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APPLICATION OF MDTA-3 DEVICE FOR OPTIMIZATION OF FIBER BLENDS FOR COTTON YARN PRODUCTION

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Abstract

In cotton spinning, one of the most critical problems, from the point of view of production economics, is trash content in the raw material. Cotton contamination influences production costs directly and indirectly. Moreover, trash content affects the quality of the produced cotton yarns, especially its evenness and the IPI per 1000 m.

There are many different measurement methods for the assessment of cotton contamination. They are still improving. Simultaneously, there are investigations on the development of new, fast and, at the same time, precise and objective methods allowing for the assessment the percentage of trash in cotton raw material as well as in semi – products originating from different spinning stages being carried out. It is required to use the obtained results from the existing methods for making conclusions on the spinning procedure, the number of waste and initial evaluation of predicted material costs of production.

In the Institute of Textile Architecture, research on cotton raw material processing effectiveness at a determined trash content is being carried out. We propose a parameter which can be used to predict the real yield from the given blend, as well as for the assessment and comparison of cotton blends at different proportions of the components. We also proposed a method for the assessment of a unit increase of raw material utilization due to the introduction of a component to the blend of high trash content, especially during processing of blends with cotton waste.

The proposed method can be used for negotiation of prices during cotton purchasing, taking into consideration two factors: predicted costs of raw material for producing 1 kg of yarn and if it is possible to achieve the price of produced yarn. The advantage is that it can be used for even small trade samples occurring in the cotton trade.

Introduction

In cotton spinning, one of the most important problems from the point of view of production economics is the trash content in the raw material. Cotton contamination influences directly and indirectly the production costs. The percentage of trash content, as well as their structure, influence the cotton cleanability [Schlichter S., Kuschel A. 1995, Kearny .R., Lawrance J.B. 1995] and fiber behavior during processing. A large amount of trash content implies the necessity of intensive cleaning, increase in the amount of waste and a higher material costs, as well as costs dealing with the energy and labor consumption.

Trash is removed in the all stages of the technological process. In the initial stages of the spinning process, i.e., during cleaning, opening/blending and carding, due to a small opening and blending of raw material, spinable fibers are removed in addition to trash. The presence of these fibers in all kinds of waste [Artzt P., Schmid H.P. 1998] is also a lost in the technological process causing an increase of unit raw material consumption and an increase of production direct material costs. Moreover, cotton contamination influences the quality of produced yarns, especially its evenness and IPI, and also their price [Naardig W. 1989].

All these factors that cause faults and trash content are some of the most important parameters characterizing the class of raw material and its price. Therefore, also an important problem in cotton trade and textile industry is a precise and fast assessment of faults and trash content in cotton.

There are many different measurement methods for the cotton contamination assessment [Frydrych I., Matusiak M. 2001]. They are still in need of improvement. Simultaneously, there are investigations carried out on a development of new, fast and at the same time, precise and objective methods allowing the assessment of trash content in raw material as well as in spinning semi-products from the different spinning stages. It is required that results obtained by existing measurement methods could be used for drawing conclusions on processing, amount of waste and the initial evaluation of predicted material costs of spinning production.

Assessment of Yield of Cotton Blends

In the Institute of Textile Architecture, there were investigations carried out aimed at an analysis of usefulness of using the MDTA-3 device for assessment of effectiveness of raw material processing by determination of the yield of the cotton blend possible to obtain the determined trash content [Frydrych I., Matusiak M. 2000]. The yield obtained from blends is a yarn amount, which can be obtained from the raw material mass unit used for production.

The value of the cotton blend yield influences the unit material costs, and at the same time, costs of the yarn production and thus its profitability. For research purposes, we used 3 middle staple cotton lots and 3 kinds of waste; nuts and flat strips, husk and noils, blended with cotton in appropriate shares. Application of waste aimed at more differentiation of trash level in blends produced in laboratory conditions.

Processed cotton lots were assigned as follows:

A – lot 044-180,
B – lot 031-020,
C – lot 025-143.

Using MDTA-3 combined with the Rotorring unit, the appropriate blend components were mixed; and next, the sliver of linear density 5 ktex was formed. For each cotton lot we produced 12 variants of blends with waste:

1. cotton 90% flat strips 10%
2. cotton 80% flat strips 20%,
3. cotton 70% flat strips 30%,
4. cotton 60% flat strips 40%,
5. cotton 90% husk 10%,
6. cotton 80% husk 20%,
7. cotton 70% husk 30%,
8. cotton 60% husk 40%,
9. cotton 90% noils 10%,
10. cotton 80% noils 20%,
11. cotton 70% noils 30%,
12. cotton 60% noils 40%.

We also produced slivers from cotton without the addition of waste. Slivers produced in a laboratory way, the rotor yarn of linear density 30 tex was manufactured. Particular samples of cotton raw materials and waste were measured on MDTA-3 and the percentages of lint and contaminants classified into trash, dust and fiber fragments were determined.

Based on these results, the theoretical mean lint content was calculated using the following formula:

$$FC_{cal} = a_1 \cdot L_1 + a_2 \cdot L_2 + ... + a_i \cdot L_i + ... + a_n \cdot L_n \quad (1)$$

where:
- FC_{cal} – calculated lint content in a blend,
- a_i – share of i-th component in the total mass of blend,
- L_1 – lint share in the mass unit of i-th blend component according to MDTA-3,
- n – the number of blend components.

Calculated according to equation (1) mean lint content FC_{cal} in the unit mass of particular blends were compared with shares determined in the laboratory FC_{lab}, by examining the blend specimens using MDTA-3. Mean lint content values were calculated and experimental data are presented in Table 1.

On the basis of the presented data, it was stated that in a majority of cases mean lint content values determined in a laboratory are lower than the calculated ones (Fig.1). This results from the fact that adding very trashy raw material to the blend causes an increased liberation of lint fibers with the cotton contaminants. In extreme cases, the values determined in a laboratory, lint shares were lower, about 6.5% and 3.5%, than the calculated ones. Both parameters, calculated and laboratory, mean lint content can be used for a comparison of different cotton blend variants. On their basis we cannot conclude about the predicted yield of cotton blend and predicted consumption of raw material for production of unit yarn mass.

The parameter, which can be used for predicting the real yield of raw material, is the real yarn linear density produced from the proposed blends. The size of samples used for measurements and sliver formation using MDTA-3 was 5 grams. From this amount of fibers we produced 1m of sliver, and next – the yarn. Without loss in the technological process, the linear density of sliver should be 5 ktex. At a draft ratio on the rotor spinning frame R=167.9, the yarn linear density should be 29.78 tex.

Nevertheless, on the MDTA-3 and later during the spinning process on the rotor spinning frame, a removal of trash, dust, neps and fiber fragments and also lint fibers takes place. Therefore, the linear density values of produced yarns for all variants were lower than the nominal linear density, i.e., 29.78 tex.

The difference between the nominal and real yarn linear density reflects the real waste amount removed during the laboratory process of yarn manufacture, thus it can be used for calculation of yield of the processed blend. This yield called "the laboratory yield" is calculated according to the equation:

$$Y_{lab} = \frac{Tt_{real}}{Tt_{nom}} \tag{2}$$

where:

Y_{lab} - laboratory yield of blend of raw material,
Tt_{real} - real linear density of yarn,
Tt_{nom} - nominal linear density of yarn.

$$Tt_{nom} = \frac{m \cdot 100}{R} \tag{3}$$

where:

m - mass of the sample used for MDTA-3 sliver manufacture,
R - draft ratio on the rotor spinning frame.

Laboratory yield does not fully reflect the real yield obtained in the industrial conditions, because it depends on many factors dealing with the processing in the spinning mill. First of all, we should mention here the number of cleaning points in the opening/blending machinery and adjustment of working elements of the machinery. In the same industrial conditions, from the same blend, different yields can be obtained by applying different cleaning intensity.

The proposed parameter can be used for predicting the real yield of raw material after the introduction of appropriate correction coefficient. This coefficient can be determined experimentally by a comparison of laboratory yield value Y_{lab} determined on MDTA-3 with the real one obtained in the industrial conditions. The correction coefficient should be determined for each technological order for a given type of cotton blend.

The parameter called "the laboratory yield" Y_{lab} can be used for an assessment and comparison of cotton blends of different component shares. It can be also applied for assessment of the degree of increase of the raw material unit consumption due to introducing into a blend the trashy raw material, particularly at processing the blends with cotton waste.

The waste application as a blend component allows using more rationally an expensive raw material, limiting the amount of production waste difficult to utilize, and first of all diminishing the production costs. Nevertheless, waste processing also causes the negative results. It implies a reduction of the produced yarn quality. Also important is the increased energy consumption, especially in the initial cleaning, opening in the schutching room and carding as well as accelerated wearing away of the working elements of machinery. It raises a question, if the savings resulting from the much lower price of waste than the full cotton recompense is worth a loss due to the above mentioned negative results.

Based on determined laboratory yield Y_{lab} we can calculate the unit consumption of raw material blend:

$$Z = \frac{1}{Y_{lab}} \tag{4}$$

where:

Z - unit consumption of processed raw material blend,
Y_{lab} - yield obtained according to the MDTA-3 for assessed raw material blend.

A degree of increase of unit consumption of raw material due to the application of very trashy blend component, for example, waste is:

$$ID = \frac{Z_1}{Z} \tag{5}$$

where:

ID - degree of increase of unit consumption of raw material,
Z - basic blend consumption per unit,
Z_z - unit consumption of a blend with trashier component.

For blends used for the experimental production, a degree of increase of unit consumption of raw material ID ranged from 1.01 to 1.18 and was the higher, the higher was a waste percentage in a lay-down.
The predicted unit raw material costs for the blend can be calculated from equation (6):

$$MC = Z \cdot P_m \quad (6)$$

where:

MC - material costs for production of yarn mass unit,
Z - raw material utility per unit,
P_m - price of 1kg of raw material calculated according to the formula:

$$P_m = a_1 \cdot P_1 + a_2 \cdot P_2 + ... + a_n \cdot P_n \quad (7)$$

where:

a_i - share of i-th blend component,
P_i - price of 1 kg of i-th blend component,
n - the number of blend components.

Calculated according to equation (6), the predicted unit raw material costs for different blends allow the comparison of different blend variants and assessing their profitability. In the case of waste application, we propose the following result interpretation:

- if the predicted unit raw material costs are much lower for a blend with a share of waste than for a pure cotton, then we can conclude about a profitability of waste application for the yarn production,
- if the predicted unit material costs of blend with waste are insignificantly lower than a pure cotton, then the profitability of waste application is questionable due to the increase of energy consumption and wear of working elements of machinery as well as decreasing the yarn quality. In such a case we must admit to carry out further trials and evaluate the predicted unit costs of blend of different waste percentage,
- in the case when predicted costs are on the same level or the waste application causes the increase of material costs, introducing wastes into the production does not make any sense. In such a situation we can negotiate diminishing the waste price to the level assuring the profitability of their application.

The proposed method can be used at the price negotiation during the cotton trading taking into account two factors: the predicted material costs of manufacturing 1 kg of yarn and the possibility to achieve the price of produced yarn. An advantage of this method is the fact that it can be used even at small trade samples.

Summing Up

On the basis of research carried out we found that:

1. Using the MDTA-3 device the cotton cleanability as well as costs of cleaning the blends of cotton raw materials differentiated by the intrinsic fiber parameters and trash level can be assessed.
2. Results from MDTA-3 can be used:
   a. for predicting the yield of raw material blends of different percentage of components,
   b. for evaluating the unit consumption of raw material for cotton yarn production,
   c. for evaluating a degree of increase of unit consumption of raw material caused by an application of very trashy component.
3. Proposed parameters characterizing the raw material and raw material consumption per unit can be used in the industrial conditions after determination of a correction coefficient characterizing the given spinning mill.

References

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Table 1. The set of calculated and assessed mean shares of lint fibers in blends of raw materials.

a)

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A7**	**A9**	**A10**	**A11**	**A12**
FC_{cal}	0,9567	0,9411	0,9254	0,9098	0,9559	0,9394	0,92230	0,9065	0,9739	0,9754	0,9769	0,9784
CF_{lab}	0,9543	0,9279	0,9117	0,8995	0,9269	0,9252	0,8573	0,8789	0,9622	0,9649	0,9747	0,9750
FC_{lab}-FC_{cal}	0,0024	0,0132	0,0137	0,0103	0,0290	0,0142	0,0657	0,0276	0,0117	0,0105	0,0022	0,0034
$FC_{cal/}$ FC_{lab}	1,003	1,014	1,015	1,011	1,031	1,015	1,077	1,031	1,012	1,011	1,002	1,003

b)

	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B7**	**B9**	**B10**	**B11**	**B12**
FC_{cal}	0,9559	0,9403	0,9248	0,9092	0,9551	0,9387	0,9223	0,9059	0,9730	0,9746	0,9762	0,9778
CF_{lab}	0,9502	0,9397	0,9018	0,9330	0,9393	0,9300	0,9391	0,8695	0,9668	0,9679	0,9713	0,9725
FC_{lab}-FC_{cal}	0,0057	0,0006	0,0230	-0,0238	0,0158	0,0087	-0,0158	0,0364	0,0062	0,0067	0,0049	0,0053
$FC_{cal/}$ FC_{lab}	1,006	1,001	1,025	0,974	1,07	1,009	0,982	1,042	1,006	1,007	1,005	1,005

c)

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C7**	**C9**	**C10**	**C11**	**C12**
FC_{cal}	0,9603	0,9442	0,9282	0,9121	0,9595	0,9426	0,9257	0,9088	0,9774	0,9786	0,9796	0,9808
CF_{lab}	0,9508	0,9367	0,9195	0,8947	0,9357	0,9330	0,9219	0,9271	0,9693	0,9771	0,9758	0,9804
FC_{lab}-FC_{cal}	0,0095	0,0075	0,0087	0,0174	0,0238	0,0096	0,0038	-0,0183	0,0081	0,0014	0,0038	0,0004
$FC_{cal/}$ FC_{lab}	1,010	1,008	1,009	1,019	1,025	1,010	1,004	0,980	1,008	1,001	1,004	1,000

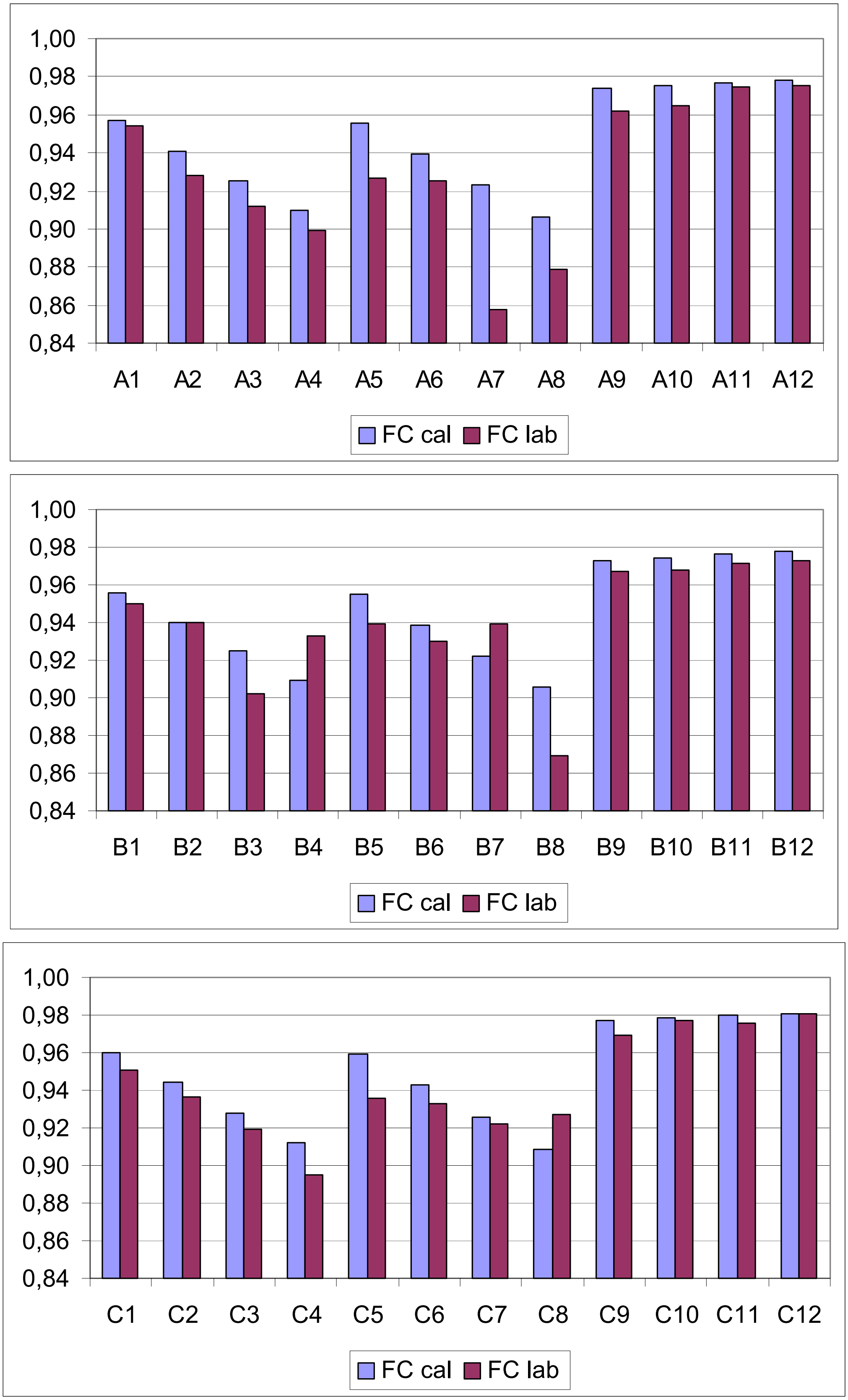

Figure 1. The set of calculated and assessed mean shares of lint fibers in raw material blends.