DESIGN OF A HIGH PRECISION YARN EVENNESS TESTER

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Yarn evenness is a vital parameter in maintaining quality in fabric manufacturing where uneven yarn can result in poor quality in fabric. Moreover, uneven yarn has a tendency to break during the knitting process which will bring a production line to a standstill for some time. Consequently, high attention is paid in selecting yarn with an acceptable evenness for fabric manufacturing. Among many yarn evenness measuring techniques, the capacitance-based Uster machine and the image processing-based optical technique are very popular. The Uster technique passes the yarn between two capacitor plates where the capacitance variation in the arrangement reflects the yarn evenness variations. This technique is cost-effective but readings are severely affected by environmental factors such as humidity and the yarn material. Thus, the two camera-based optical technique is preferred in view of its high accuracy and lower dependency on external factors. The optical technique captures two images of yarn in planes perpendicular to each other and then calculates the diameters employing image processing which we named the 2D technique. Furthermore, the Uster machine outputs coefficient of variance (CV_m) of mass per unit length readings while the optical technique outputs the diameter (d) of yarn. We first brought the two dimensions to a single platform by using the fact that $m = \frac{\pi d^2}{4} \times \rho$ where m, d and ρ represent the mass per unit length, cross sectional diameter and the density of yarn. Thus, $CV_m = CV_{d^2}$ where CV_{d^2} represents the coefficient of variance of d^2. Moreover, we implemented a prototype optical testing unit including an adjustable camera. With this setup, the diameter readings of 10 selected sample reels of yarn were measured and the CV_{d^2} were calculated. At the same time, the same set of samples were measured for CV_m using the Uster machine.

We also proposed a three camera-based optical technique (3D technique) and expected the same to be more accurate since three cameras placed in planes angled 120 degrees to each other can capture the yarn diameter variations hidden to the two perpendicular planes in the 2D system. Using the same camera setup three camera-based images were captured, diameters calculated and the CV_{d^2} was also calculated. Moreover, the average diameters for each reel were also calculated under the two techniques.

From the results it was clear that the average diameter values were similar, but the CV values under 3D were higher than that under 2D. Since the CV value is the ratio between the variance and the mean value, it implies that the 3D technique had a higher variance value than the 2D for the same individual yarn reels tested. It can be concluded that the 3D technique was able to capture the variations in diameter better than the 2D technique. At the same time the 2D optical measurement-based CV value was higher than the Uster technique-based CV value converted to the same d^2 dimension. However, we did not have the explicit mean values of the mass per unit length under the Uster technique so we could not directly conclude that the 2D technique was more accurate than the Uster technique. Measuring the mean value of the mass per unit length of a given yarn, converting the same to the mean diameter using $= \frac{\pi d^2}{4} \times \rho$ and comparing with the mean diameter reading of the 2D optical technique could be interesting future work which enables one to perform a clear accuracy comparison between Uster and 3D techniques.

Key words: Yarn evenness, Uster technique, Optical technique, Coefficient of variance

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