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INFLUENCE OF MEASUREMENT LENGTH IN YARN EVENNESS CONTROL

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ABSTRACT

In order to be able to quantify yarn evenness, most of the testing instruments use the principle based on drawing the yarn under test between the plates of a condenser, so that the yarn and the air are the dielectric material that changes the capacitor characteristics, which is proportional to the mass of small lengths of the yarn (8 mm). A mathematical study was made in order to determine the yarn evenness in multiples of 1mm length in the range of 1 to 8 mm. To analyse the influence of measurement length in the determination of yarn evenness, a statistical study was carried out. The results show that the ones obtained in 1mm length statistically influence the yarn mass variation.

KEYWORDS: Yarn regularity, evenness, control, statistical analysis.

1. INTRODUCTION

All staple-fibre yarns vary in linear density and most problems of yarn quality are related to this basic property. Yarn regularity in yarn is recognised in a number of ways, namely: variation in linear density, thickness, twist, strength and colour. These all arise from the same underlying cause: the uneven distribution of fibres along the length [1]. The control of these yarn factors is, therefore, important in order to improve the process and the quality.

For detection of such irregularities it is still applied nowadays, to a great extent, the capacitive testing of yarn evenness (determination of mass every 8 mm). The system signals when the mass value is greater or lower than pre-defined thresholds. These thresholds are related to the mass average value, and allow the detection of either thick points (mass greater than the mass average plus a fixed amount) or thin points in the opposite case. The system does not recognise deviations just within these

thresholds (or tolerance limits for defects) [2]. Moreover, the test results are influenced by the material properties and the testing conditions so that they are not easily reproducible.

The method proposed determines the yarn mass variation in portions of 1 mm from an 8 mm experimental measure. To analyse the influence of length measurement in the determination of yarn evenness, a statistical study was carried out.

2. THEORETICAL CONSIDERATIONS

Among the more important identifying specifications for yarn are linear density, structural features and fibre content. The combination of varying number of fibres per cross section with varying forces binding these together because of twist variation leads to varying yarn properties. An example of yarn configuration is shown in Figure 1.

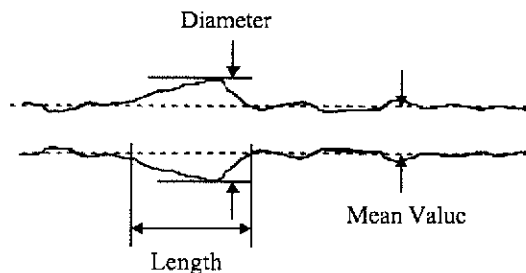


Figure 1 – Example of yarn configuration

In order to obtain yarn mass irregularity electronic capacitance tests are established as a convenient method of testing [3]. The basic requirement of this type of unevenness tester is that the output of the measuring circuit is directly proportional to the linear density of that part of the strand within its capacitor, that is, the relationship between capacitance and the mass of fibre

between the plates must be linear. The changes of capacitance brought about by alteration of the total fibre cross-sectional area between the plates enables the automatic indication of the mean deviation (U%) and coefficient of variation (CV%).

The irregularity U% can be described graphically according to Figure 2 [4].

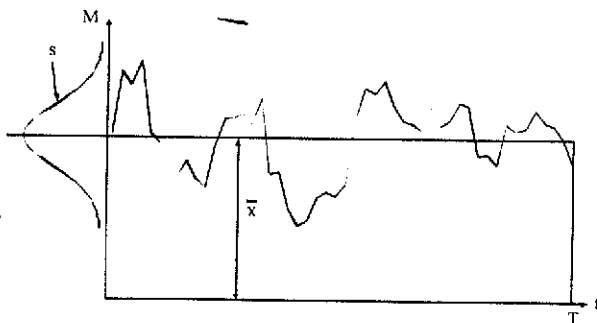


Figure 2 - Graphical representation of U and CV

In mathematical form U is defined (as a percentage) by Equation 1.

$$U = \frac{100}{\bar{x}T} \int_0^T |x_i - \bar{x}| dt \quad (1)$$

where, x_i instantaneous value of the mass
 \bar{x} - mean
 T - evaluation time

The irregularity U is proportional to the intensity of the mass variation around the mean value, and is independent of the evaluating time or tested material length with homogeneously distributed mass variation.

The coefficient of variation CV is graphically represented in Figure 2.

The mass variation can be considered to conform approximately to a normal distribution when a homogeneous fibre composition is available. As a measure of the size of these mass variation is the standard deviation s , which is defined as the distance from the mean value to the point of inflexion of the normal distribution curve (Figure 2). The standard deviation is equated to the mean value as defined in equation 2.

$$CV = \frac{100}{\bar{x}} \sqrt{\frac{1}{T} \int_0^T (x_i - \bar{x})^2 dt} \quad (2)$$

Apart from this yarn irregularity it is important, in order to produce a quality yarn, to provide data on the number and kind of imperfections. These are commonly named faults and are of three kinds (Figure 3):

- thin places - a decrease (50%) in the mass during a short length of about 4 mm;
- thick places - an increase in the mass, usually lower than 200% and lasting more than 4 mm;
- NEP's - huge mass of yarn in a short length, typically from 1 to 4 mm.

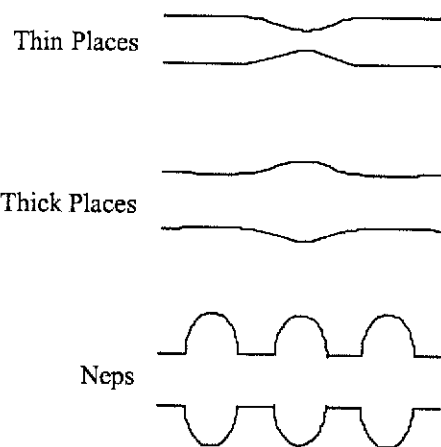


Figure 3 - Types of yarn faults

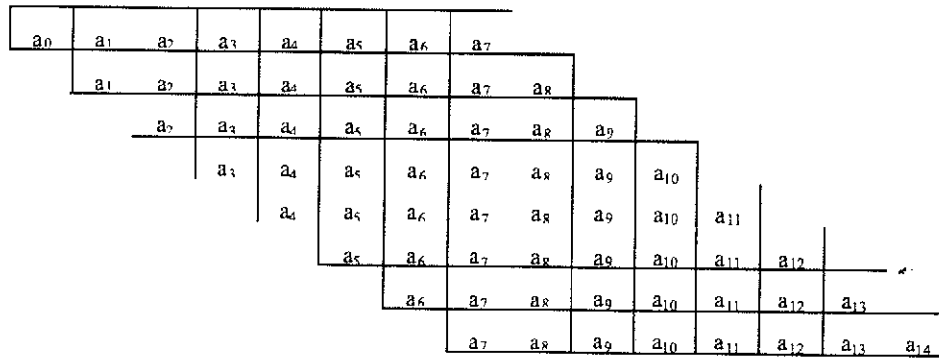
The number of faults and mass measurements enable a quality rating of the product. An accurate measurement of these properties is of major importance [5].

3. EXPERIMENTAL PROCEDURE

For the experiments we use an Uster Tester I equipped with an 8 mm capacitive sensor and a LabVIEW based data acquisition system (Evenness Tester), previously validated with an Uster Tester III. The input signal to the data acquisition system is a tension (0 to 10 V) from the galvanometer proportional to the dielectric between the plates of the condenser sensor, i.e. proportional to the yarn mass [6].

It was developed a LabVIEW based software tool that interfaced with the acquisition board for data collecting and signal processing. This tool allowed us to set not only the normal parameters such as speed and yarn length, but also the sampling rate. This later characteristic made possible the yarn evenness measurement in 1 mm range, although using an 8 mm length capacitive sensor.

**Yarn under
the 8mm
sensor**



- Sample 1
- Sample 2
- Sample 3
- Sample 4
- Sample 5
- Sample 6
- Sample 7
- Sample 8

Figure 4- Method used in the determination of mass in 1 mm yarn length

Table 1 - U% value

Samples	1 mm	2 mm	3 mm	4mm	5 mm	6 mm	7 mm	8 mm
1	12,48855	12,18584	12,10521	12,00694	11,9319	11,82903	11,74725	11,64868
2	12,19555	11,85068	11,77871	11,65469	11,57621	11,45805	11,3648	11,29968
3	12,43189	12,078	11,99118	11,87722	11,76168	11,68992	11,60554	11,47208
4	12,26092	11,92136	11,84232	11,72615	11,63962	11,52561	11,46135	11,34869
5	12,31575	11,98133	11,9297	11,78799	11,70142	11,62111	11,5182	11,39227
6	12,48855	12,18584	12,10521	12,00694	11,9319	11,82903	11,74725	11,64868

The mathematical study aimed to extract 1 mm mass values, using measurement of 8 mm length sensor acquiring with a sample rate proportional to a 1 mm yarn length. Figure 4 displays, graphically, the method employed in order to obtain this measurement.

Sequential samples of the mass signal are acquired in such a way that the length interval is in the 1mm range. With this approach, each new sample includes a new segment with 1 mm length. To evaluate the value of this new segment, there it is necessary to know previous samples in the 1mm range.

In order to obtain the mass value of the yarn with a step of 1mm it is always necessary to know the mass of previous samples, using the following approach,

$$a_i = \sum_{j=i-7}^i a_j - \sum_{k=i-8}^{i-1} a_k + a_{i-8} \quad (3)$$

where a_i are the values in the 1mm range.

As the sums are the values of each acquired sample with the 8mm sensor, there is only the need to know previous values of a . To achieve this, during the calibration, signal acquired from the sensor has no material.

4. RESULTS

The values acquired from the sensor allow the evaluation of mass in 1mm multiple if we consider the values acquired when there is no material (yarn) between the plates of the sensor. The values during this period present some small variation that is due to noise. However, its peek-to-peek value is small if compared with the variation due to the yarn.

With the yarn mass evaluated signal it is possible to calculate all evenness values in several segment length, which is of utmost importance to extract information regarding the quality of the yarn.

Table 1 displays the U in several yarn length segments. The average of the mass changes are small and due only

to the number of samples considered for each set. U decreases when they are evaluated in larger segments.

In order to evaluate the hypothesis that several population means are equal we used an Anova method in SPSS (Statistical Package for Social Sciences) package. The values obtained for U parameter are represented in Table 2.

Table 2 - ANOVA results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.509	7	.501	29.004	.000
Within Groups	.691	40	1.728E-02		
Total	4.200	47			

As we can see the significant F statistics obtained only indicates that the population mean are probably unequal. It does not pinpoint where the differences are. In order to determine which population mean are different from each other we used a Scheffe method for pairwise comparisons of means. Pairs of means that are significantly different at the 0.05 level in this case, are those obtained in comparison with 1 mm range. No other pair is found to be significantly different at this level.

As can be seen from Table 3 the only measurement that is significantly different is the one obtained from 1mm range (subset 4). The other measurement lengths are correlated in groups of four, as point out by subsets 1 to 3.

The values of U decrease with the increase of the segment length as expected. With a segment of 8mm, the values U are close to those extracted with a sampling rate adequate to assure no overlap of segments. The quick decrease from 1 to 2 mm can be explained by the torsion of the yarn.

Table 3 - Means for groups in homogeneous subsets are displayed (Scheffe Method)

Measurement length	Sample size	Subset for alpha = .05			
		1	2	3	4
8.00	6	11.4537			
7.00	6	11.5582	11.5582		
6.00	6	11.6440	11.6440		
5.00	6	11.7397	11.7397	11.7397	
4.00	6		11.8370	11.8370	
3.00	6			11.9481	
2.00	6			12.0204	
1.00	6				12.3565
Sig.		.075	.091	.086	1.000

5. CONCLUSION

The results obtained with the mass yarn evaluated in 1mm range are of utmost importance for a correct detection of irregularities as most of them have a short length. The results obtained in 1mm range statistically influence the yarn mass variation. It has the advantage of using a sensor that measures the yarn mass in a low cost operation, but has the drawback of suffer influence in the dielectric due to electric noise.

Next step in the research is to compare the values of 1mm measurement obtained with the mathematical mode developed with a specific sensor that measures directly 1mm yarn mass.

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