STUDIES ON THE BREAKING AND TENSILE STRENGTHS OF KAGHANI WOOL FIBRES AS A FUNCTION OF THEIR DIAMETER

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Various samples of Kaghani wool fibres collected from the hill tracts of Kaghan valley and Azad Kashmir (where crossbreeding resulting from the Rambouillet and indigenous breed has improved to a considerable extent) were tested for diameter, elongation and strength. It has been observed that there is 0.978 mean coefficient of correlation between 41.73 μ mean fibre diameter and breaking strength and 0.947 mean coefficient of correlation between the same fibre diameter and tensile strength of true, heterotypical and medullated fibres of 1.6" average staple length. Similarly the mean breaking strength and elongation in per cent were 22.6 g. and 41%, respectively, against the diameter of the three types of fibres.

Introduction

A comparative study on the Kaghani wool fibres was undertaken, in order to study the relationship between specific strength and their diameters, in attempting to devise a rapid method for determining the dynamometric resistance of wool fibres. Measurements have been confined to 48 Kaghani wool samples collected from different parts of Kaghan valley and Azad Kashmir in July, 1961 (in the order of decreasing fineness corresponding to diameters of 28.02, 40.17 and 57.1 μ). Fibre bundles of each of the 48 samples, ranging from 1", 1.5" and 2" in length and 0.03, 0.045 and 0.06 g., respectively in weight were sorted out for true, heterotypical and medullated fibres[1] and tests were carried out on these individually. The strength determination was carried out fibre wise on a hydraulic-type single fibre strength testing machine and the diameters of the same fibres on a lanameter.

Experimental

Measurements were carried out on Kaghani wool fibres at 20°C. and 65% relative humidity approximately. The diameter of each fibre was determined and the force required to rupture the fibre and the resulting elongation were recorded.

Measurement of Diameter.—Twenty fibres were withdrawn at random from an average reference sample. The fibres were aligned on a microscope slide and were covered by a cover slip which was secured by Canada balsam. Fibres were always measured at their centre before and after rupture.

Dynamometric Measurements.—A Schopper dynamometric scale was used with clamp 1 cm. apart and a pre-tension of 200 mg. wt. One end of the single fibre was suspended from the upper clamps of the hydraulic type single fibre strength testing machine, while the pre-tension was suspended freely from the other end of the fibre and then fixed in the lower clamps of the machine. The flow of water was maintained in such a way that the time to break the fibre was at least 20 seconds. At the time of rupture of the fibre, the breaking force from the dynamometric scale and elongation in percentage from the elongation scale were recorded.

Calculations.—To avoid excessive calculations the results were arranged by grouping the fibres[2] according to their increasing order of diameters. The number of fibres and mean force required to cause the rupture in a particular group was measured and the mean breaking stress (P')[2] and the tensile strength [3,4,5] calculated from:—

Breaking stress (P') = Breaking force in mg. wt./cross section area in μ^2.

Tensile strength (p.s.i.) = g./denier × 12800 × sp. gr.

where g./denier = breaking strength in g./900,000 × area of cross section × density.

Discussion

Breaking strength is considered to be the force required to effect the rupture of a fibre or a fibre bundle, whereas tensile strength represents the breaking strength calculated on unit area. The whole literature reflects the difficulty in obtaining average strength figure for any type of wool based on single fibre tests. By breaking a large number of fibres in the forms of bundles, a much clearer insight can be obtained into the relationship between fineness and strength. In a study of Kaghani wool fibres using the bundle method the following was established.

TABLE 1.—MEAN BREAKING FORCE, ELONGATION, BREAKING STRESS AND TENSILE STRENGTH AS A FUNCTION OF THE DIAMETER OF KAGHANI TRUE WOOL FIBRES. MEAN DIAMETER=28.02 μ(280 MEASUREMENTS).

Diameter μ	No. of fibres	Mean breaking force (g. wt.)	Mean elongation (%)	Mean breaking stress (P′)	Tensile strength
25.4	432	14.2	24	28.01	2847
25.7	298	14.0	24	26.9	2728
26.4	459	14.2	30	25.9	2631
26.4	312	14.4	31	26.3	2610
28.9	590	16.5	32	25.1	2574
29.3	430	16.8	32	24.9	2547
29.6	376	16.9	34	24.5	2492
30.0	453	16.9	36	24.0	2443
30.1	215	17.1	36	24.02	2431
30.5	322	17.3	40	23.6	2408
30.7	234	17.4	42	23.4	2396
31.2	287	17.6	42	23.10	2373
31.9	384	18.0	37	22.5	2322
32.3	410	18.4	43	22.4	2254

Coefficient of correlation: Fineness, breaking strength, 0.975; Fineness, tensile strength, 0.950; Density, 1.304; Average bundle size, 1″, 0.03g.

TABLE 2.—MEAN BREAKING FORCE, ELONGATION, BREAKING STRESS AND TENSILE STRENGTH AS A FUNCTION OF THE DIAMETER OF KAGHANI HETEROTYPICAL WOOL FIBRES. MEAN DIAMETER=40.17 μ (280 MEASUREMENTS).

Diameter μ	No. of fibres	Mean breaking force (g. wt.)	Mean elongation (%)	Mean breaking stress (P′)	Tensile strength
35.0	98	19.3	41	20.05	1814
35.4	205	19.5	43	19.8	1807
35.8	144	19.8	34	19.6	1804
36.1	63	19.1	40	18.6	1700
38.4	75	20.6	41	17.7	1601
38.5	120	20.3	48	17.4	1494
38.6	36	20.8	40	17.7	1601
39.1	347	21.1	42	17.5	1548
41.6	135	22.3	46	16.2	1494
42.3	102	22.7	42	16.1	1473
42.6	102	22.8	39	15.9	1462
43.5	251	23.8	39	15.7	1440
46.0	72	24.7	38	14.8	1355
48.2	205	25.9	47	14.07	1291

Coefficient of correlation: Fineness, breaking strength, 0.967; Fineness, tensile strength, 0.931; Density, 1.172; Average bundle size, 1.5″, 0.045 g. and 2″, 0.06 g.

TABLE 3.—MEAN BREAKING FORCE, ELONGATION, BREAKING STRESS AND TENSILE STRENGTH AS A FUNCTION OF THE DIAMETER OF KAGHANI MEDULLATED WOOL FIBRES. MEAN DIAMETER, = 57.1 μ (158 MEASUREMENTS).

Diameter μ	No. of fibres	Mean breaking force (g. wt.)	Mean elongation (%)	Mean breaking stress (P′)	Tensile strength
51.0	65	27.5	44	13.3	1213
51.5	44	27.7	47	13.2	1192
52.0	171	27.9	52	13.1	1182
55.7	180	28.7	54	11.8	1055
58.2	165	30.0	50	11.2	1013
60.2	18	31.1	46	10.9	985
62.4	110	32.3	48	10.5	981
65.7	122	34.2	52	9.8	918

Coefficient of correlation: Fineness, breaking strength, 0.991; Fineness, tensile strength, 0.960; Density, 1.160; Average bundle size 1.5″, 0.045 g. and 2″, 0.06 g.

Within the same staple the coarse fibres were 64% stronger than the fine fibres. There was a significant correlation of 0.978 between fibre diameter and breaking strength, and a significant negative correlation of 0.947 between the fibre diameter and tensile strength. The average breaking strength per fibre was 1 to 34.2 g. (mean 22.6 g.) and the tensile strength 918-2847 kg./cm.^{2} (mean 1818 kg./cm.^{2}). With different samples, the correlation between fibre fineness and breaking strength was significant and that between fibre fineness and tensile strength insignificant. The regression coefficient of the breaking load on fibre fineness was 0.512, indicating that on an average every increase of one micron in fibre diameter was associated with an increase of 0.512 g. in the breaking strength.

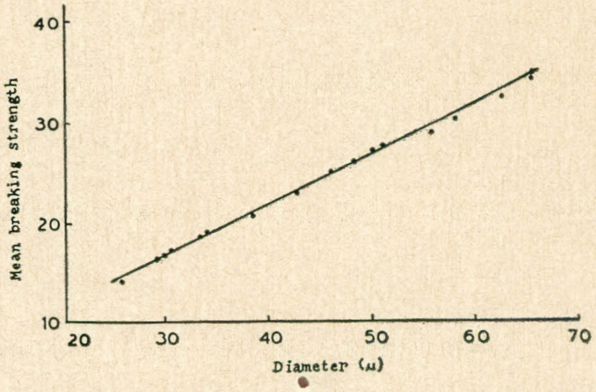

Fig. 1.—Relationship between the breaking strength and the diameter of Kaghani wool fibres.

A marked variation in breaking stress as a function of the diameter was demonstrated in Kaghani wool fibres (Fig. 1), the breaking strength increases with the increase in the diameter. On the other hand there is a difference between the curves relating to breaking stress and diameter on passing from fine to coarser wools (Fig. 2). The graph between load and elongation (Fig. 3) drawn by the hydraulic type single fibre strength testing machine also indicates that elongation increasing on passing from fine to coarser wool, which agrees with the readings taken.

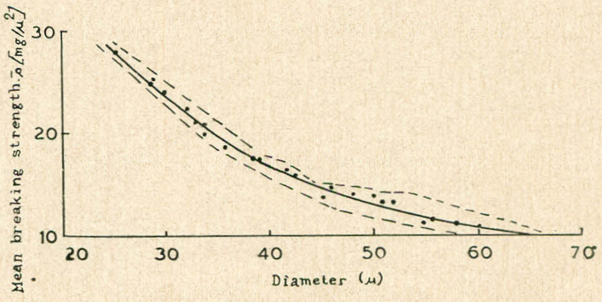

Fig. 2.—Relationship between the breaking stress and the diameter of Kaghani wool fibers.

Conclusion

It is essential that a fibre should be strong enough to be converted into yarn and then into fabric that will be durable enough to satisfy the purpose for which it is intended. Cloths which are used for wearing apparel should withstand wear, tear and other daily weather changes. Part of the strength of a fabric is determined by the size of the yarn used in its construction, but

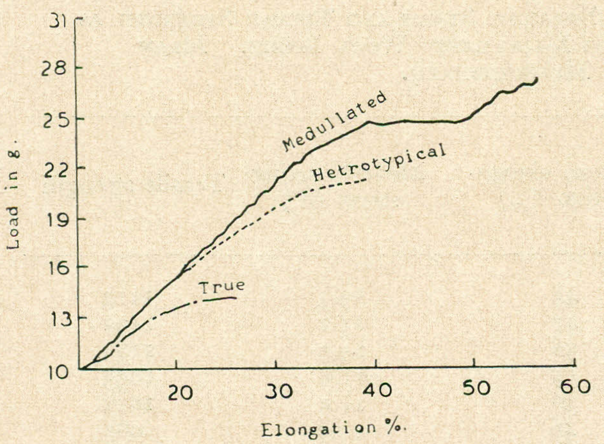

Fig. 3.—Relationship between load and elongation.

no yarn can be strong enough than the sum of the strength of the individual fibres in the yarn, and thus we must consider the strength of the fibres themselves. Studies on the Kaghani wool fibres indicate that this type of wool can be used for the manufacture of medium to coarse woollen cloth.

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