Algorithms for Evaluating Data on the Quality of Mixing of Natural and Chemical Fibers

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Abstract: the article discusses the methods of collecting data from sensitive elements with the optical method of quality control of mixing natural and chemical fibers in a tape obtained on a tape machine, which are based on a sequential survey or simultaneous, but with a shifted period of data formation. Data processing algorithms for determining the proportion composition of dissimilar fibers in the cross section of the tape with multichannel data collection from measuring elements are presented. The dependence of the change in the linear density of the tape when determining the fractional composition of the fiber mixture is established. The developed evaluation algorithms allow us to characterize the distribution of dissimilar fibers along the entire section of the tape and obtain a percentage quality indicator. For the studied samples, according to the data obtained, the probability of uniform distribution of fibers in the section of the tape from the first transition of the tape machine was 55%, from the second transition – 79%.

1 INTRODUCTION

The uneven mixing of fibers of different types or properties is one of the key problems in the production of textile materials, since their uneven distribution in the cross section can lead to undesirable effects and a decrease in the quality of the products produced. At the same time, the laboratory methods currently used to assess the quality of the tape produced on tape machines are based mainly on determining the share composition of each of the fibers and practically do not take into account their uniform distribution in the cross section. In addition, these studies require large material and labor costs.

To solve the problem of assessing the quality of mixing, the method of static simulation of the process, which is currently considered the most effective, has become increasingly used (Vinter, 2014; Gromov, Sevost'yanov, 2009; Sevost'yanov, 2021). However, as practice shows, the implementation of mathematical and simulation models in technological processes is not always possible. Therefore, the issue of the need to use non-destructive methods to control the uniformity of mixing of dissimilar fibers is particularly acute.

2 MATERIALS AND METHODS

Earlier studies (Vinichenko, Ryzhkova, Nikonov, 2019; Vinichenko, Ryzhkova, Nikonov, 2020; Vinichenko, Masanov, Ryzhkova, 2022) have shown the prospects for the development of an optical method for assessing the distribution of natural and chemical fibers in the cross section of tapes obtained at the output of a carding machine or at the transitions of tape machines. This method is based on the analysis of changes in the transmission capacity of infrared (IR) radiation by various textile fibers.

Taking into account Booger's law, the quantitative assessment of the radiation flux coming out of the material depends on such factors as absorption, reflection, refraction and scattering of radiation passing through the material (Kazarova, Vinichenko, 2016). At the same time, depending on the wavelength of the IR radiation, the constructive location of the source and receiver, as well as the

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interaction of infrared radiation with the fibrous material, various approaches can be implemented in assessing changes in the intensity of the flow passing through the material under study, thereby determining not only the fractional composition of the fibers, but also the uniformity of their mixing. Thus, the IR transmission capacity of wool is lower than that of acrylic, and as experiments have shown (Vinichenko, Masanov, 2022), the uniform distribution of these fibers in the cross section of the product under study gives a smaller spread of the values of the received signal from the photodetector.

In the implemented method for assessing the quality of the distribution of dissimilar fibers in the cross section, several sensitive elements located with a certain offset from each other are used to obtain more complete information about the object. The geometric dimensions of the measuring device and the location of the sensing elements were determined based on the analysis of the interaction of the fibrous material with IR radiation, and taking into account the scattering of radiation in the product under study (Vinichenko, 2022). At the same time, in the developed methodology for assessing the quality of mixing natural and chemical fibers, information is collected from the sensitive elements of the technical measuring instrument using various algorithms.

In the first case, knowing the parameters of the tape speed and the location of the sensitive elements, it is possible to determine the period of their survey and obtain an array of measurement data at one point, thereby performing a full scan of the transverse and longitudinal sections of the tape.

Thus, data collection can be carried out either through sequential recording of information from all measuring elements (photodetectors) with a given time interval Δt, 2Δt, etc., which is easily implemented through a simple polling algorithm, however reducing the number of points surveyed. Or with simultaneous polling of the elements of the measuring device (Vinichenko, Masanov, 2022), but with an offset period of data generation

$$T = k_t \cdot t, \qquad (1)$$

where k_t is a variable coefficient depending on the speed of the technological process and the geometric dimensions of the measuring instrument;

t is the fixed polling time.

The use of simultaneous polling of elements allows to significantly increase the amount of data received from the device and increase the accuracy of further processing.

In the second case, the signals from the sensing elements are removed simultaneously, i.e. multi-channel data collection is carried out. However, the evaluation of the received signals is carried out from each photodetector separately. Thus, readings are taken n times during the control time, thereby realizing several arrays of data.

3 RESULTS AND DISCUSSION

Data processing and analysis also play an important role in the correct interpretation of the received signals.

Thus, the main task in statistical data analysis is to determine the acceptable boundaries and estimate the probability of signals entering these boundaries.

In the first case, when scanning at one point, it is determined that the values fall within the specified UCL and LCL interval for all parameters of the resulting LM1p array.

```
for i=1:n;
    for j=1:m;
     if LM1p(i,j)<=UCL & LM1p(i,j)>=LCL
        emp_probl(i,j)=0;
        Np=Np+1;
        else
         emp_probl(i,j)=1;
         Ep=Ep+1;
      end
    end
end
```

The boundaries are set in accordance with the studied fibers and the linear density of the tape.

After that, the probability of non-falling into the specified boundaries in sections along the entire length of the tape is estimated,

```
for j=1:m;
    Ver_i_str=Ver_i_str+emp_probl(:,j);
End
```

Also, when implementing algorithms for evaluating the quality of mixing of dissimilar fibers, it is necessary to take into account such a factor as a decrease in the intensity of the flow passing through the fibers from an increase in the linear density of the tape under study (Vinichenko, Nikonov, Ryzhkova, 2020).

To do this, it is necessary to exclude all rows of the array where signals from all sensitive elements go beyond the specified boundaries.

```
Ocen_sign=Ver_i_str/m;
for i=1:n;
if Ocen_sign(i,1)>=0 & Ocen_sign(i,1)<1
   q=q+1;
   Kach(q,1)=Ocen_sign(i,1);
```

```
else
    Ocen_sign(i,1)=NaN;
    r=r+1;
end
end
```

Visualization of the change in the mixing quality of the tape is a change in probability throughout the entire section of the tape, as shown in Figure 1.

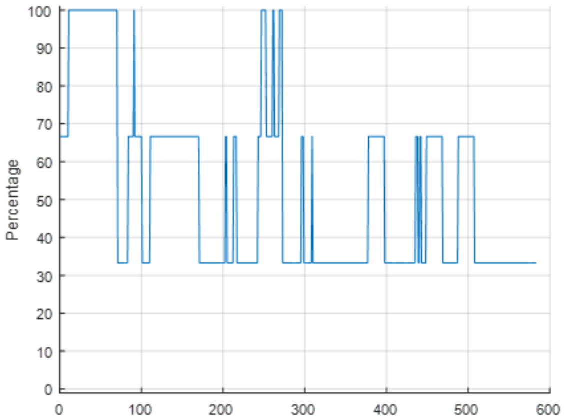

Figure 1: Percentage change in the mixing quality of dissimilar fibers in the tape section.

Thus, when removing signals from three sensitive elements, more than 60% is observed when one of the signals exceeds the permissible values. Whereas 33% if already two signals do not correspond to the set values.

When evaluating the received signals from each photodetector separately, the number of steps is calculated and the percentage by which the signals from the sensing elements go beyond the specified boundaries is determined, as can be seen in Figure 2.

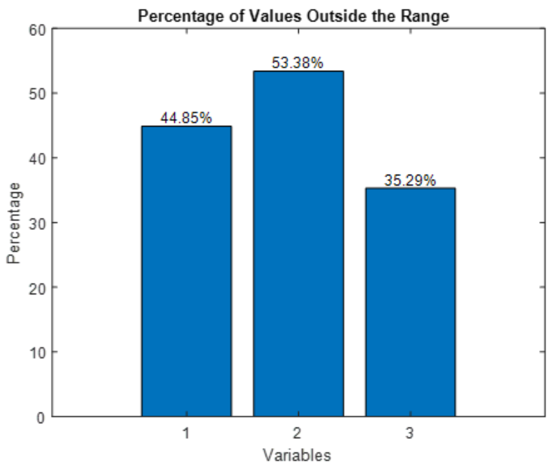

Figure 2: Visual data output.

For the studied tape sample obtained from the first transition on a tape machine, the probability of a uniform distribution of fibers in the cross section was:

Percentage of values within the range: **55.49 %**

Whereas the percentage of values outside the range from each sensitive element is:

Percentage of values outside the range 1: **44.85 %**
Percentage of values outside the range 2: **53.38 %**
Percentage of values outside the range 3: **35.29 %**

For the studied tape sample obtained from the second transition, the probability of a uniform distribution of fibers and the percentage of values outside the range from each sensor element will be:

Percentage of values within the range: **79.40 %**
Percentage of values outside the range 1: **15.73 %**
Percentage of values outside the range 2: **17.98 %**
Percentage of values outside the range 3: **28.09 %**

Comparing these algorithms, it should be noted that in the overall assessment of the mixing quality indicator of dissimilar fibers, the probability of uniform distribution is close to them. However, when evaluating the data obtained from each sensor element separately, it will not be possible to track the change in linear density, therefore, it is necessary to conduct a separate analysis and adjust the results obtained.

4 CONCLUSIONS

Summing up, it should be noted that the proposed methods of collecting data from sensitive elements are based on the formation of a single data array, carrying out both sequential polling at specified intervals, and simultaneous with a shifted period of data formation, or several arrays, also implementing simultaneous collection of information.

On the basis of the collection methods, methods for assessing the uniformity of the distribution of natural and chemical fibers in the section of the tape, taking into account their fractional composition, are compiled. At the same time, algorithms for estimating the proportion of dissimilar fibers in the tape and the uniformity of their distribution in the cross section include:

- ✓ fixing the deviation or non-deviation of the array parameters from certain confidence limits;
- ✓ analysis of mixing unevenness;
- ✓ evaluation of changes in the linear density of the tape.

Visualization and percentage representation of information allows to visually assess the quality of the distribution of dissimilar fibers in the cross section, as well as to give a timely assessment of the technological process.

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