drops and it further reduces as the number of folds increases. This is due to the fact that folding of specimen before extraction may have reduced the initial resistance of fabric bending. But for heavier fabrics (C₂ and S₂), the peak extraction force increases with one fold and then drops when the number of folds increases to two. The initial increase in extraction force may be due to the increase in stiffness with semi-circular shape of heavier fabrics, which resists more during extraction, but as the number of folds increases further the fabric specimen exerts lesser resistance force during extraction. No specific trend is observed in traverse-at-peak extraction force when the specimens are being folded.

3.4 Number of Pass

It is observed from Table 3 that the number of pass does not have any definite influence on both peak extraction force and traverse-at-peak force.

3.5 Effect of Chemical Finishes

Table 4 shows the effect of chemical finishes on extraction behaviour of three fabrics (two cotton fabrics and one polyester/viscose blended fabric). It is clear from the table that the application of chemical finish reduces the peak extraction force significantly for all the fabrics. The reduction in extraction force is maximum with cationic silicon finish for cotton fabrics, but the PV blended fabric shows a maximum drop in extraction force with amino silicon finish. The reactive finish shows a least improvement in handle force for all the samples. The lower concentration (20 g/L) of cationic silicon and reactive finishes is found to have more improvement in extraction force than the higher concentration (40 g/L) for all the samples. But the application of amino silicon finish shows a reverse trend, i.e. finish application at higher concentration results in a better fabric handle. Table 4 also shows a drop in the values of traverse-at-peak force for all the finishes and the values reduce with the increase in finish concentration. The analysis of load-displacement curves shows that the prominent stick-slip nature is visible near the peak extraction force of the curves for untreated fabrics, whereas for finished treated fabrics the stick-slip nature has been minimized substantially due to the reduction in surface friction. These results indicate that the application of finish improve the surface characteristics, which improve the fabric handle.

4 Conclusions

4.1 The presence of supporting plate increases the peak extraction force for all the samples.

4.2 The extraction of fabric sample at higher speed results in increase in peak extraction force. At slower speed, the fabric-to-nozzle surface friction plays a prominent role, whereas at higher speed the fabric bending and shearing become dominant in determining extraction force.

4.3 At higher extraction speed, the peak force reaches at lower traverse for all the fabric samples.

4.4 As the fabric specimen is folded, the peak extraction force reduces for lighter fabrics, but for heavier fabrics it increases initially and then decreases with the increase in number of folds.

4.5 The number of pass does not have any effect on extraction behaviour of the fabrics.

4.6 Application of chemical finish results in reduction in peak extraction force for all the fabrics and the
concentration of finish has significant effect on extraction force.

4.7 The traverse-at-peak force reduces with the application of finishes and at higher concentration it reduces further.

References