# YARN EVENNESS CONTROL IN 1 MM RANGE

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**Abstract:** In order to be able to quantify yarn evenness, testing instruments were developed, based on different methods and progressively improving their performance. Most of them use the principle based on drawing the yarn under test between the plates of a condenser, so that the yarn and the air are[1] the dielectric material that changes the capacitor characteristics, which is proportional to the mass of small lengths of the yarn (8 mm). Knowledge of the yarn mass in 1 mm range is of most importance to evaluate properly the yarn evenness; furthermore several irregularities can only be properly detected if this mass evaluation is possible in this range. In this paper, a study is presented in order to achieve mass variation in 1mm length. Simulation results are presented and compared with Uster Tester III.

**Keywords**: Yarn regularity, evenness, instrumentation, capacitive sensor.

## 1. INTRODUCTION

Yarn structure is subject to periodic or random irregularities. These factors generate problems in the weaving or knitting processes namely, stoppages that cause low production rates and poor quality, resulting in a poor appearance of the knit or woven fabrics and therefore in the apparel product. The control of these yarn factors is, therefore, important in order to improve the processes and the quality. But, their effects on final products (woven or knitted fabric) are difficult to be assessed.

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) (Monteiro and Couto, 1995a). Moreover, the test results are influenced by the material properties and the testing conditions so that they are not easily reproducible.

With the proposed solution for measuring mass variation each 1 mm, we shall be able to assess the most difficult irregularities of the yarn, namely those that have high mass variation during a short period.

## 2. THEORETICAL CONSIDERATIONS

Yarns can vary in properties such as strength and twist. Although it has been argued that fabric irregularity is closely related with the apparent variation of yarn diameter, the unqualified term yarn irregularity is usually taken to mean the variation of mass per unit length (Vasconcelos and Lima, 1998). Figure 1 shows an example of yarn configuration, with the representations of the corresponding diameter and means value as well as the sample length.

[1] The authors are grateful to FCT project funding, PRAXIS XXI contract n. PRAXIS/P/EEI/13189/98 )

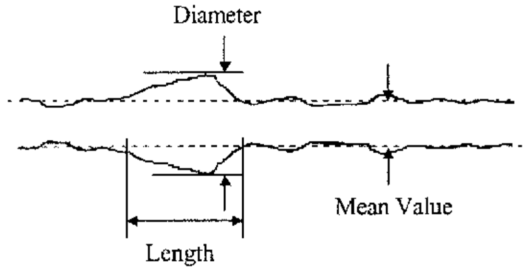


**Figure 1 – Example of yarn configuration**

The main factors involved in the formation of short term irregularity are: limit irregularity due to random fibre arrangement, imperfect fibre control which in roller drafting leads to drafting waves varying in amplitude and length and mechanical defects (Oxtoby, 1987).

In order to obtain yarn mass irregularity electronic capacitance tests are established as a convenient method of testing (Monteiro and Couto, 1995b). The material under test is drawn between the plates of a condenser. 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 (Furter, 1982).

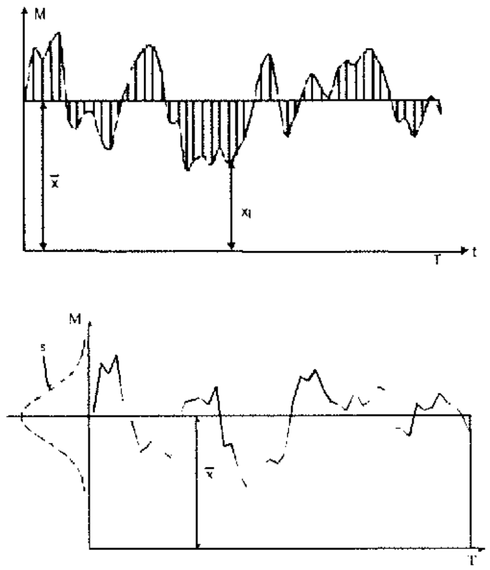


**Figure 2 - Graphical representation of U and CV**

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

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

where, $x_i$ instantaneous value of the mass
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.

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

It can be considered that if the fibre assembly to be tested is normally distributed with respect to its mass variation, a conversion is available between the two types of calculation according to the equation 3.

$$CV = 1.25\ U \qquad \textbf{(Eq. 3)}$$

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.

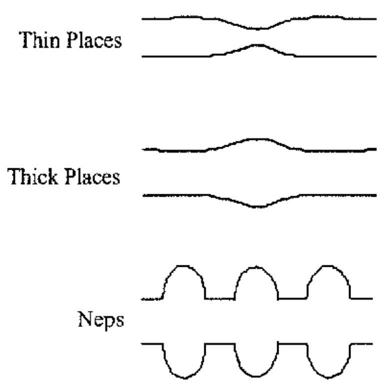


**Figure 3 – Types of yarn faults**

The number of faults and mass measurements enable a quality rating of the product. An accurate measurement of these properties is of major importance (Vasconcelos and Lima, 1998).

### 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). 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.

It was developed a LabVIEW based software tool that interfaced with the acquisition board for data collecting and signal processing (Figure 4). 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.

The first step was to validate the experimental rig. In order to do so, we reproduced, successfully, the results obtained with an Uster Tester III. The compared values were: U%, CV%, number of thick and thin places. The parameters used in data collection (8 mm length) were the same in both apparatus. Table 1 shows the results obtained.

**Table 1 – Results obtained in both apparatus**

| | Evenness Tester | USTER Tester III |
|---|---|---|
| U(%) | 11.63 % | 11.3 % |
| CV(%) | 14.57 % | 14.9 % |
| Thin places | 5 / Km | 11 / Km |
| Thick places | 215 / Km | 167 / Km |

After the validation, the second step 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 5 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.

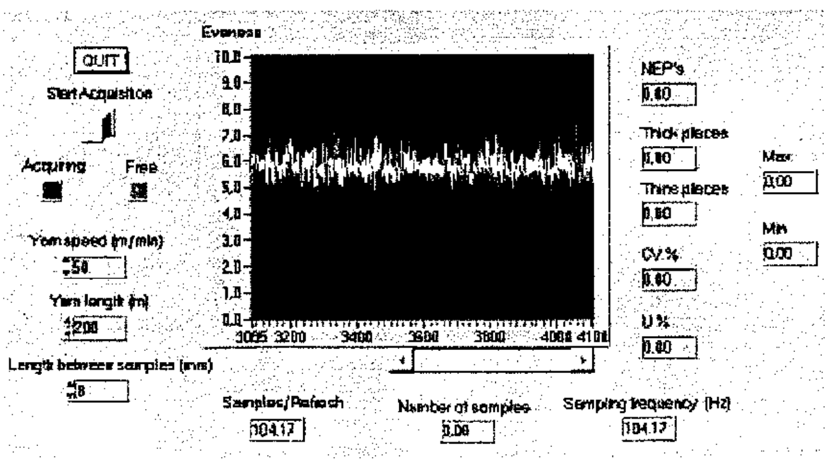


**Figure 4 – Developed tool sample window**

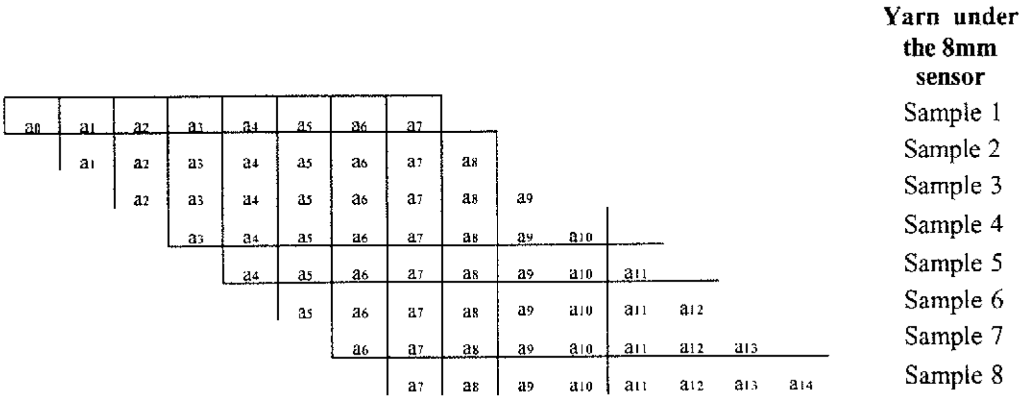


**Figure 5– Method used in the determination of mass in 1 mm yarn length**

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,

$$a_i = \sum_{j=i-7}^{i} a_j - \sum_{k=i-8}^{i-1} a_k + a_{i-8} \qquad \textbf{(Eq. 4)}$$

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. These signals are presented in Figure 6.

The values acquired from the sensor allow the evaluation of mass in 1mm range 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.

## 4. RESULTS

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.

In fact, only with values in this range it's possible to count the number of NEPs (large thick points) in the yarn that dramatically reduces its quality. Furthermore, CV and U decrease when they are evaluated in larger segments. Their value in the 1 to 3 mm should range make possible to deduct other characteristics, like torsion but further tests must be made to extract a perfect correlation.

Figure 7 displays the CV and 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. However, the difference of the Standard Deviation between 1 and 2mm can be important and eventually is related with the torsion of the yarn.

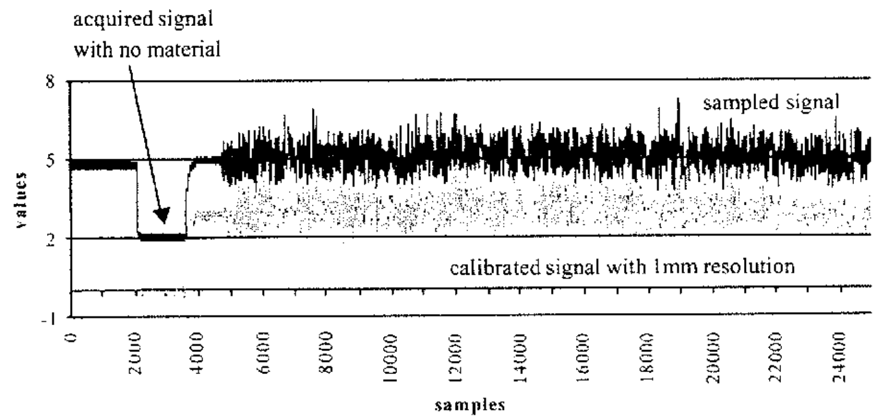


**Figure 6 – Acquired signal with an 8mm sensor and the evaluated signal with 1mm length resolution**

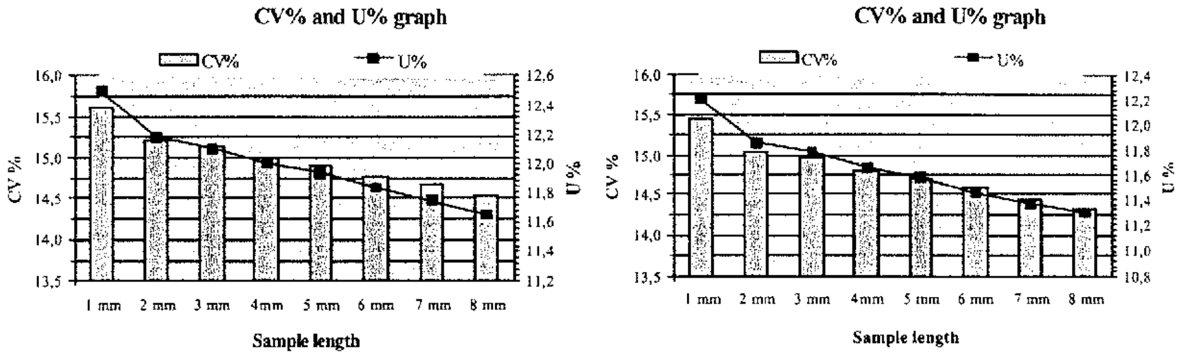


**Figure 7 – CV% and U% in 20 m yarn, using 1 to 8 mm segments (two experiments with 20 m each)**

The values of U and CV decrease with the increase of the segment length as expected. With a segment of 8mm, the values of CV and 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 2 – Irregularities in six experiments (20 meters), using the 1mm evaluated signal**

| | Experiments | | | | | | Irregularities / Km (average) |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | |
| Thin places | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thick places | 3 | 2 | 4 | 3 | 6 | 2 | 167 |
| Neps | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The number of **thick points**, **thin points** and **Neps** for the same yarns, produced in six experiments of 20 meters of yarn, as well as the evaluated value for these irregularities per kilometre, is displayed in Table 2.

Although present results are in accordance with results obtained with industrial equipment, we must state that with a short difference in the irregularity threshold, results have a strong change. These results are displayed in Table 3
Table 3

## 5. CONCLUSIONS

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 procedure described in the present paper is a low cost approach for operation. It has the advantage of using a sensor that measures the yarn mass, but has the drawback of suffer influence in the dielectric due to electric noise. Next step in the research is the development of a specific sensor that measures directly 1mm yarn mass.

**Table 3 – Difference of irregularities with different thresholds in the same experiment**

| | Thin places | | Thick places | | Neps | |
|---|---|---|---|---|---|---|
| | threshold 50% | threshold 60% | threshold 50% | threshold 45% | threshold 200% | threshold 180% |
| **Irregularities/ Km** | 0 | 150 | 125 | 425 | 0 | 100 |

## 6. REFERENCES


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