INFLUENCE OF CHEMICAL TREATMENTS ON INTER-FIBRE COHESION IN YARNS

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Abstract:

This paper discusses the influence of various chemical treatments on inter-fibre cohesion in yarns. Treatments given include mercerisation in slack and taut conditions, cytan, acetylation, benzyolation and enzymatic treatments. The studies reveal that the inter-fibre cohesion in yarns improve with these treatments.

Key words:

acetylation, benzyolation, cohesion, enzyme, mercerisation.

Introduction

The cohesion phenomena in yarns merits serious consideration as it has a direct effect on the yarn's properties, particularly yarn strength. The inter-fibre cohesion in yarns has been measured in terms of the minimum twist of cohesion (MTC). This is the difference between the number of turns present in a given length of yarn and the number of turns removed under a given load. The lesser the difference, the better is the cohesion, and vice versa. Barella [1 & 2] did pioneering work in the area. His work was concerned with the general study of the cohesion in cotton and worsted yarns. Investigations into the inter-fibre cohesion in ring and compact yarns have been carried out [3]. The studies reveal that compact yarns exhibit better cohesion than ring yarns. The influence of critical ring frame parameters on fibre cohesion has been studied [4].

Experimental

Cotton yarns of 30 tex linear density were used in the study. In the first phase of the study, mechanical treatments such as strain hardening in dry and wet conditions was carried out. In the next phase of the study, the yarn was subjected to chemical treatments. The concentration of the chemicals used in acetylation and benzyolation is 10%. The cytan (colloidal silica) solution which was used had concentrations ranging from 0.2-1.2%. Mercerisation was carried out in slack and taut conditions. Twenty readings were made in each study, and the mean of these was considered. An instrument has been designed for this purpose, based on the principle of untwisting under a given load. The gauge length of the specimen tested was 500 mm, and the yarn pre-tension was 0.1g/tex.

Mercerisation was carried out in slack and stretched conditions. Mercerisation in slack conditions was carried out at different NaOH concentrations ranging from 2-20%. Mercerisation in stretched conditions was done by stretching the sample from 0.5-5%. Strain hardening was carried out in both dry and wet states. The stretch ranged from 0.5 to 4%. The yarns were stretched to different levels using a simple device fitted with a fixed and a movable jaw, with a scale attached. The cellulase enzyme was also used in the study; the concentration of the enzyme ranges from 1-3%. This range was chosen as it had been recommended in practice; that is, earlier studies on the effect of enzymatic treatments on cotton had used this concentration range.

Results and discussion

Influence of strain hardening of yarn in dry state

The influence of strain hardening in the dry state is shown in Table 1.

Table 1. Influence of strain hardening in the dry state

Type of yarn	Linear density, Tex	% of stretch	MTC value
100% cotton	30	0.5	103
100% cotton	30	1.0	99
100% cotton	30	1.5	95
100% cotton	30	2.0	91
100% cotton	30	2.5	89
100% cotton	30	3.0	87
100% cotton	30	3.5	86
100% cotton	30	4.0	89

The yarn was subjected to different levels of stretch in the dry state. The stretch levels ranged from 0.5 to 4%. Strain hardening of the yarn in the dry state improved the fibre cohesion. Considerable improvement was seen up to 2% stretch level. Beyond 2% stretch level there was no significant improvement in the yarn cohesion. Stretching a twisted yarn up to a limit (2% stretch in this case) tends to bind the fibres closer together, and thus improves the packing of fibres in the packing of fibres in the yarn. When the stretch exceeds this optimum limit, the fibres overcome the frictional resistance and begin to slip. At higher levels of stretch, the fibre slippage will reduce the inter-fibre cohesion. Thus a higher level of stretch will cause fibre slippage and breakage, which will have a negative effect on the cohesion of the fibres in the yarn.

Influence of strain hardening of yarn in wet state

The influence of strain hardening of yarn in the wet state is shown in Table 2.

Table 2. Influence of strain hardening in the wet state

Type of yarn	Linear density, Tex	% of stretch	MTC value
100% cotton	30	0.5	96
100% cotton	30	1.0	91
100% cotton	30	1.5	87
100% cotton	30	2.0	84
100% cotton	30	2.5	82
100% cotton	30	3.0	82
100% cotton	30	3.5	83
100% cotton	30	4.0	83
100% cotton	30	4.0	85

The yarn was subjected to four different levels of stretch, ranging from 1 to 4% in the wet state. The trend was similar to the previous case. However, there was a slight improvement compared to the previous dry-state method. In this case, the contribution to cohesion was also less beyond 2% stretch, for the same reason mentioned above.

Influence of slack mercerisation

The influence of slack mercerisation on the MTC is shown in Table 3.

Mercerisation showed a good effect on the cohesion of fibres in the yarn. It is well-known that mercerisation causes swelling and change in crosssections of the fibres. The cotton fibre, which has a bean-shaped cross section, changes to a circular cross-section due to multidirectional swelling. The swollen fibre has a greater surface area of contact, which improves the cohesion. Beyond 16% concentration of NaOH, no improvement in the cohesion can be seen, since there would be no further swelling beyond this level.

Table 3. Influence of various levels of concentration of NaOH, on MTC

Type of material	Yarn linear density, Tex	Concentration of NaOH, %	MTC value
100% cotton	30	2	101
100% cotton	30	4	97
100% cotton	30	6	92
100% cotton	30	8	88
100% cotton	30	10	85
100% cotton	30	12	83
100% cotton	30	14	80
100% cotton	30	16	78
100% cotton	30	18	78
100% cotton	30	20	78

Influence of taut mercerisation

The influence of stretch mercerisation at different levels of stretch is shown in Table 4.

Table 4. The influence of different stretch levels in mercerisation, on the MTC

Type of material	Yarn linear density, Tex	Stretch %	MTC value
100% cotton	30	0.5	98
100% cotton	30	1.0	95
100% cotton	30	1.5	91
100% cotton	30	2.0	87
100% cotton	30	2.5	81
100% cotton	30	3.0	76
100% cotton	30	3.5	73
100% cotton	30	4.0	72
100% cotton	30	4.5	72
100% cotton	30	5.0	75

The influence of the level of stretch during mercerisation on the inter-fibre cohesion of the yarn is seen to be significant only up to 3.5%. There is no significant change in the cohesion beyond this. However, from a stretch level of 5% the cohesion falls. This could suggest that the initial level of stretch would compact the fibres' increasing cohesion, and the fibre slippage would begin later, thus contributing to the fall in cohesion.

Influence of Cytan (colloidal silica treatment)

The influence of colloidal silica at different concentrations on the MTC of yarn is shown in Table 5.

Table 5. Influence of colloidal silica at different concentrations on yarn MTC

Type of material	Yarn linear density, Tex	Cytan conc., %	MTC value
100% cotton	30	0.2	108
100% cotton	30	0.4	103
100% cotton	30	0.6	99
100% cotton	30	0.8	96
100% cotton	30	1.0	92
100% cotton	30	1.2	89
100% cotton	30	1.4	87
100% cotton	30	1.6	86
100% cotton	30	1.8	86
100% cotton	30	2.0	86

The addition of colloidal silica improved the cohesion, as can be seen from the table. The improvement can be seen only up to 1.4% concentration; beyond this level of concentration, the cohesion remains unchanged. Colloidal silica tends to modify the surface of the fibre, thereby increasing the frictional resistance of the fibres, and thus contributing to better inter-fibre cohesion. However, concentration beyond 1.4% does not tend to change the surface characteristics further, and thus the cohesion is not affected beyond this level of concentration.

Influence of acetylation and benzyolation treatments

The influence of acetylation and benzyolation treatments on the MTC of yarn is shown in Table 6.

Table 6. Influence of acetylation and benzyolation treatments on MTC

Type of material	Yarn linear density, Tex	Type of treatment	MTC
100% cotton	30	Acetylation	99
100% cotton	30	Benzyolation	91

Both acetylation and benzyolation cause an improvement in the cohesion. However, benzyolation gives better cohesion as compared with that of the acetylation treatment. The increase in the fibre cohesion in both the treatments suggests an improvement in the frictional properties of the treated cotton. Benzyolation appears to impart greater frictional resistance to the fibres as compared with that of the acetylation treatment.

Influence of enzymatic treatments

The influence of enzymatic treatments on the cohesion is shown in Table 7.

Table 7. Influence of enzymatic treatment on the MTC of cotton yarn

Type of material	Linear density, Tex	Enzyme conc., %	MTC value*
100% cotton	15	1.0	103
100% cotton	15	1.5	108
100% cotton	15	2.0	111
100% cotton	15	2.5	115
100% cotton	15	3.0	118

The results show that enzyme treatment reduces the cohesion, which can be ascribed to the fact that the enzyme has a smoothening effect on the fibre surface. The convolutions in the cotton fibre are removed and the fibre becomes cylindrical in shape. The smoother fibre surface reduces the frictional resistance between the fibres in the yarn, and thus it reduces the cohesion.

Conclusion

The following conclusions could be drawn from our studies:

- The strain hardening of cotton yarn in the dry state showed that the cohesion improved to up to 3% level of stretch. A stretch level beyond 4% showed deterioration in the inter-fibre cohesion.
- Strain hardening in the wet state showed a greater improvement in the fibre cohesion of up to 3% stretch level. Cohesion decreased beyond 4.5% stretch level.
- Mercerisation improves the fibre cohesion. The improvement is significant up to 16% concentration of NaOH, beyond which cohesion remains unaffected.
- Mercerisation in the taut condition gives even better fibre cohesion compared with the previous case. However, the cohesion decreases from 5% level stretch.
- Fibre cohesion improves with an increase in the concentration of colloidal silica up to 1.4% concentration.
- Both acetylation and benzyolation give better fibre cohesion. The latter gives an even greater cohesion as compared with the former treatment.
- Cohesion reduces with enzyme concentration.

References:

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