Short Communication

Development of predictive model for setting stitch length value of single jersey cotton fabrics

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A statistical approach has been used to predict the stitch length of single jersey fabrics from known yarn counts and fabric area densities in the grey reference state. The model has been based on the observational data from two hundred and sixty samples of tubular weft-knitted single jersey cotton fabrics produced under bulk conditions in a knitting plant. The multiple regression analysis technique is used to develop the predictive equation. Validation of the model by follow up on knitted samples reveals that the predicted stitch length value from the equation is acceptably close to the real value. The statistical model can therefore be used to eliminate the need for trial and error methods in the development stage of single jersey fabrics.

Keywords: Cotton, Knitting, Regression analysis, Single jersey, Stitch length

Engineering of cotton knits depends on the relationships between the fully relaxed fabric that has been wet processed and the construction parameters in knitting[1]. Nowadays, dedicated computer software assists fabric manufacturers to design and control cotton knits from the selection of yarn and knitting machine through dyeing, finishing and apparel processing. The Starfish software, one of the most popular in this field, enables the prediction of finished fabric performance and quality, and gives targets of weight and width from inputs of knitting variables and wet processing regimes[2]. But, with the ever-increasing demands in terms of fabric quality and the ability to meet customer specifications within narrow ranges of tolerance, such tools are generally used for indicative purposes only. So far, the design of basic knitted fabrics in the knitting industry still involves trial and error methods.

In practice, the finished area density (g/m²) of a fabric and the acceptable level of shrinkage are specified by the customer. For weft-knitted single jersey cotton fabrics, these specifications can be used to estimate the corresponding area density of the grey fabric in the fully-relaxed state, commonly referred to as the grey reference weight. The task of the knitter is to select the appropriate yarn count and determine the stitch length value that would yield the required grey reference weight. The selection of yarn count can be considered as a relatively easy task, given the limited range of available yarn counts from the yarn stock of most knitting plants. However, finding out the correct value of the stitch length is still an activity that relies heavily on the knitter’s expertise and often involves a substantial amount of counter-productive sample-knitting trials.

The present study is an attempt to eliminate the need for knitting trials and to provide a right-first-time approach to the fabric development process of tubular single jersey cotton knits. The purpose of the project is to come up with a predictive model to forecast the stitch length to be used on a knitting machine when the count of the yarn and the grey reference specific weight are known. Expected benefits include savings in resources, such as raw materials, labour, machine utilisation, and productive time. Implementation of this approach will allow a continuous run of the production lines and also ensure quicker response to customers’ requirements.

A Microsoft excel database was created from raw production data for a total of two hundred and sixty knitted rolls of eight different single jersey fabrics, representing six months of knitting production. For each roll of fabric, the yarn count, stitch length, and grey reference area density were recorded. The fabrics were made of yarns with linear densities ranging from 20 tex to 36 tex, and knitted on machines with the specifications 20, 24 and 28 needles/inch machine gauge for 30 inch machine diameter and 24 needles/inch for 26 inch machine diameter.

The stitch length for each fabric was calculated as the ratio of course length to the number of needles. The grey reference area density was determined according to the Starfish relaxation procedure, i.e. after five cycles of washing at 40°C in a domestic washing machine and tumble drying. The mean value

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of the grey reference area for each fabric was obtained from individual roll results.

To formulate the predictive equations, the multiple regression analysis method was found to be the most appropriate statistical tool, based on its effectiveness, ease of application, and popularity. Regression analysis is a technique used for the modeling and analysis of numerical data consisting of values of a dependent variable and one or more independent variables.

The regression equation obtained is as follows:

\[
SL = 0.09C - 0.01G + 2.56 \quad \ldots (1)
\]

where \(SL\) is the stitch length in mm; \(C\), the count in tex; and \(G\), the grey reference specific weight in g/m\(^2\).

The validity of the equation was initially tested by knitting a sample using the stitch length predicted for a grey reference area density of 200 g/m\(^2\). The knitting parameters of the test sample and the test results are: machine diameter, 30 inch; needles/inch, 24; no. of needles, 2268; course length, 750 cm; stitch length, 3.30 mm and count, 29.53 tex.

The course length to be used on the machine was calculated from the predicted stitch length. The grey reference area density of the fabric is found to be 208 g/m\(^2\), i.e. 4% higher than the targeted value.

Data from ensuing production trials were subsequently used for assessing the reliability of the model, by comparing the actual stitch lengths used for obtaining fabrics of typical grey reference area densities with the stitch lengths predicted by the model for the same fabrics (Table 1).

Based on the above results, the predictive model was judged to be reliable, taking into consideration that the tolerance set by most standards for fabric area density is in the range of \(\pm 5\)% and that in general, the area density of cotton jersey fabrics does not change significantly with small changes in stitch length.

It is found that by using simple statistical methods, the mathematical models with acceptable predictive capabilities can be developed to reduce the dependency of knitted fabric development on counter-productive trial and error methods.

The accuracy of the model can be further improved by investigating the effects of other parameters, such as yarn twist, fibre length and yarn type. Parameters having a high correlation with the area density could then be included as dependent variables in the predictive equation. Similar studies can also be carried out on weft-knitted fabrics with other types of design.

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**References**