APPARATUS FOR MEASURING THE ABSOLUTE SOFTNESS OF YARNS

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ATTORNEYS
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This invention relates to an apparatus for measuring the absolute softness of yarns. The apparatus of the invention measures yarn softness in terms of the percent increase in yarn width when the yarn is subjected to lateral pressure between two parallel plane surfaces, a softer yarn giving a larger percent increase in width than a harder yarn. The apparatus comprises two major parts—a device for compressing a yarn laterally between two parallel plane surfaces with a constant applied force, and a device for measuring the width of the yarn before and after compression.

Yarn softness is an important but ill-defined yarn property. It has a major effect on many important fabric properties such as coverage, permeability, luster, drape, hand, dimensional stability, abrasion resistance, and penetrability to chemical finishing agents.

The absolute softness of a yarn is known to be a complex function of a large number of parameters. These parameters include various yarn properties such as the yarn number, the yarn diameter, the number of plies, and the amount and direction of twist; and also various fiber properties such as chemical composition, weight-fineness, stiffness, crimp, cross-sectional area and shape, staple length and maturity. Yarn softness is also affected by chemical or physical treatments such as partial acetylation, mercerization, etc.; and further depends upon whether these treatments are performed on the fibers before spinning the yarn or on the yarns after spinning.

The present methods of designing and estimating yarn softness are entirely inadequate since they are indefinite and only roughly qualitative and since they cannot be used reliably even qualitatively for comparison of the softness of two yarns of different construction. In fact, neither “soft yarn” nor “hard yarn” is defined under these headings in various standard dictionaries of textile terms. However, Calloway Textile Dictionary defines “soft twist” as “any twist that is less than the normal turns per inch, thus making the yarn “soft,” and it defines “hard twist” as “any twist that is considerably more than the average or usual number of turns per inch, thereby making the yarn “hard.” The Mercury Dictionary of Textile Terms defines “soft twist” as “a term used in the hosiery trade to mean yarn with less than normal turns per inch. Yarns vary in softness and, according to the amount of twist, are soft, X soft, XX soft, and XXX soft,” and under “hard-twist yarns” it states, “All spun yarns have twist but a hard twist yarn has more twist than usual, such extra twist or turns per inch are for special purpose such as for weaving voiles, gabardines, crepes, canvas, etc. Any twist more than the square root of the count multiplied by four is termed hard twist.”

In the present state of the art the degree of softness of a yarn is designated or evaluated only qualitatively as greater or less than an empirical reference value, which will be referred to as “the empirical reference value.”

This method of designating degree of yarn softness will be referred to hereinafter as the “empirical method.” The empirical reference value corresponds to the absolute yarn softness which would have been exhibited by the given yarn if it had been spun with the “normal number of turns per inch.” Yarns having the normal turns per inch are known to vary widely in absolute softness, and therefore in empirical reference values, depending upon parameters such as those enumerated hereinbefore.

For example similar cotton yarns or similar worsted and woolen yarns having the normal turns per inch would have decidedly different absolute softness values. The empirical method of designating degree of softness of yarns is therefore entirely inadequate for comparing different yarns. A yarn which is designated by the empirical method as “hard” might actually be softer in terms of absolute softness than one which is designated as “soft.” Similarly, the absolute softness of a plied yarn may remain constant or, in some cases, actually increase as the twist in the ply is increased.

By means of the apparatus of the invention, the absolute softness of yarns can be measured quantitatively. By this apparatus it is possible for the first time to determine and designate yarn softness in terms of numerical values on a uniform, standardized, absolute scale of softness value, regardless of the nature or magnitude of the various parameters, mentioned hereinbefore, which affect the softness of yarns. The invention therefore affords a means of quantitatively comparing and intercomparing the absolute softnesses of staple and filament yarns regardless of the yarn construction, the physical properties and chemical composition of the constituent fibers, and the nature and extent of the physical or chemical finishing treatment to which the fibers or the yarn have been subjected. The “absolute softness value,” as determined according to the present invention, is defined as the percent increase in yarn width when a fixed length of yarn is compressed laterally between two parallel plane surfaces with a constant applied force.

An embodiment of the apparatus for practicing the invention is described in the accompanying drawing which illustrates a view, partially in section and partly broken away, of the entire apparatus.

Referring with more particularity to the drawing, the apparatus is provided with a frame 11, mounted on a table top 12 by means of casters 13 and 14. A transparent plate 15, having an upper surface 6 and a lower surface 17, is fixed to table top. By raising or lowering the leveling bulb 32, a desired pressure, measurable on the manometer 33,
may be applied and maintained constant on the ram. As the hydraulic fluid is introduced into the cylinder, the ram is actuated to move the anvil towards the plate and, as will be described later, to compress the yarn 40, the softness of which is to be measured, at a desired interval of length and at a desired constant force between the parallel surfaces 17 and 21 to produce a deformation of the yarn laterally at its longitudinal axis.

The method of the invention is further provided with means for moving the yarn 40 between the parallel surfaces 17 and 21 and parallel thereto, while holding the yarn straight to provide for the taking of measurements along the yarn at desired intervals of length. Such means include a spool 41 of the yarn 40, mounted on table 12 through the medium of projection 42, from which the free end of the yarn is reeled off and passes successively over pulleys 43, 44, and 45, each of which is mounted on the frame through the medium of projections 46, 47, and 48, respectively. Pulleys 44 and 45 are placed on opposite sides of cylinder 24 so as to align the yarn horizontally between the parallel surfaces 17 and 21, the yarn resting against the lower surface 17 of the plate 15. A spring clip 49, acting as a weight, hangs free from the free end of the yarn over pulley 45 to straighten the yarn and maintain it horizontal and parallel to the parallel surfaces 17 and 21.

Means are also included for observing the yarn 40, when compressed between the surfaces 17 and 21, through the transparent plate 15 to measure the lateral deformation thereof—which is a measure of the softness of the yarn. Such means include a microscope 55, the base 56 of which is secured to the top of the frame by clamp 57, and a filar micrometer 58, fitted to the microscope, for measuring yarn width.

The microscope is so mounted on the frame that the objective of the microscope is in a position above and in the same vertical plane as the ram of the hydraulic cylinder.

The method of procedure in order to measure the absolute softness of a yarn using the above described embodiment of the apparatus of this invention is as follows:

With the mercury leveling bulb 32 sufficiently low to move the anvil 20 away from the plate 15, the yarn 40 is reeled off its spool 41 and is passed successively over pulleys 43 and 44, thence between the plate 15 and the anvil, and finally over pulley 45. The spring clip 49 is hung from the free end of the yarn to apply just sufficient weight to straighten and maintain the yarn horizontally between the plate and the anvil, the yarn resting against but lightly touching the lower surface 17 of the plate as shown in the drawing. The position of the ram 23, and therefore of the anvil affixed thereto, is so adjusted that the length of yarn pressed between the two parallel surfaces 17 and 21 will always be the same. The yarn width is then measured in filar micrometer units using the microscope 55 at a suitable magnification. The reading is preferably taken at the widest portion of that yarn twist which comes to rest beneath the vertical cross-hair of the filar micrometer 58. Then the leveling bulb 32 is raised to a suitable predetermined position so that the hydrostatic head of mercury and corresponding pressure on the ram 23 are increased sufficiently to cause the ram to rise and press the yarn between the upper surface 21 of the anvil and the lower surface 17 of the plate at a constant applied force. The yarn width is then measured again in the same manner and at the same magnification, and the increase in width is converted to a percent increase. A series of such measurements are taken under identical conditions at random locations along the length of the yarn sample to obtain representative sampling and representative measurements. An average of the percent increases in width found for the series of measurements is calculated and is reported as the "absolute softness value." If the component single yarns of any sample obviously spread apart when pressure is applied, that measurement is discarded and additional readings are taken.

When using the embodiment of the apparatus shown in the drawing, it is preferred that the flat upper surface 21 of the anvil be at least approximately 4 mm. in the dimension corresponding to the longitudinal axis of the yarn thus allowing at least an approximately 4-mm. length of yarn to be pressed laterally between the two parallel surfaces under the applied force. For conventional yarns, the number of turns per inch is such that a 4 mm. length of yarn will usually include several of the turns. Therefore, a 4-mm. length of yarn will generally provide an adequate sample length for a softness measurement. Limiting the dimension corresponding to the longitudinal axis of the yarn of the upper surface of the anvil to about 4 mm. is usually advantageous, since the smaller such dimension the greater the force which can be applied per unit area upon the yarn for a given pressure applied to the ram. A ram of about 1.55 cm. diameter is generally preferred. With a hydrostatic head of 625 mm. of mercury, the pressure exerted on the ram is about 12 lb./sq. in. At this chosen hydrostatic pressure and when employing a ram of the preferred diameter, the yarn is pressed between the two parallel surfaces 17 and 21 with a constant applied force of 3.51 lb. An applied force of about this magnitude or greater is generally preferred for making the softness measurements. It has been discovered that as the force applied on a yarn increases, the yarn width increases rapidly at first and then more slowly, tending to become relatively constant after an applied force of about 3.51 lb. is reached. It would be preferable to make the measurements of yarn width at constant lateral pressure instead of at constant force, but this is not experimentally feasible, since a knowledge of the effective area of yarn surface involved in each instance would be required.

As mentioned earlier, the apparatus of the present invention is suitable for measuring the absolute softness of all types of staple and filament yarns. Illustrative absolute softness data obtained on three 12/2 cotton yarn samples of different constructions and different softnesses using the apparatus illustrated in the drawing under the aforementioned preferred conditions are given in the following table:

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Twist Multiplier (Single)</th>
<th>Twist Multiplier (Ply)</th>
<th>Absolute Softness Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.75</td>
<td>4.75</td>
<td>144.2</td>
</tr>
<tr>
<td>2</td>
<td>2.75</td>
<td>4.75</td>
<td>40.8</td>
</tr>
<tr>
<td>3</td>
<td>2.75</td>
<td>5.75</td>
<td>142.0</td>
</tr>
</tbody>
</table>

1 Softest yarn.
2 Hardest yarn.

In obtaining the absolute softness values reported in the above table, a hydrostatic head (625 mm. of mercury) corresponding to a pressure of 12 lb./sq. in. on the 1.55 cm.-diameter ram was used; the dimension corresponding to the longitudinal axis of the yarn of the upper surface of the anvil was 4 mm.; a 3.5 g. spring clip was used; approximately 50 softness measurements were made at 25× magnification for each sample and averaged to obtain the absolute softness value.

The apparatus of the present invention can also be used to characterize yarns by the shape of the curve obtained by plotting percent increase in yarn width at various pressures over a range. The pressure can be applied at ambient air pressure and is passed by the yarn through two plates. It is also possible to obtain hysteresis curves with the apparatus by measuring the change in softness as the pressure is increased over a given range and as it is decreased over the same range.

I claim:

1. An apparatus for measuring the softness of yarn comprising a transparent plate, an anvil having a surface adjacent to a surface of the transparent plate and parallel
thereto, means for moving the yarn between the parallel surfaces of said transparent plate and anvil and parallel thereto while holding the yarn straight to provide for the taking of measurements along the yarn at desired intervals of length, means for compressing the yarn at each such desired interval of length between said parallel surfaces at a constant force to produce a deformation of the yarn laterally of its longitudinal axis, and means for observing the thus-compressed yarn through said transparent plate to measure such lateral deformation which is a measure of the softness of the yarn.

2. An apparatus for measuring the softness of yarn comprising a frame, a transparent plate fixed on said frame, an anvil having a surface adjacent to a surface of the transparent plate and parallel thereto, means for moving the yarn between the parallel surfaces of said transparent plate and anvil and parallel thereto while holding the yarn straight to provide for the taking of measurements along the yarn at desired intervals of length, a fixed hydraulic cylinder positioned normal to said surface of the transparent plate, a ram slidably mounted within said cylinder and movable towards said transparent plate, said anvil being fixed to the head of said ram, means for introducing hydraulic fluid into said cylinder to activate the ram to move the anvil towards said transparent plate, and means for maintaining the hydraulic fluid at a desired constant pressure, whereby as the hydraulic fluid is introduced into the cylinder, the ram is activated to move the anvil towards the transparent plate and compress the yarn at a desired interval of length and at a desired constant force between the parallel surfaces of said transparent plate and anvil to produce a deformation of the yarn laterally of its longitudinal axis, and means for observing the thus-compressed yarn through said transparent plate to measure such lateral deformation which is a measure of the softness of the yarn.

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