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# USE SINE FUNCTION TO PREDICT MODEL FOR KNITTED FABRIC IRREGULARITY BASED ON YARN IRREGULARITY FOR 14NE POLYESTER/VISCOSE (65/35) YARN

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## ABSTRACT

This study was carried out in order to predict the knitted fabric irregularity based on yarn irregularity. Using the Uster statistics of yarn mass irregularity, the knitted fabric specifications were determined. In order to build up a theoretical model, the sine function of the Non-linear regression function was applied for 14Ne polyester/viscose (65/35) yarn using the Orign program. The sine function was chosen because it shows the best fitting results compared with the different functions. The result obtained from the proposed model shows a high correlation and good significant. Furthermore, the results obtaining using the Non-linear regression equations shows optimal correlation with experimental results for yarn used in this study.

**KEYWORDS:** Irregularity , Evenness, Variation, Mass variations, Spectrogram, Knitted fabric.

## INTRODUCTION

Yarn evenness is a measure of the level of variation in yarn linear density or mass per unit length. In other words, it refers to the variation in yarn count along its length.Continuously filament yarns have virtually no variation in linear density so evenness is not an issue for those yarns. A yarn with poor evenness will have thick and thin places along yarn length, while an even yarn will have little variation in mass or thickness along length. While a yarn may vary in many properties, evenness is the most important quality aspect of a yarn, because variations in other yarn properties are often a direct result of yarn count irregularity. We already know that twist tends to accumulate in the thin places in yarn, so irregularity in yarn linear density will cause variations in twist along yarn length. This preferential concentration of twist in thin places along a yarn also exacerbates the variations in yarn diameter or thickness, which often adversely affects the appearance of the resultant fabrics. An irregular yarn will also vary in strength along the yarn. The ‘weakest link’ theory says a chain is only as strong as its weakest link. Similarly a yarn is only as strong as its weakest spot. When there are large variations in yarn linear density, there will be many thin spots in the yarn, which are often the weak spots (despite its relatively high twist concentration).

### 1.1 Sources of yarn irregularity [2]:

The regularity of a yarn fundamentally depends on fibers and their arrangement within the yarn**.** The causes of irregularities are:

a. **Random fiber arrangement and fiber-length:** the fibers are randomly arranged through blending, carding, doubling, roving, and spinning.

b. **Effect of drafting waves:** In drafting process fibers move in groups causing non-random wave-like patterns called drafting waves, which they are responsible for periodic thin and thick places over a yarn.

c. **Twist variation**: Spun yarn production fundamentally involves twisting of a random fiber array.Twisting tends to concentrate the yarn structure into an irregular close-packed polygonal shape [3], but the cross-section still possesses a concave-convex irregular shape.

d. **foreign elements:** Neps are caused by foreign elements, immature raw material, and insufficient and improper cleaning during preparation processes. These faults are usually random and visible to the human eye. They are detected by many evenness-testing instruments.

**1.2 yarn evenness test:** There are many way of assessing yarn evenness:

**a. Visual examination** [4]**:** Yarns to be examined are wrapped onto a matt black surface in equally spaced turns so as to avoid any optical illusions of irregularity. The blackboards are then examined under good lighting conditions using uniform non-directional light. Generally the examination is subjective but the yarn can be compared with a standard if one is available; the ASTM produce a series of cotton yarn appearance standards. Motorized wrapping machines are available: in these the yarn is made to traverse steadily along the board as it is rotated, thus giving a more even spacing.

**b. Cut and weigh methods[4]:** This method consists of cutting consecutive lengths of the yarn and weighing them. The mass of each consecutive length of yarn is plotted on a graph as in Fig.1.1, a line showing the mean value can then be drawn on the plot. The scatter of the points about this line will then give a visual indication of the unevenness of the yarn. The further, on average, that the individual points are from the line, the more uneven is the yarn.

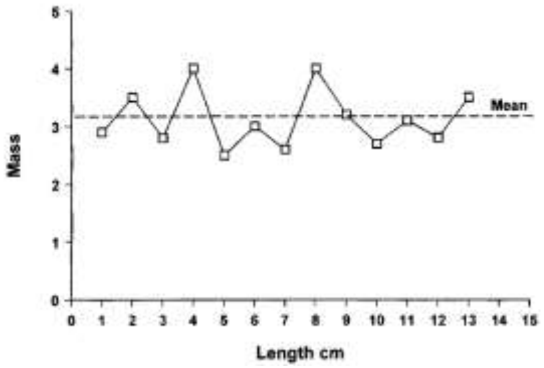

*Fig.1.1 The variation of weight of consecutive 1 cm lengths of yarn.*

A mathematical measure of the unevenness is required which will take account of the distance of he individual points from the mean line and the number of them. There are two main ways of xpressing this in use:

1 .The average value for all the deviations from the mean is calculated and then expressed as a percentage of the overall mean (percentage mean deviation, PMD). This is termed U% by the Uster ompany.

2. The standard deviation is calculated by squaring the deviations from the mean and this is then expressed as a percentage of the overall mean (coefficient of variation, CV %).This measurement is in accordance with standard statistical procedures. When the deviations have a normal distribution about the mean the two values are related by the following equation:

$CV = 1.25\ PMD \qquad (1)$

**c. Uster evenness tester[4]:** The Uster evenness tester measures the thickness variation of a yarn by measuring capacitance. The yarn to be assessed is passed through two parallel plates of a capacitor whose value is continuously measured electronically. The presence of the yarn between the plates changes the capacitance of the system which is governed by the mass of material between the plates and its relative permittivity (dielectric constant). If the relative permittivity remains the same then the measurements are directly related to the mass of material between the plates. For the relative permittivity of a yarn to remain the same it must consist of the same type of fibre and its moisture content must be uniform throughout its length. The presence of water in varying amounts or an uneven blend of two or more fibres will alter the relative permittivity in parts of the yarn and hence appear as unevenness.

**d. Zweigle G580[4]:** This instrument measures yarn evenness by a fundamentally different method from the mass measuring system of the Uster instrument. Instead of capacitance measurements it uses an optical method of determining the yarn diameter and its variation. In the instrument an infra-red transmitter and two identical receivers are arranged. The yarn passes at speed through one of the beams, blocking a portion of the light to the measuring receiver. The intensity of this beam is compared with that measured by the reference receiver and from the difference in intensities a measure of yarn diameter is obtained. The optical method measures the variations in diameter of a yarn and not in its mass. For a constant level of twist in the yarn the mass of a given length is related to its diameter by the equation:

$Mass = C * d \qquad (2)$

Where $C \equiv$ constant,
$D \equiv$ diameter of yarn.

However, in practice the twist level throughout a yarn is not constant [4].

Therefore the imperfections recorded by this instrument differ in nature from those recorded by instruments that measure mass variation. However, the optical system is claimed to be nearer to the human eye in the way that it sees faults. Because of the way yarn evenness is measured, this method is not affected by moisture content or fibre blend variations in the yarn.

### 1.3. Fabric irregularity:

The appearance of fabrics is affected by the irregularity of yarns and fabric production process problems. Irregular yarn will have an uneven strength and will likely to disturb the fabric production process because of frequent breakage. The fabric defects caused by irregular yarns may be grouped in two categories: random and periodic fabric irregularities. While random fabric irregularities may occur at any location in a fabric, periodic

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irregularities may create visible patterns in certain directions. ASTM [4].

### 1.3.1 Random irregularities:

Random yarn irregularity may cause rough fabric appearance. Cloudiness, rough, fuzziness is a fabric condition characterized by a hairy appearance due to broken fibers or uneven twist. Irregular reed marks are due to cracks between warp ends at random intervals for short distances. Missing or -faulty yarns are visible at a portion of the fabric. Holes, cuts, knots or slubs are local defects mainly caused by mechanical problems.

### 1.3.2. Periodic fabric irregularities:

Bárre is a striped effect in a fabric caused by a series of picks, which have apparent difference in color or luster that is repeated at intervals in the warp direction. See Figure 1.2. Warp streak is characterized by a narrow bar running warp-wise and has difference in color from neighboring ends. Filling bar is a weft that runs parallel with the picks and that is different in material, linear density, twist, and luster from the adjacent wefts. Diamond bar/Moiré is caused by sinusoidal periodic thickness variations in weft yarn whose wavelength is less than twice the width of the cloth [5], [6]. See Figure 1.2. Reed marks, unlike irregular reed marks, occur in regular intervals and run along the pick. Skewing, bowing, non-symmetric placements are usually caused by excessive tension in fabrication.

*Figure 1.2: Appearance of some fabric defects [4]*

### 1.4 Fabric irregularity testing:

It was suggested that [7], [8] the quality of fabric can be predicted from the coefficient of variation, the CV (%), of the yarn that is used. However, in industry, the evaluation of fabrics is still commonly done by the experts through eye and hand judging. This is primarily due to the fact that the CV (%) is grossly insufficient to predict the features of irregularities, since it is not location specific within the fabric. Several researchers in the past tried to characterize numerous fabric properties, some through introduction of quality indices and others by new methods of measurement using time series, Fourier transform, and Wavelets. Consequently, methods such as the Kawabata System (KES) [9], fabric assurance by simple testing (FAST), and the Total Quality Index [10] have been proposed for total appearance rating. Nowadays yarn quality testers are equipped with devices for obtaining information on yarn properties on-line or off-line and then mapping them into weave or knit fabric structures in order to help visualize the final product [11], [12] and [13].In this study knitted fabric irregularity measured as the CV mass irregularity.

## MATERIALS AND METHODS

14Ne polyester/viscose (65/35) carded ring spun yarn used in this study .The measured yarn properties are given in table 2.1.

***Table 2.1: measured yarns properties***

| | | |
|---|---|---|
| Material | | p/v<br>65/35 |
| Yarn count (Ne) | | 14 |
| Yarn diameter (mm) | | 0.242443 |
| Yarn twist (t/m) | | 650 |
| Evenness | CV % | 10.65 |
| | U % | 8.48 |
| Appearance (visual inspection) | | Grade A |

The knitted fabric properties are given in table2.2.

***Table 2.2The knitted fabric properties***

| Knitted fabric type | Interlock |
|---|---|
| Course length (cm) | 110 |
| Stitch length (cm) | 0.92 |
| Stitch density (stitch/cm$^2$) | 30 |

Uster 3 evenness tester was used to measure yarn CV. The passap dumatic 98 machine used to knit the fabric.

## RESULTS AND DISCUSSION

### 3.1 Yarn irregularities:

For yarn irregularity was tested using Uster3 tester. The mass diagram and the coefficient of variation were obtained.Ten tests were performed. The results are given in table 3.1

***Table 3.1 total result for 14Ne polyester/viscose 65/35yarn***

| Test No | Um % | CVm % | Thin - 40% | Thin -50% | Thick +35% | Thick +50% | Nebs +200 % | Nebs +280 % | Hairiness (-) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 8.84 | 10.09 | 1 | 0 | 9 | 0 | 0 | 0 | 6.54 |
| 2 | 8.68 | 10.81 | 4 | 0 | 14 | 3 | 2 | 2 | 6.21 |
| 3 | 8.74 | 10.97 | 5 | 0 | 14 | 0 | 2 | 0 | 6.37 |
| 4 | 8.43 | 10.57 | 0 | 0 | 13 | 1 | 2 | 1 | 6.25 |
| 5 | 8.43 | 10.59 | 3 | 0 | 13 | 3 | 4 | 1 | 6.16 |
| 6 | 8.69 | 10.92 | 6 | 0 | 12 | 4 | 2 | 2 | 5.97 |
| 7 | 8.37 | 10.54 | 6 | 0 | 9 | 1 | 1 | 1 | 5.85 |
| 8 | 8.45 | 10.61 | 7 | 0 | 10 | 1 | 2 | 1 | 5.98 |
| 9 | 8.67 | 10.92 | 10 | 0 | 14 | 5 | 4 | 3 | 5.81 |
| 10 | 8.35 | 10.58 | 2 | 0 | 18 | 3 | 2 | 0 | 5.91 |
| Mean value | 8.48 | 10.65 | 11/km | 0/km | 32/km | 5/km | 5/km | 3/km | 6.10 |
| CVb (%) | 2.46 | 2.49 | 68.8 | 8.0 | 21.9 | 82.3 | 57.0 | 90.4 | 4.83 |
| 0.95% +/- | 0.15 | 0.19 | 5 | 0 | 5 | 3 | 2 | 2 | 8.18 |

The diameter in millimeters for yarn was determined. For each yarn type 100 tests were performed. For each test the sample length was 20 meters. Therefore a total of 2000 meters was tested.The variations in yarn diameter plotted in figure3.1.

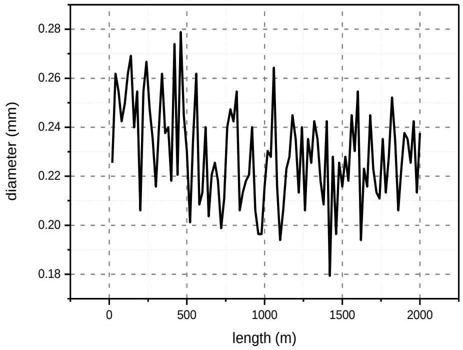

*Figure 3.1: The variations in the yarn diameter for 14Ne, polyester/viscose (65/35) blended yarn.*

### 3.2 Fabric analysis:

Figure 3.2 shows the image of the knitted fabric knitted from 14Ne, polyester/viscose (65/35) blended yarn. As can be seen from the image the produced fabric is more regular.

*Figure 3.2: Image of the knitted fabric*

The weight in grams was determined for fabric sample. Sample was 18 courses height. The length used to knit 18 courses was equivalent to 20 meters. The results obtained are plotted in figure 3.3. As can be seen in figures the curves behavior it nearly the yarn diameter variation curves. See figures 3.1

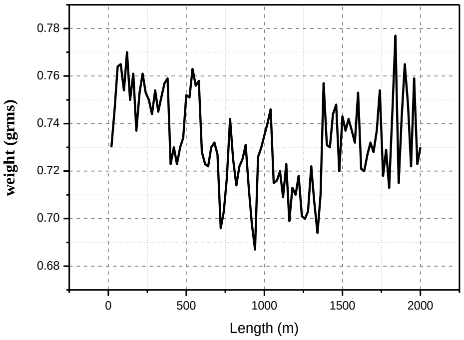

*Figure 3.3: The variations in fabric weight for the knitted fabric*

### 3.3 Model:

The final CVs for yarn and fabric were calculated and shown in table 3.2. The Origin program was used to establish an equation (model) that could better correlate the data obtained from the yarn and fabric. Nonlinear regression analysis curve fit was used to choose the best model.

***Table 3.2 Yarn and fabric CV's***

| CV (yarn) (%) | CV (fabric) (%) |
|---|---|
| 7.7152 | 1.6926 |
| 6.9176 | 1.4517 |
| 11.5704 | 1.9979 |
| 7.6458 | 1.8819 |
| 8.5057 | 2.1438 |
| 8.6385 | 1.9824 |
| 6.282 | 2.6266 |
| 9.7942 | 1.2958 |
| 6.4176 | 1.5948 |
| 5.9995 | 2.7367 |

The *Non-linear fit* functions were tested in order to select best nonlinear model for (14Ne polyester/viscose (65/35) yarn). The results are given in table 3.3.

***Table 3.3: The result obtained***

| Errors | R | MSE | Prob>F |
|---|---|---|---|
| Model | | | |
| Sine** | 79 | 0.35 | 0.00003** |
| Polynomial | 91 | 0.33 | 0.24 |
| Exponential | 70 | 0.37 | 0.00001 |

The correlation coefficient; R, mean square error; MSE and significant value were used to choose the best model. From table 3.3 it can be seen that the Polynomial model is not suitable because, it is insignificant (sig ≤ 0.05). On the other hand, the correlation coefficient; R and mean squared error; MSE values for the Exponential are less the Sine. Therefore the model chooses was the Sine. The best curve fit is illustrated in figure 3.4.

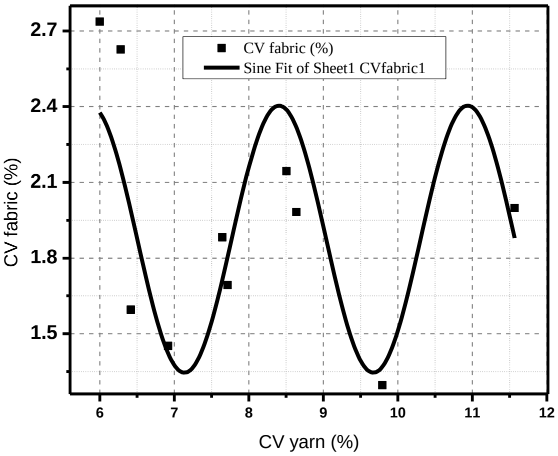

*Figure 3.4: best curve fit for sine function*

The mathematical model is as follows:

$$Y_1 = 1.87 + 0.53\sin(2.49X_1 - 6.69) \qquad (3)$$

Where $Y_1$ is the CV (%) for knitted fabric

$X_1$ is the CV (%) for yarn

**Compare model with the data:**

Predicted value calculate from equation (3) and compared with the actual data the result show in table 3.4 below.

*Table 3.4: CV fabric, CV predicted*

| CV (fabric) (%) | CV (predicted) (%) |
|---|---|
| 1.6926 | 1.42144 |
| 1.4517 | 1.87929 |
| 1.9979 | 1.71383 |
| 1.8819 | 2.38764 |
| 2.1438 | 2.31761 |
| 1.9824 | 2.15014 |
| 2.6266 | 1.36941 |
| 1.2958 | 1.98563 |
| 1.5948 | 2.37672 |
| 2.7367 | 1.42144 |

The CV curve for the actual and predicted values for fabric are plotted in figure 3.5. Which represented the relation between actual value and predicted value calculate using the equation (3). The figure shows the relation the measured values and those calculated using equation1. As can be seen from the figure, the trends are nearly the same. The correlation is nearly 79%.

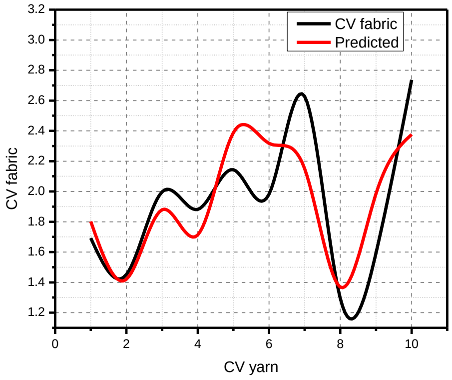

*Figure 3.5: CV curve for the actual and predicted values*

### 4.4 Proposed specification for knitted fabric:

Grading specification system for knitted fabric CV proposed based on CV of the yarn used. The Uster statistic for yarn was used. The range of the yarn CV given in Uster statistic guide was substituted in the proposed model equations to give the predicted specification of a fabric that knitted with specific yarn. The obtained results are given in table 3.5

*Table 3.5: Proposed specification for knitted fabric*

| Material (yarn) | Fabric CV (%) | specification |
|---|---|---|
| Polyester/viscose (65/35)%<br>14 Ne | 2.02 | v. good |
| | 2.04 | good |
| | 2.07 | Acceptable |
| | Above 2.07 | fail |

## CONCLUSION

- The yarn mass variations (CVm) and the knitted fabric mass variations (CVfm) curves follow a sinusoidal curve. It is behavior was the same as the sine function curve.
- The sine function was the best model to estimate the knitted fabric mass variations (CVfm) from the yarn mass variations (CVm). The correlation coefficients were high.
- Using equation1 predict mass variation (CVfm) of the fabric knitted from blended polyester/viscous (65/35) yarn having 14Ne can be determined.
- The proposed mathematical equations(model) was tested.
- The results obtained from the proposed model was in good agree with those obtained from experiments.
- The proposed specifications of the knitted fabrics are given in table 3.5.

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