EVALUATION OF THE YARN QUALITY CHARACTERISTICS THROUGH SYNTHETIC INDICATORS

BY

LILIANA LUTIC

Abstract. The paper presents the evaluation based on USTER Statistics of OE cotton yarns, with different counts, for the production of knitted fabrics on circular machines, using synthetic quality indicators.

Key words: quality, evaluation, characteristics, yarns, indicators for quality.

1. Introduction

Determining the most important product quality characteristics is the first step in the correct quality evaluation, the starting point for a multicriterial analysis that is the base for the decisions regarding the optimum beneficiary’s request and product quality ratio.

In this paper are presented the results of the quality evaluation of several OE cotton yarns, which were processed on large diameter circular knitting machines.

2. Evaluation of Yarn Quality as a Function of its Features

2.1. The Methodology for Quality Factor Determination

Estimation of yarn quality includes the following stages [1]:

− Selection of yarn features that will be compared with the standardized features or the ones existing in USTER Statistics;
− Establishing the importance factor of the adopted features in relation to yarn’s final use; the direct comparison method was used;
− Reference values estimation (existent values in USTER Statistics for different quality levels);
− Determining the simple quality factors \((I_{ci})\) – the ratio between the features’ reference values and actual values, respectively the ratio between the actual values and reference values, depending on the preferable decrease or increase direction for a certain feature;

− The calculus of the technical quality factor \(I_t\) (synthetic quality factor) with formula:

\[
I_t = \frac{\sum p_i \cdot I_{ci}}{\sum p_i}
\]

where: \(p_i\) – represents the weight of each feature.

The value of this factor allows the inclusion of the analysed yarns in one of the following four quality groups:

− \(I_t > 1\) – quality over the worldwide technical level;
− \(0.85 < I_t < 1\) – high quality within the worldwide technical level;
− \(0.5 < I_t < 0.85\) – medium quality within worldwide technical level;
− \(I_t < 0.5\) – quality under the worldwide technical level.

a) Choosing yarn characteristics and determining the importance coefficient. The most important characteristics for the yarns used in knitting are [2]:

− \(C_1\) – coefficient of variation for the yarn count (yarn count irregularity on long portions);
− \(C_2\) – yarn tenacity;
− \(C_3\) – coefficient of variation for yarn tenacity;
− \(C_4\) – breaking elongation;
− \(C_5\) – coefficient of variation for elongation;
− \(C_6\) – USTER irregularity (irregularity of linear density on short portions).

The direct comparison method was used for determining the importance coefficient for the adopted features.

The resulted importance coefficients as well as their corresponding ranges are:

\[
\begin{align*}
\alpha_1 &= 0.10 \quad \text{− range 3}; \\
\alpha_2 &= \alpha_4 = 0.32 \quad \text{− range 1}; \\
\alpha_3 &= \alpha_5 = 0.06 \quad \text{− range 4}; \\
\alpha_6 &= 0.14 \quad \text{− range 2}.
\end{align*}
\]

It results that the most important characteristics are yarn tenacity and elongation, followed by USTER irregularity, count variation and finally the variation of tenacity, respectively of yarn elongation.

b) Establishing the reference values. The USTER reference values considered for the chosen features corresponded to levels of 95%, 75%, 50%, 25% and respectively 5% of the worldwide OE cotton yarn production.

c) Determination the simple quality factors \((I_{ci})\) was made with formula (2), for the case when a feature increase is wanted, respectively formula (3) for
the case when a decrease is preferred [3]:

\[ I_{ci} = \frac{x_{ef}}{x_{ref}} \]  

\[ I_{ci} = \frac{x_{ref}}{x_{ef}} \]

where:  
- \( x_{ef} \) – feature actual value;  
- \( x_{ref} \) – feature reference value.

Tables 1 and 2 exemplify for yarns count Nm 50/1, 60/1 the actual values of the analysed yarns features, the simple quality factors \( I_{ci} \), importance factors \( \alpha_i \), and also the estimation against the USTER reference levels. The data was used to determine the synthetic technical quality factor \( I_t \).

Based on the calculated simple quality factors \( I_{ci} \) we can say that the yarns considered for study are characterised by:
- good uniformity;
- medium tenacity and breaking elongation;
- reduced variation of tenacity and breaking elongation.

As such, it can be appreciated that these yarns are behaving well during their knitting machine processing, determining the achievement of evenly knitted fabrics. By means of the simple quantity factors \( I_{ci} \) there were computed the synthetic factors of the technical features \( I_t \) for five levels of quality of the USTER Statistics.

A suggestive representation of the level position for 5%, 25%, 50%, 75%, respectively 95% of the USTER Statistics on a scale from 0 to 100 corresponding to the quality level of the yarns is presented in Fig. 1.

![Fig. 1 – Positioning of the quality levels from USTER Statistics and the quality levels for the analysed yarns on a 0 – 100 scale.](image-url)
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>MU</th>
<th>Preferred variation</th>
<th>Actual value</th>
<th>Simple quality factor $I_s$</th>
<th>Importance coefficient</th>
<th>Evaluation by comparison with reference levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>95%</td>
<td>75%</td>
<td>50%</td>
</tr>
<tr>
<td>Cv count</td>
<td>%</td>
<td>↓</td>
<td>1.20</td>
<td>2.50</td>
<td>1.67</td>
<td>1.25</td>
</tr>
<tr>
<td>Tenacity</td>
<td>cN/tex</td>
<td>↑</td>
<td>10.88</td>
<td>1.15</td>
<td>0.99</td>
<td>0.91</td>
</tr>
<tr>
<td>Cv tenacity</td>
<td>%</td>
<td>↓</td>
<td>9.23</td>
<td>1.21</td>
<td>1.14</td>
<td>1.03</td>
</tr>
<tr>
<td>Elongation</td>
<td>%</td>
<td>↑</td>
<td>5.60</td>
<td>1.10</td>
<td>1.02</td>
<td>0.93</td>
</tr>
<tr>
<td>Cv elongation</td>
<td>%</td>
<td>↓</td>
<td>7.62</td>
<td>1.27</td>
<td>1.12</td>
<td>1.05</td>
</tr>
<tr>
<td>Irregularity USTER</td>
<td>%</td>
<td>↓</td>
<td>10.00</td>
<td>1.40</td>
<td>1.31</td>
<td>1.25</td>
</tr>
</tbody>
</table>

$\Sigma = 1$

It = 1.32
It = 1.14
It = 1.02
It = 0.95
It = 0.85
### Table 2

**Evaluation of yarn count Nm 00/1**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>MU</th>
<th>Preferred variation</th>
<th>Actual value</th>
<th>Simple quality factor ( L_q )</th>
<th>Importance coefficient</th>
<th>Evaluation by comparison with reference levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( 95% )</td>
<td>( 75% )</td>
<td>( 50% )</td>
</tr>
<tr>
<td>Cv count</td>
<td>%</td>
<td>↓</td>
<td>1.10</td>
<td>2.55</td>
<td>1.73</td>
<td>1.36</td>
</tr>
<tr>
<td>Tenacity</td>
<td>cN/tex</td>
<td>↑</td>
<td>12.80</td>
<td>1.35</td>
<td>1.16</td>
<td>1.07</td>
</tr>
<tr>
<td>Cv tenacity</td>
<td>%</td>
<td>↓</td>
<td>9.49</td>
<td>1.21</td>
<td>1.16</td>
<td>1.05</td>
</tr>
<tr>
<td>Elongation</td>
<td>%</td>
<td>↑</td>
<td>5.26</td>
<td>1.05</td>
<td>0.99</td>
<td>0.91</td>
</tr>
<tr>
<td>Cv elongation</td>
<td>%</td>
<td>↓</td>
<td>7.71</td>
<td>1.27</td>
<td>1.17</td>
<td>1.06</td>
</tr>
<tr>
<td>Irregularity USTER</td>
<td>%</td>
<td>↓</td>
<td>10.50</td>
<td>1.37</td>
<td>1.30</td>
<td>1.24</td>
</tr>
</tbody>
</table>

\( \Sigma - 1 \) | \( H = -1.37 \) | \( H = 1.18 \) | \( H = 1.07 \) | \( H = 0.99 \) | \( H = 0.89 \)
On the same scale there were presented also the positions occupied by the analysed yarns resulted from the comparison of the synthetic factors of the technical features for these yarns to the corresponding factors of different levels in USTER Statistics.

The following ideas can be pointed out from the analysis of the quality indexes:

− For the yarns with a count of Nm 34/1 and Nm 60/1 the technical factor for the level 25% is $I_t = 0.99$ while for the level 50% this is $I_t = 1.08$. As such we can say about the quality of these yarns that is very good.

− In case of the yarns with count of Nm 40/1 the technical factor for level 50% is $I_t = 0.94$, and the factor corresponding to the level of 75% is $I_t = 1.05$. As such, through its position on the scale 0 – 100, it can be estimated a quality under average for this yarn.

− The yarns with count Nm 50/1 have a technical factor of 0.95 for the 25% level and a factor equal with 1.02 for the 50% level. As in the case of Nm 34/1 by means of the position occupied on the axis (scale 0 - 100) we can say that these yarns have an over average quality.

− In case of the yarns with count of Nm 60/1 the technical factor for level 25% is $I_t = 0.99$ and the factor corresponding to the level of 50% is $I_t = 1.07$. As such, through its position on the 0 – 100 scale there can be estimated a quality of these yarns that is very good.

− In conclusion the yarns with count Nm 34/1, 50/1 and 60/1 have a very good quality and as such a greater probability that they will behave better in the knitting process, resulting knitted fabrics with an evenly aspect.

− The yarns with count Nm 40/1 have an under-average quality and this can lead to flaws in the knitted fabric and on the other hand to deficiencies during their processing by knitting machines.

3. Conclusions

Manufacturing knitted fabrics with a high quality level and also rational processing of raw materials on knitting machines implies knowledge of the main features of yarns in close connection to the end-use of the knitted fabric. The selection of features through which the quality of raw materials for knitted fabrics can be evaluated can be considered from two points of view: from the manufacturer’s point of view (processability features) and user’s point of view (features given by the knitted fabric during use).

The paper presents a modality to evaluate quality for yarns used for circular knitting machines, considering the manufacturer’s point of view and using the quality factor system.

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“Gheorghe Asachi” Technical University of Iaşi, Department of Knitting and Ready - Made Clothing

e-mail: lliliana@tex.tuiasi.ro

EVALUAREA CARACTERISTICILOR DE CALITATE A FIRELOR PRIN INTERMEDIUL INDICATORILOR TEHNICI

(Rezumat)

Lucrarea prezintă evaluarea firelor de bumbac tip OE, de diferite fineţi, ce urmează a fi prelucrate pe maşini circulare de tricotat, prin intermediul indicatorilor de calitate.

Acest sistem de indicatori ai calităţii are menirea să servească drept instrument în analiza critică a modului de realizare a obiectivelor propuse, pentru orientarea eforturilor spre înălţurarea deficienţelor şi îmbunătăţirea continuă a calităţii produselor.