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Scanning Electron Microscopic Studies on Jute Yarn: Effect of Twist on Surface Structure

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Scanning electron microscopic studies of jute yarns of different twists and counts showed that at low twists, all the filaments in the yarn did not lie in the direction of twist; as the twist gradually increased, the filaments took up the direction of the twist and made the yarn structure compact. Although some of the jute filaments making up the yarn suffered various types of damage during processing, increased damage like surface peeling, cracks and, in some cases, complete fracture of surface filaments in the yarn of higher twist took place. At lower twists the effect of carding on the filaments was predominant, and at higher twists both carding and twisting resulted in damaging effects on the filaments.

Keywords: Jute yarn, Scanning electron microscopy

1 Introduction

Jute filaments in the plant are joined together in a long reed forming a big mesh. To make the filaments spinnable the mesh needs to be split and broken into filaments by the processing system and finally the filaments need to be made finer and more suitable for spinning. The dependence of strength of yarns of jute and other fibres on twist has been studied by several workers. Chakrabarty[1,2] studied the relationship of the strength of jute yarns with twists of yarns of different grists. Below a certain twist the yarn does not have a measurable strength. Above this twist the yarn strength gradually increases till it reaches a maximum. On further increase in twist the yarn strength falls off. Degruy *et al.*[3] investigated the effect of yarn twist on the abrasion resistance of cotton yarns. Bandyopadhyay[4] examined the tex-tenacity relationship in jute yarns of different twist factors. Gregory[5] observed that in cotton yarn twisted to maximum strength, the majority of the fibres breaks by virtue of the twist, but the full contribution of the fibres to the strength is not realized because of their inclination to the axis. Fibres near the axis of the yarn are less inclined and less strained, whereas the fibres on the surface suffer maximum strain with increase in twist, and rupture of the yarn is mainly due to rupture of surface fibres. Hearle[6] showed how the details of cotton fibres showing twisting and bending in the yarn could be studied by scanning electron microscopy. He also showed how a particular fibre could be spotted in a yarn and then examined in more detail. Betrabet *et al.*[7] made SEM observations on OE-spun yarns from cotton and polyester and acrylic and viscose blends and showed how damage to surface fibres and even fibrillation could be examined by SEM. Munshi *et al.*[8] examined the twisting of fibres, cracks and other damages on the fibre surfaces of sewing threads. Paralikar *et al.*[9] made SEM observations on rotor-spun polyester yarns and examined the influence of processing factors on rotor-spun yarns. Although yarns from cotton and synthetic fibres have been studied by SEM, no such study has been made on jute yarn. Hence the present work in which the changes in the surface structure of jute yarns with increasing twists have been studied by using an SEM.

2 Materials and Methods

W-2 grade jute was processed in a standard jute machinery[10]. Each sample was spun to 276 and 345 tex with variation in the number of twists per inch as given below:

	Tex	Twists/in.
Yarn 1	276	3,3.53,3.83,4.40,5 and 6
Yarn 2	345	3,3.53,3.83,4.40,4.86 and 6

Segments of the yarns of 60 cm in length tying both ends were selected and only those segments corresponding to the particular tex were examined. From these segments, 1.5 cm long pieces were made, both ends being tied to preserve twist. These pieces were stuck to the specimen holders with a conducting copper tape. The samples were coated with a silver layer, about 20 nm thick, in vacuo in a vacuum-coating unit. The coated samples were examined on a Hitachi S-430 SEM at accelerating potentials of 10kV and 15kV with the specimen tilted through 30°, and representative micrographs were taken.

3 Results and Discussion

Various types of damage occur to the filaments as a

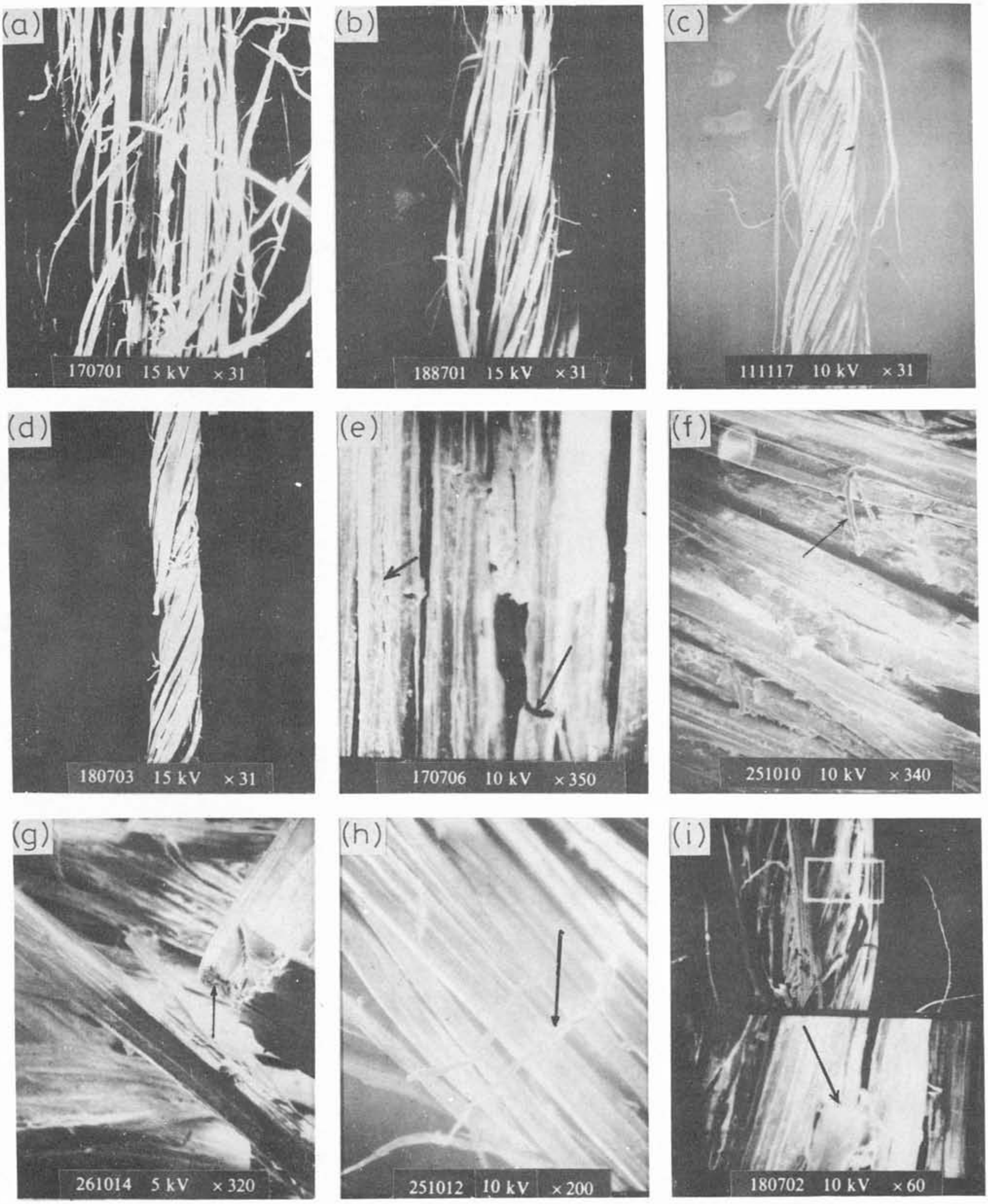

Fig. 1 — Electron micrographs of jute yarn of 276 tex [(a) Twist 3 TPI, × 31; (b) twist 4.40, × 31; (c) twist 5 TPI, × 31; (d) twist 6 TPI, × 31; (e) twist 4.40 TPI, × 350; (f) twist 5 TPI, × 340; (g) twist 6 TPI, × 320; (h) twist 6 TPI, × 200; and (i) twist 6 TPI, × 60 — Fractured end of the filament at the twisting zone (× 300)]

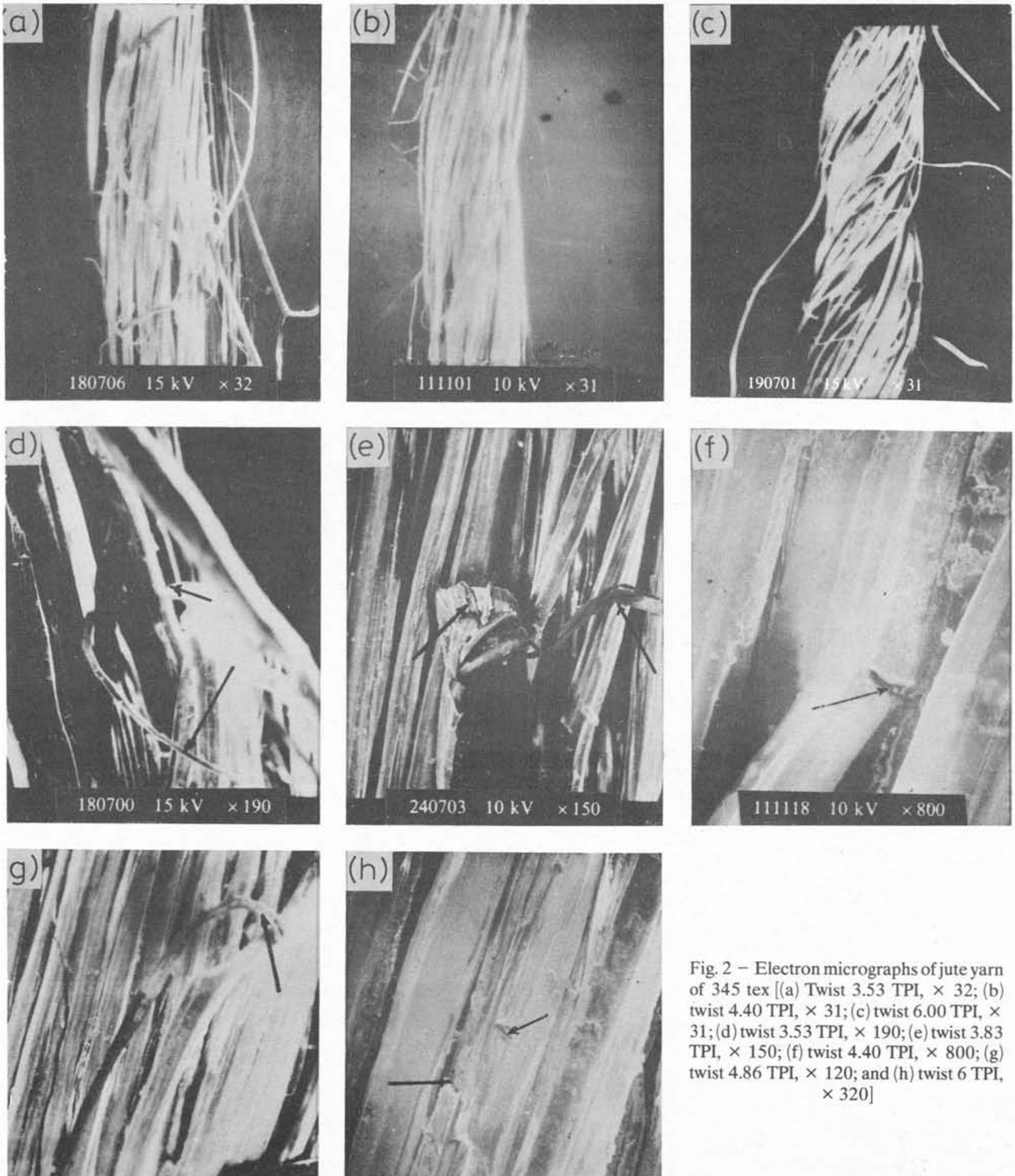

Fig. 2 – Electron micrographs of jute yarn of 345 tex [(a) Twist 3.53 TPI, × 32; (b) twist 4.40 TPI, × 31; (c) twist 6.00 TPI, × 31; (d) twist 3.53 TPI, × 190; (e) twist 3.83 TPI, × 150; (f) twist 4.40 TPI, × 800; (g) twist 4.86 TPI, × 120; and (h) twist 6 TPI, × 320]

result of processing operations[11]. Surface peeling, abrasion, pulling out of ultimate fibres and cracks were observed in some of the filaments from breaker and finisher cards and in the drawing stages. In some cases, cracks ultimately resulted in fracture. Such damages to the untwisted filaments were observed in about 20% of the cases.

Figs 1 and 2 are the electron micrographs of jute yarns of 276 and 345 tex respectively. From Fig.1a, it is seen that at low twist (3 TPI) the filaments are loosely arranged in the yarn of 276 tex and some of the filaments do not lie in the direction of the twist and therefore do not contribute to the yarn strength. Some filaments stand out of the yarn body and make the yarn hairy. The structure of the 345 tex yarn of the same twist was similar. The ultimate fibres are clearly visible as a result of the peeling off of the surface of the filaments; broken ultimate fibres are also seen. As the twists are low it is likely that these damages are due to carding and drawing actions.

The micrographs of the 276 and 345 tex yarns of twist 3.53 TPI showed that the filaments were still loosely arranged; ultimate fibres were seen in the filaments. Filaments in the different layers of the yarn were seen and many filaments did not follow the direction of the twist. At higher magnifications, the details of the fibre surface and peeling off of the surface and broken ends of the filaments were seen (Fig.2d). As the filaments lay along the yarn axis, the damages had already been caused owing to processing operations and were unlikely to be caused during spinning with this low twist.

The micrographs of yarns of twist 3.83 TPI showed that some filaments were still loosely packed and stood out from the yarn body, but at this twist the filaments start taking up the direction of twist and hence the yarn strength increases[1,4,7]. At higher magnifications, surface abrasion and fractured fibres were seen (Fig.2e).

Owing to increase in twist, compactness of the filaments in the yarns is seen (Figs.1b and 2b). Segments of ultimate fibres are also seen on the surface which make the yarn hairy. Surface peeling and fracture across the fibres are seen in Fig.1e and a crack at the bend of the fibre is seen in Fig.2f.

Fig.1c, relating to 276 tex yarn of twist 5 TPI, indicates that because of increase in twist the arrangement of fibres is compact. At higher magnifications, in 276 tex yarn of twist 5 TPI (Fig.1f) and in 345 tex yarn of twist 4.86 TPI (Fig.2g), pulled-out fibres and cracks on the surface of the fibres can be seen. Fig.1f shows the internal fibrillar structure of S2 layer of the secondary wall because of surface peeling.

Fig.1d (276 tex yarn of twist 6 TPI) and Fig.2c (345 tex yarn of twist 6 TPI) show that fibre arrangement is compact at this highest twist. At higher magnifications (Figs 1g, 1h, 1i and 2h), the damage to the fibre surface can be seen. Figs 1g and 2h show cracks and broken ends of the filaments. In Fig.1g, the whole fracture zone is seen.

In some of the filaments the ultimate fibres are pulled out of the filaments as shown in Fig.1h. In Fig.1i, the fracture in the twisting zone is shown with the help of a split diagram. The fractured end in the marked space in the upper half of the micrograph is magnified 5 times that in the lower half. As a result of surface peeling the internal fibrillation in the structure of the fibres is visible in Figs 1g, 1h and 1i.

It is therefore concluded that jute filaments suffer damages like surface peeling, abrasion and fracture in various stages of processing and with high twist. It is, however, difficult to differentiate the damages caused to the filaments owing to the processing operations and those due to high twist.

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