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A NEW METHOD FOR MEASURING AND DEFINING CRIMP OF TEXTILE FIBRES*

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SUMMARY

The crimp of textile fibres is one of their important characteristics, influencing their processing behaviour and the properties of yarns and fabrics made therefrom. Despite the importance of crimp, little is actually known about its physical or chemical nature, and methods of measuring and defining crimp are inadequate.

Existing methods of testing fibres do not take into account the crimp, and therefore may introduce considerable errors in tensile and other measurements. Some works deal with the behaviour of the crimped fibres under the application of loads, and efforts have been made to express such changes mathematically. No work has been done in order to establish a method for measuring the crimp parameters in a systematic way so as to be able to distinguish quantitatively between various crimps. Such a method is suggested in the present work.

The statistical nature of the waves has to be taken into account, as the crimped fibres are not of a regular shape. It is also necessary to include tests for ascertaining the size of representative samples of the fibres, considering the variations in crimp within the varieties.

The main parameter used to describe the geometry of the crimp of a fibre is the *crimp-diameter*. This corresponds to an average amplitude of the fibre in space, while it is kept in a static position of stress.

In order to measure the crimp-diameter, it is necessary to measure the coordinates of a sufficient number of points on the fibres. From these measurements a "fibre-axis" can be defined as the straight line for which the sum of squares of the distances of the fibre points from this line is a minimum. The crimp-diameter is then defined as:

$$D = 2\sqrt{S/N}$$

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where S is the mentioned minimum sum and N the number of the points measured along the fibre. The calculation of S according to its definition involves the solution of third order equations. Therefore the following simplified equation was developed and suggested:

$$S = \mathrm{Var}(x) + \mathrm{Var}(y) - (1/\mathrm{Var}(z)) \cdot (\mathrm{Cov}^2(x,z) + \mathrm{Cov}^2(y,z))$$

It was found that this equation can, for all practical purposes, serve as a satisfactory approximation for the results obtained when S is calculated according to the definition, i.e., from the fibre-axis.

The crimp-diameter depends upon the size of the intervals, or the number of measurements N. When the size of the interval is decreased, N increases, and the measurements become more precise. As a limiting case we may also get the following equation in an integral form:

$$\lim_{N\to\infty} S/N = \lim_{N\to\infty}(S_x/N + S_y/N)$$

and after integrating we get:

$$\lim_{N\to\infty}(S_x/N) = (1/L)\int_0^L x^2\,dz - (4/L^2)\,(\int_0^L x\,dz)^2 + (12/L^3)\,(\int_0^L zx\,dz \cdot \int_0^L x\,dz) -$$
$$- (12/L^4)(\int_0^L zx\,dz)^2;$$

where L is the distance between the fibre endpoints.
and a similar expression for $\lim_{N\to\infty}(S_y/N)$.

These are later introduced for the calculation of the crimp-diameter:

$$D^2 = 4(\lim_{N\to\infty}(S_x/N) + \lim_{N\to\infty}(S_y/N))$$

In order to measure the crimp-diameter, a special apparatus had to be built.

At first a simple uniplanar device was used as a crimp-meter, where the crimp-diameters were measured from one plane of the fibres. However, it was found that the crimp-diameter varies with the plane of measurement; therefore this method was followed by a rotatory crimp-apparatus: Here the fibre was rotated throug hits endpoints, and its image was projected on a screen. From this image the "width" values can be measured at N intervals, and used for the calculation of D. A series of limitations of the rotatory crimp-apparatus led to the modification of the measuring method and to the development of the method of two perpendicular planes of a fibre. Here the fibre's upper end is clamped to the hook of a torsion balance and its lower end to a moving screw, so that the load-elongation data are also easily obtained. The coordinates of N fibre points are measured on each screen, when the line connecting the endpoints of the fibre is used as the z-axis; S is then calculated and the crimp-diameter is obtained. Also, with the aid of any curve-tracer, both perpendicular projections of the crimped fibre can be traced and the $x = x(z)$ and $y = y(z)$ functions can be obtained and used in the continuous equations.

The same equations can be used to measure the sums of squares of the deviations of any curves from their regression lines, either in their continuous or in the non-continuous forms.

This method of measurement and definition was applied to various types of fibres, such as cotton and fine wools, and some interesting results have been obtained.

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