Morphological Deformities in Cotton

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SYNOPSIS

Eight types of structural deformities have been identified in cotton fibers by using the SEM, and their incidence has been quantified in four varieties grown in India. Although the total number of deformities per cm was found to be nearly equal in these four varieties, their number showed a wide spread when structural reversals (which constitute one class of deformity) were excluded. The correspondence found between the number of defects other than reversals and the drop in bundle tenacity with increase in gauge length seems to suggest that weak links other than reversals might strongly influence fiber strength.

INTRODUCTION

The tenacity of cotton fibers at zero gauge length is quite high and is known to be well correlated with the orientation of microfibrils within its cell wall. The tenacity, however, is observed to fall rapidly as a function of gauge length.[1–5] Further, the rate of fall in tenacity as a function of gauge length differs for different cottons. It is broadly observed that varieties characterized by long, fine fibers (*G. barbadense* species) show a much smaller drop in tenacity as compared to those possessing short and coarse fibers (*G. arboreum* and *G. herbaceum* species).[1,4,5]

Several researchers in the past have regarded structural reversals as weak links in cotton fibers[6–8] and have attempted to explain the fall in tenacity in terms of the frequency of reversals observed in different cottons. But these attempts failed because *barbadense* and *hirsutum* varieties were found to have better strength and strength uniformity than did *arboreum* and *herbaceum* cottons in spite of the higher incidence of reversals.[1,4,5] This result led to the surmise that other weak points besides structural reversals distributed along the length of fibers might be responsible for the observed tenacity fall.

To ascertain whether weak links other than structural reversals exist in cotton, we scanned broken ends of fibers under the scanning electron microscope (SEM) and found that rupture is associated with one or another of different types of morphological deformities in the fiber. A detailed study of the types of deformities in different varieties and their likely association with the fiber strength is being carried out at the Cotton Techological Research Laboratory (CTRL), Bombay, India. This communication highlights some of the initial findings based on observation of fibers from four cotton varieties, each chosen from a different species.

EXPERIMENTAL

Four varieties of cotton, one from each species, were chosen for the study. One hundred fibers from each cotton variety were examined under the SEM (Cambridge Stereoscan S-150) for the number of deformities of different kinds. Preliminary study had shown that deformities occur randomly along the length of fibers and that there is no significant change in their number toward the base or tip of the fiber. Hence, in the present work, scanning was restricted to 1 cm length from the middle portion of each fiber. The average number of deformities of each type was then calculated for the cotton.

Fiber bundle tenacity was determined at nominal zero and 3.2 mm gauge lengths by using a Stelometer by the standard procedure.[9] Ten bundles were tested from each cotton sample. Each broken bundle was individually weighed so as to arrive at the tenacity.

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The average of 10 values of tenacities is presented here as the bundle tenacity of each cotton variety.

RESULTS AND DISCUSSION

SEM micrographs of broken ends of cotton fibers observed during the preliminary study referred to in the Introduction are shown in Figure 1. Morphological deformities near the zone of break are discernible in these micrographs. From careful SEM observations of unbroken fibers belonging to different varieties of cotton, the following eight types of morphological deformities could be identified:

(i) V-bend
(ii) U-bend
(iii) Sharp twist
(iv) Knee

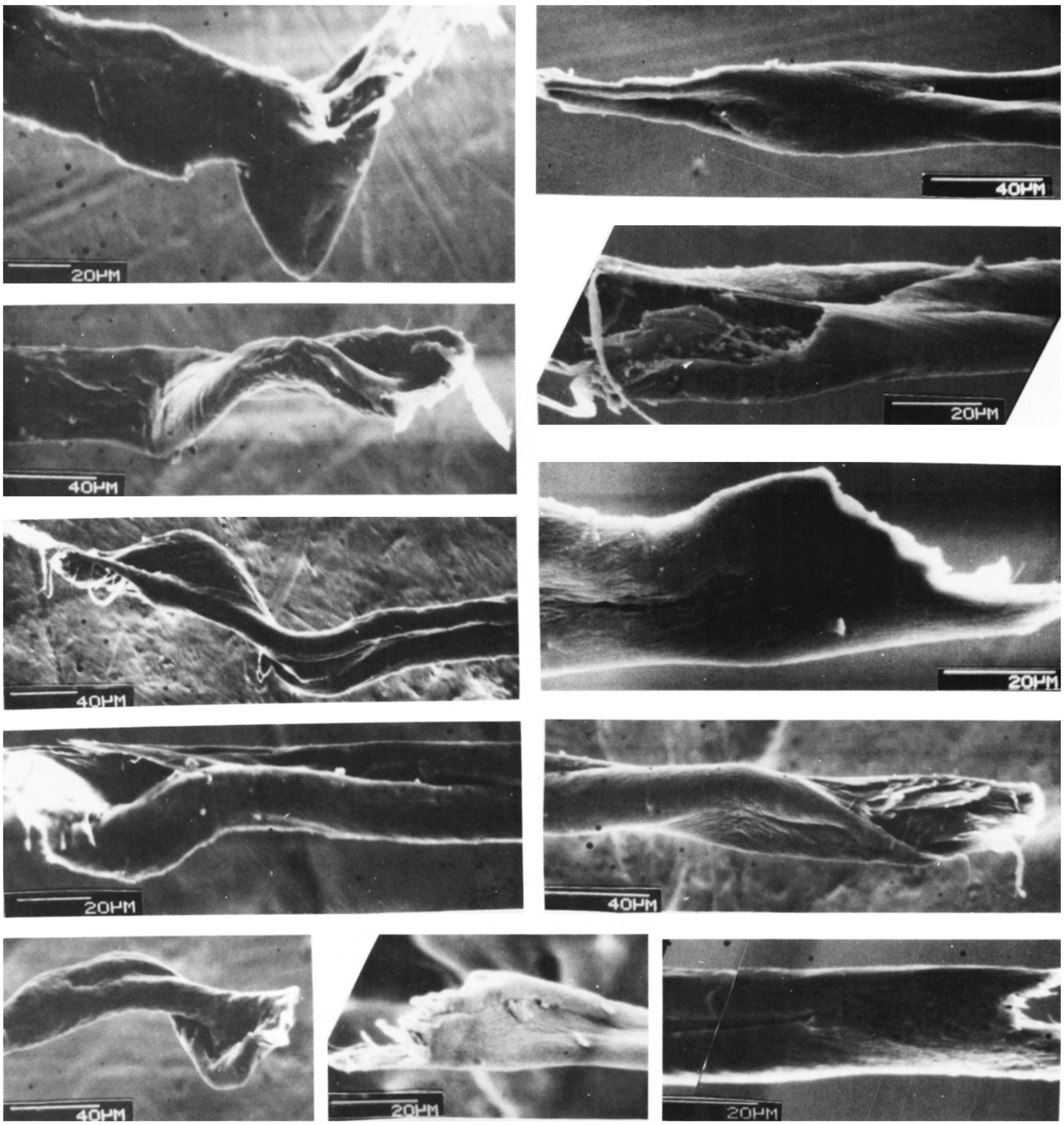

Figure 1 Different kinds of morphological deformities in cotton fibers occurring near the zone of breaks in a tensile test.

(v) Reversal of direction of convolution associated with structural reversals
(vi) 90° rotation of bean-shaped cross section
(vii) 180° rotation of bean-shaped cross section
(viii) Edge twist

The physical nature of these deformities are quite clear from the micrographs in Figure 2. Defect (v), as noted above, is the reversal of convolution direction. Since this occurs invariably with each structural reversal, the two can be taken to be synonymous.

Data on structural deformities in different varieties of cotton are given in Table I together with data on bundle tenacity. From these data, it is clear that structural reversals constitute the most common type of deformity. The total number of deformities is nearly equal (35–36/cm) in three varieties,

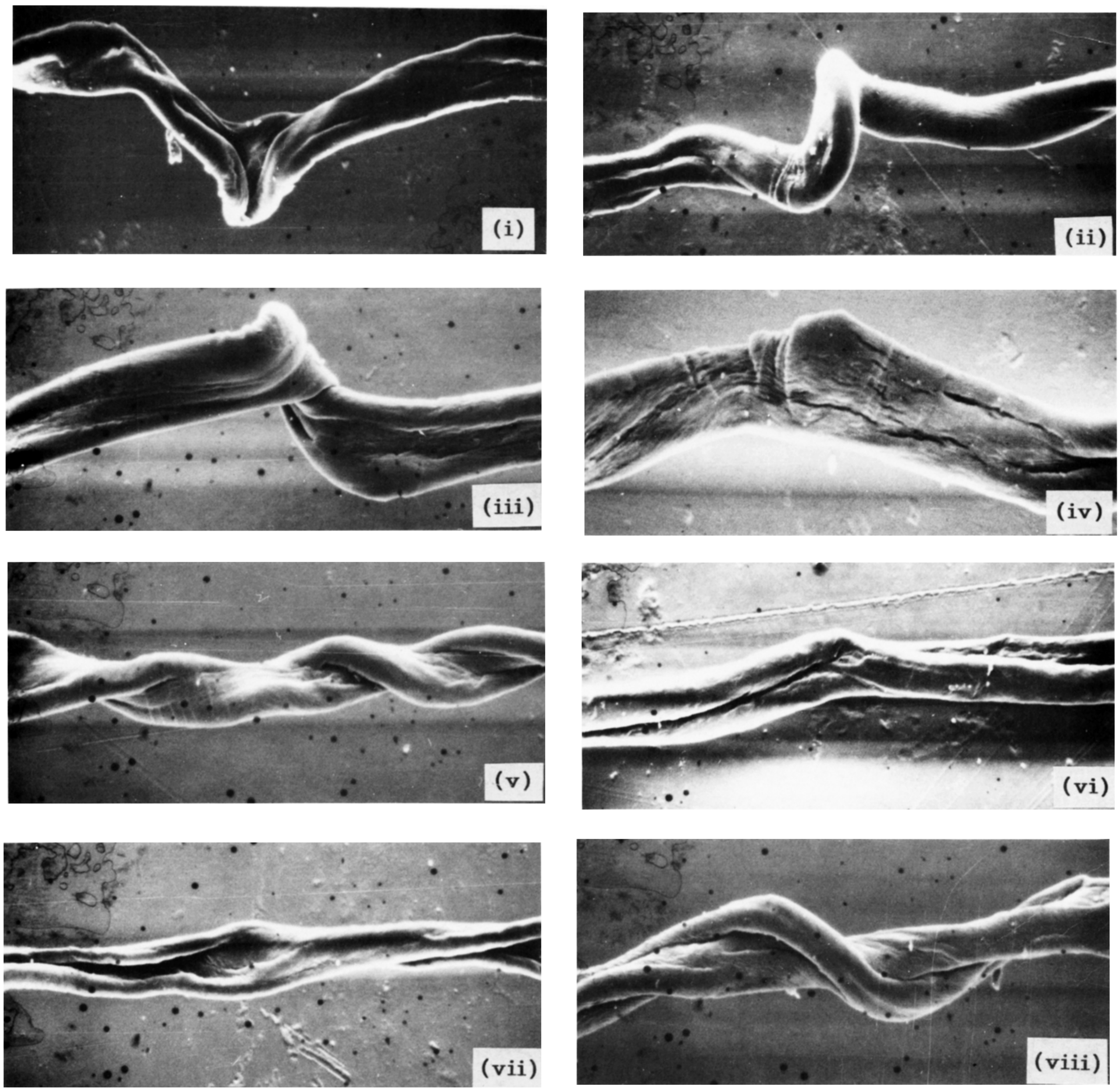

Figure 2 Morphological deformities in cotton fibers: (i) V-bend; (ii) U-bend; (iii) sharp twist; (iv) knee; (v) reversal of direction of convolution associated with structural reversal; (vi) 90° rotation of the bean-shaped cross section; (vii) 180° rotation of the bean-shaped cross section, (viii) edge twist.

Table I Different Kinds of Morphological Deformities in Four Cottons Belonging to Different Botanical Species and Their Bundle Tenacity

Variety	No. Deformities/cm of the Type					Total No. Deformities/cm	Deformities per cm Excluding (v), the Structural Reversals	Bundle Tenacity (g/t) at a Gauge Length of		Drop in Tenacity (%)
	(i–iv)	(v)	(vi)	(vii)	(viii)			0 mm	3.2 mm	
Suvin (*G. barbadense*)	0.9	22.2	1.9	8.0	2.8	35.8	13.6	53.1	38.8	27
Varalaxmi (*G. hirsutum*)	0.8	18.8	2.3	10.0	2.2	34.1	15.3	48.2	26.9	44
Jayadhar (*G. herbaceum*)	2.9	11.9	1.7	6.5	6.7	29.7	17.8	47.2	24.1	49
AK.235 (*G. arboreum*)	2.3	15.1	1.6	8.6	7.0	34.6	19.5	47.7	23.2	51

whereas one (Jayadhar) presented a lower figure (29.7/cm). However, when structural reversals are excluded, the number of deformities show a wide spread among the varieties (13.6–19.5/cm).

A significant feature of the results in Table I is the apparent association between deformities and fiber strength. Although three of the samples have nearly equal strength at zero gauge length, the tenacity values obtained at 3.2 mm show a spread. Although the data were not put to any test for statistical significance, the percentage decrease in tenacity resulting from an increase in test length from zero gauge to 3.2 mm seems to have excellent correspondence with the number of deformities other than structural reversals. Suvin, with 13.6 deformities per centimeter, suffers the least fall (27%) in tenacity when the gauge length is raised to 3.2 mm. On the other hand, AK.235, with as many as 19.5 deformities per centimeter, shows a strength reduction of 51%. The other two cottons also show a similar trend.

It is interesting to note that when structural reversals are also taken into account, the deformities as noted earlier, are nearly equal in all varieties and the correspondence tends to disappear. Although the data presented here are too meager to justify generalization, they do contribute to strengthening the view that weak links other than structural reversals might have a major role in the tensile behavior of cotton fibers.

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