Marek Idzik

Technical University of Łódź,
Department of Technology
and Structure of Yarns
ul. Żeromskiego 116,
90-543 Łódź, Poland

Effect of Operating a Control System on Linear Density Distribution of a Fibre Stream

Abstract

This article presents a part of technological studies concerning the recognition of phenomena connected with the retardation of sliver levelled with a card short-term controller, the so-called autoleveller. Studies were conducted for long- and medium-fibre cotton and for polyester fibres, over a wide range of linear density of slivers and autoleveller drafts. For the purposes of these studies, an original measuring stand was constructed on the basis of the prototype model of the autoleveller.

Key words: *autoleveller, card, evenness of mass.*

Introduction

Until recently, irregularity of the linear density of spinning products was reduced mainly by employing linkings of slivers or rovings on drawing frames, roving frames and spinning frames. Several years ago, about 3500 linkings were used during the whole production process of yarns of 20-25 tex on all machines. After introducing single-process scutching, this number decreased to about 900 (and to as low as 144 after eliminating the third drawing frame). In modern spinning systems, when flow production lines are used, this number can be lower than 10.

Nowadays linking cannot be the basic operation for decreasing the irregularity of linear density of spinning half-products, which is decisive for the quality of yarn. Yarn, whose irregularity of linear density is above 3% on 100 m lengths, may be a reason for the so-called weft or warp stripe in woven fabrics or slurgalling in knitted fabrics. Maintaining the average value of the coefficient $CV_{100m} \approx 2\%$ makes it possible to avoid these defects. Thus, it is necessary to use special controllers (the so-called autolevellers) in the technological process, which as a result of the decreasing number of linkings are the elements which level the linear density of spinning half-products.

Purpose and Subject of Studies

The card short-term autoleveller which was the object of this study was designed and produced in COBR 'Polmatex-Cenaro' in Łódź. This is the first completely Polish construction. All short-term autolevellers working up to the present in the spinning factory were produced abroad. The aim was to construct an autoleveller of equivalent work parameters but which was decidedly cheaper. A description of the construction and work of the prototype autoleveller has already been published [7]. The completed autoleveller was delivered for studies to the Department of Yarn Technology and Structure of Łódź Technical University to determine its behaviour during the regulation process. The subject of studies was a card autoleveller operating on short lengths, installed in the delivery zone of a cotton revolving flat card, type CZ-693. The autoleveller levelling the card sliver was developed for highly efficient card processing cotton, chemical fibres and their blends. Levelling in an open system was chosen, so that levelling on short lengths could be obtained.

The first phase of studies included the evaluation of the efficiency of the autoleveller's work in an on-line system by comparing chosen quality parameters of the feed and delivery slivers, and was described in publication [7]. The present studies which are aimed at recognising the phenomena connected with retardation of sliver levelled with a card short-term autoleveller, lay the foundations for devising

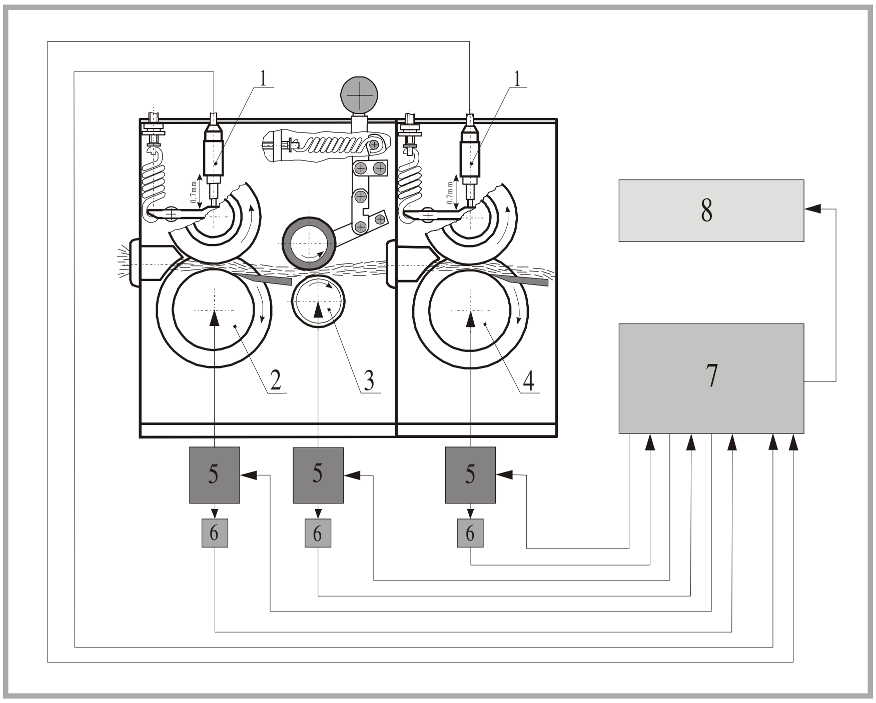

Figure 1. Scheme of measuring system: 1 - linear displacement sensor, 2 - measuring feed rollers, 3 - bottom delivery rollers, 4 - measuring delivery rollers, 5 - direct-current motor, 6 - rotational-impulse transducer, 7 - control device, 8 - recording device.

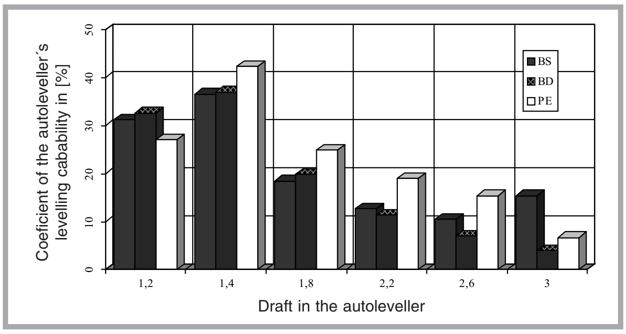

***Figure 2.** Levelling capacity of the autoleveller for card slivers made of medium-fibre cotton (BS), long-fibre cotton (BD) and polyester fibres (PE) in the studied range of drafts.*

an algorithm of autoleveller operation where the regulated sliver reaches optimum quality parameters (enabling the technological process to be shortened), and finally producing yarn on an open-end spinning frame directly from a card sliver.

A measuring stand was built on the base of this autoleveller, which enabled immediate and reliable evaluation of effectiveness of regulation, eliminating the influence of sliver retardation, and also enabling determination of the retardation of the sliver from various raw materials of different linear density and produced with different work parameters of the autoleveller. The stand also lets us define the base that the structural changes at retardation can be referred to, and enables recognition of the phenomenon of sliver retardation in a wide range of autoleveller drafts and fibre lengths. A scheme of the measuring system is shown in Figure 1.

Construction of the measuring stand consisted in completing the autoleveller with an additional measuring system unit in the delivery zone (1,4,5,6), whose construction is identical with that of the measuring system in the feeding zone (1,2,5,6). An additional measuring system unit was connected with the control device (7) and the recording device (8). In both measuring systems, linear displacement sensors of identical frequency of free vibration (62 Hz) were used. A frequency of 15 Hz is sufficient to register the analysed signals coming from fluctuations in linear density (thickness) of the slivers. The frequency of free vibration of the sensors was checked and regulated on a vibrating table by changing the pressure of spring on the ferrite core. Studies showed that an additional measuring system unit in the delivery zone works properly up to a frequency of 40 Hz. Fluctuations of the draft in the delivery zone do not exceed 1%.

Levelling the sliver consists in temporary changes of the draft *R(t)* in the draft zone, in proportion to the temporary changes of the sliver linear density (thickness) measured in the feeler, according to the regulation equation:

$$R(t)=\frac{R}{m}\cdot m_1[Q;(t-t_z)] \qquad (1)$$

This equation indicates that fibre density m_l, or the quantity which is its function (linear density, thickness) determined in the moment *t* in the measurement section *Q* (rollers 2, Figure 1), should be changed by changing the draft *R*, that is, the change of delivery speed after time t_z which is the delay time.

The studies conducted so far (author's grant no. 3 T09B 131 10) showed that the sliver, having left the regulation zone of the card short-term autoleveller, that is, the zone of variable drafting time, is subjected to the process of retardation. Within 3-4 hours, certain internal stresses are still present in the sliver. These cause gradual deterioration of some of the sliver's quality parameters, and primarily they increase the irregularity of linear density measured by the CV coefficient according to Uster. This phenomenon is observed for the regu-

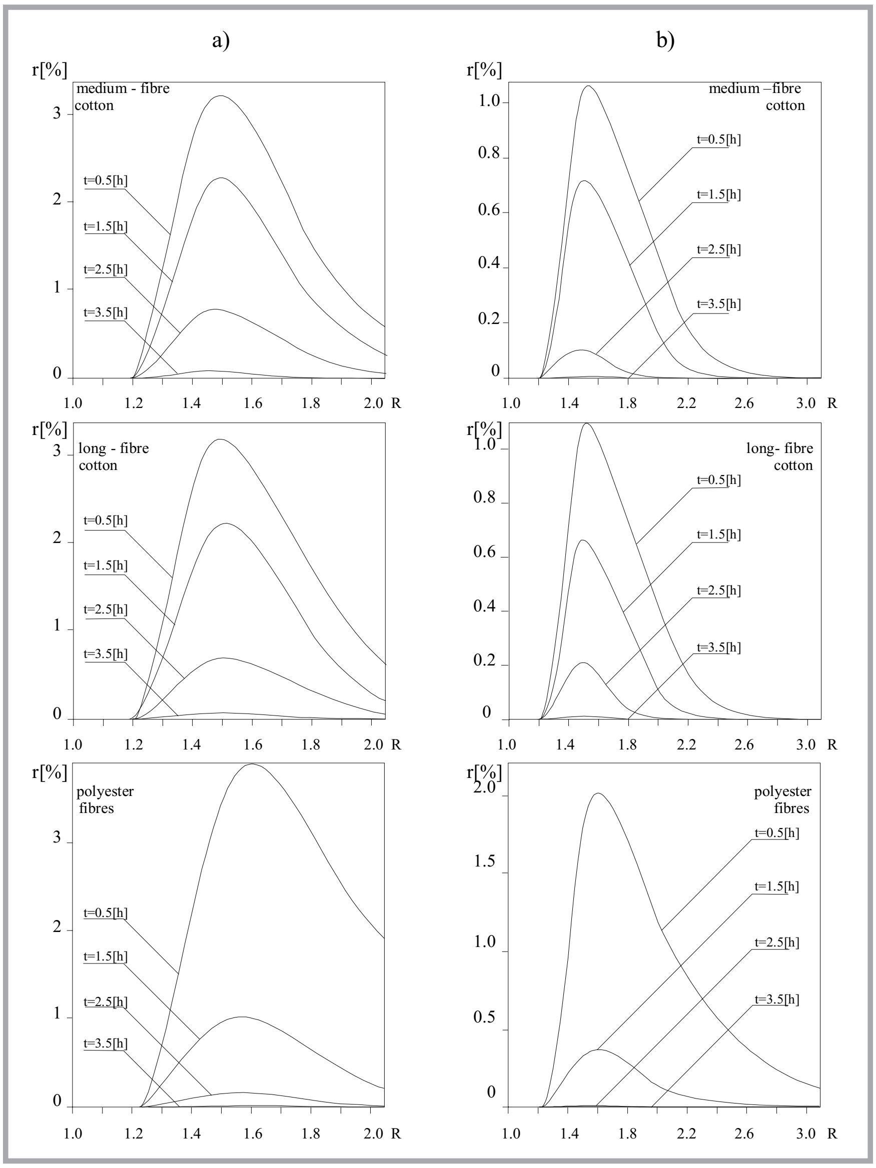

***Figure 3.** Retardation of the regulated card sliver as a function of an instantaneous draft in the autoleveller, determined at various times after regulation as an approximation of instantaneous values for chosen variants: a) for draft 1.4, b) for draft 2.6.*

lated sliver. The non-regulated sliver, that is, the one which passes through an autoleveller with a constant draft, shows about 4 times smaller retardation properties. The measurements were carried out by multiple studies of the density distribution of the same length of regulated and non-regulated slivers at various times after having left the autoleveller, and by analysis of the obtained results by means of a computer programme specially written for this purpose.

The retardation properties of a regulated card sliver are a result of fluctuation in the drawing force during the regulation process caused by continuous changing of the draft. Thus, relations describing the course of the drawing force, as a composition of an exponential function and a parabola, should also describe the character of the retardation of the sliver thickness. As a result of mathematical analysis, the equation of retardation *r* was obtained:

$$r = a \cdot (R-k)^{b} \cdot e^{c \cdot (R-k)} \qquad (2)$$

where:
- R - draft in regulator,
- k - limiting draft,
- a, b, c - coefficients of shape showing the changes in the retardation curve.

Coefficient a is decisive for the magnitude of retardation, whereas coefficients b and c determine the draft value, where retardation reaches the maximum:

$$r_{\max} = -\frac{b}{c}$$

Course of Studies and Analysis of Results

The proportional principle of regulation used so far in all autolevellers, operating in such a way that a change in the linear density (thickness) of sliver produced a proportional change in draft, should be changed in order to limit the unfavourable phenomenon of retardation of sliver after short-term regulation. If this is to be possible in the future, it is necessary to recognise all the phenomena occurring during the process of retardation of regulated sliver.

Studies were conducted for slivers of linear densities in the range of 2.3-5.8 ktex and delivery speed of the autoleveller of 1.0-2.5 m/s. These values were a result of the feeding sliver used of constant linear density 7 ktex, and of variable draft in the autoleveller: 1.2; 1.4; 1.8; 2.2; 2.6; 3.0. Studies were carried out for medium- and long-fibre cotton and for polyester fibres.

The measurement process consisted in repeatedly passing the same length of sliver through the measuring system shown in Figure 1 and registering the signals obtained in an on-line system at various times after regulation (0.5-3.5 h) by means of the 'Wave View' programme. Analysis of the linear density distributions obtained was conducted by means of a computer programme specially written for this purpose in Visual Basic. It was important to check whether the initial thickness of the feeding sliver and the corresponding value of instantaneous draft in the regulation

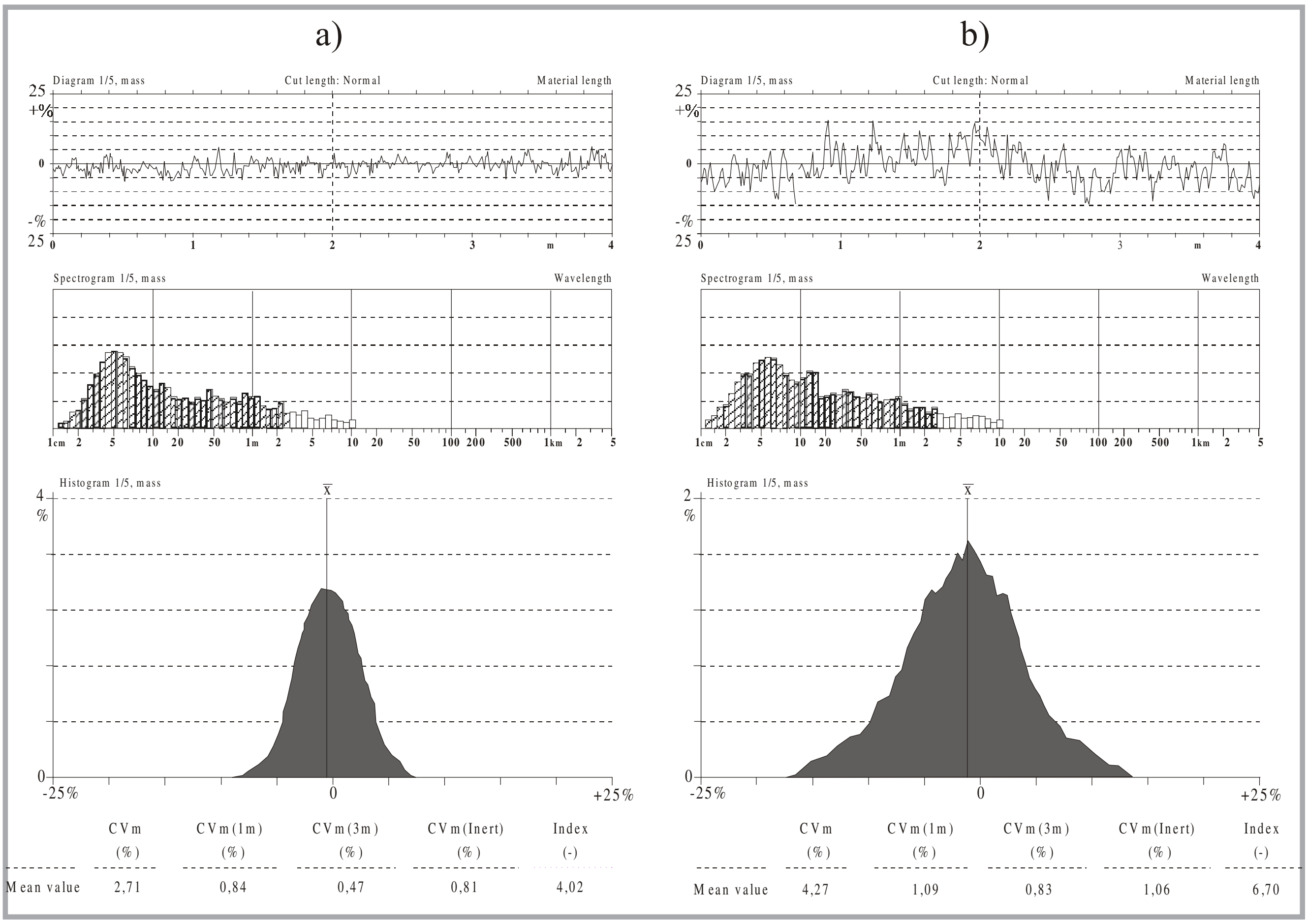

Figure 4. *Results of the analysis of sliver made from medium-fibre cotton at nominal draft in the autoleveller R=1.4, determined with Uster Tester 3 apparatus, at travelling speed V=25 m/min, in time t=2.5 min; a - regulated sliver, b - non-regulated sliver.*

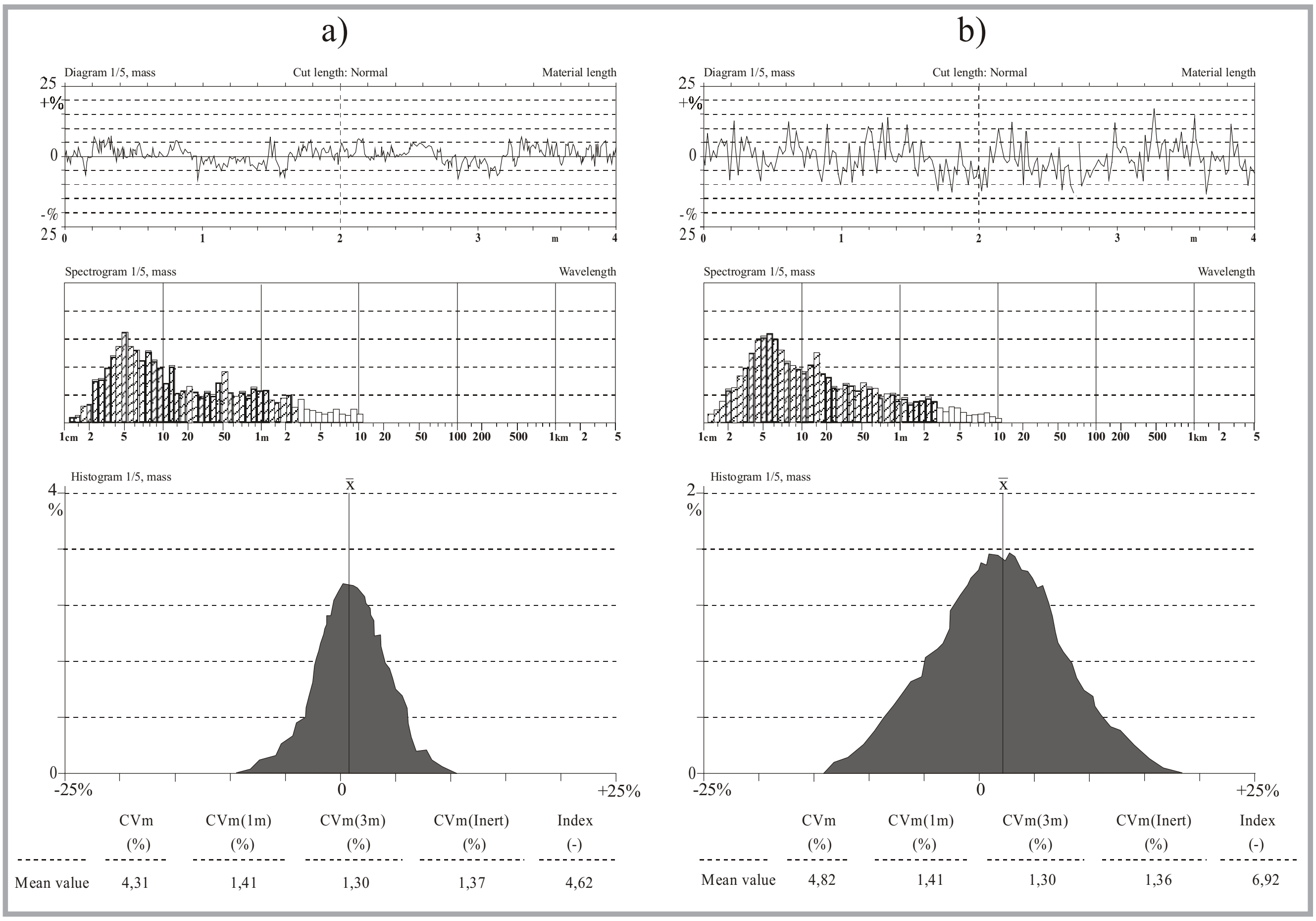

Figure 5. *Results of the analysis of sliver made from medium-fibre cotton at nominal draft in the autoleveller R=2.6, determined with Uster Tester 3 apparatus, at travelling speed V=25 m/min, at time t=2.5 min; a - regulated sliver, b - non-regulated sliver.*

zone influence the magnitude of retardation of the sliver at various times after leaving the autoleveller. Particular attention was paid to the behaviour of long-fibre cotton (not hitherto analysed) during the retardation processes, and to the influence of drafts above the value R=2 on these processes.

To evaluate the efficiency of the autoleveller, the coefficient of the autoleveller's levelling capability η was used, as expressed by the formula:

$$\eta = \left(1 - \frac{CV_R}{CV_N}\right) \cdot 100\% \qquad (3)$$

where:

CV_R - CV coefficient according to Uster for regulated sliver,

CV_N - CV coefficient according to Uster for non-regulated sliver.

The following criteria of evaluation have been proposed:

1. $\eta \geq 50\%$ - good regulation,
2. $25 < \eta < 50\%$ - satisfactory regulation,
3. $0 < \eta < 25\%$ - insufficient,
4. $\eta = 0$ - no regulation,
5. $\eta < 0$ - deteriorating.

Figure 2 illustrates levelling capacity of the autoleveller for card slivers made of different raw materials. The autoleveller shows better levelling capacity for small drafts, namely 1.2 and 1.4 (satisfactory regulation). The improvement in regulation conditions at higher drafts is due to the nature of polyester fibres (the cross-sections of which have a more regular form). On the other hand the regulation conditions worsen with fine long-fibre cotton. However, higher drafts should not be used because of the high irregularity in linear density of both regulated and non-regulated slivers.

In Figure 3, functions of retardation of the studied slivers in various time after regulation are shown for the chosen variants. Maximum retardation changes occur at these lengths of the regulated sliver, which were drawn with draft R≈1.5 for long- and medium-fibre cotton and R≈1.6 for polyester fibres (Figure 3). There is a minimum regulation (draft) limit, below which retardation of sliver does not occur. The limit draft value for medium-fibre cotton is R=1.18, for long-fibre cotton R=1.20, and for polyester fibres R=1.22 (Figure 3). Comparative studies conducted for non-regulated sliver showed that retardation of non-regulated sliver (in comparison with regulated sliver) is 3 to 5 times smaller for small drafts (R=1.2-1.8) and 1.5 to 3-times smaller for high drafts (R=2.2-3.0).

Examples of research results obtained by spectral analysis with the use of an Uster Tester 3 apparatus are presented in Figures 4 and 5. A visibly considerable improvement in the sliver uniformity on sliver segments up to 3 m was achieved by using small drawing ratios in the leveller (for example 1:4, as is shown in Figure 4).

The diagrams of mass distribution presented in Figures 4 and 5 indicate a distinct improvement in fibre dislocation in the sliver which is not dependent on the value of the nominal drawing ratio. The diagrams for regulated slivers (Figures 4a and 5a) demonstrate smaller deviations from the nominal values in comparison with the diagrams for unregulated slivers (Figures 4b and 5b). These trends are clearly reflected in the mass histograms. The most uniform diagram was obtained for the sliver regulated at a small drawing ratio (R=1.4) in the leveller (Figure 4a). When analysing the diagrams presented in Figures 4 and 5, we should note that the graduation of the vertical co-ordinates differs between the records for the regulated and the unregulated slivers; this is caused by automatic graduation selection performed by the Uster Tester. All errors, even small, in the leveller operation (in other words of the drawing apparatus with variable drawing ratio) are visible in the spectrogram for high drawing ratios (Figure 5a). These take the form of greater amplitudes of some harmonic components, which is clearly visible in comparison to the diagram for a drawing ratio more approximate to the optimal drawing ratio (spectrogram in Figure 4a).

Summary

Evenness of the linear density of sliver levelled by means of a short-term autoleveller is a function of time, and only its direct measurement in an on-line system enables immediate and reliable conclusions to be drawn regarding the effectiveness of the regulation process. The duration of retardation processes in regulated slivers decreases with the growth of an average length of fibres and the growth of nominal draft in the autoleveller. However, drafts exceeding R=1.8 result in a decrease in the levelling capacity of a short-term autoleveller (Figure 2). The phenomenon of retardation causes a deterioration in quality parameters of regulated sliver.

The results of the studies conducted confirm that it is necessary to construct a short-term autoleveller, whose algorithm of operation would allow for the phenomenon of sliver retardation.

References

1. *Grosberg P., Iype C., 'The automatic control of card-web linear density. Part I. The theoretical possibility of short-term control', Journal Textile Institute 1992, No .3.*
2. *Grosberg P., Iype C., 'The automatic control of card-web linear density. Part II. Experimental verification of short-term control', Journal Textile Institute 1992, No. 3.*
3. *Uster News Bulletin 1997.*
4. *McAllister I., 'Parkdate moves up to a new quality level', Textile Word 1993, No. 5.*
5. *Remmerige J., Cruycke B., 'Qualitätsüberwachung an der Strecke', Melliand Textilberichte 1993, No. 6.*
6. *Leifeld F., 'Untersuchungen für die Langstapelspinnerei', Chemiefasern Textilindustrie 1990, No. 12.*
7. *Idzik M., 'Optimization of work parameters of a short-term autoleveller',Fibres & Textiles 2000, No. 4.*

Received 22.10.2001 Reviewed 04.12.2002