ANALYSIS OF REGULARIZED CARD SLIVER AFTER SHORT-TERMLEVELLING PROCESS

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Abstract:

Doubling of sliver has ceased to be the fundamental operation for reducing the weight irregularity of spinning halfproducts, which are decisive for the quality of yarn. Its role has now been taken over by the general use of autolevellers. After leaving the regulation zone, card sliver, whose weight irregularity is reduced by a short-term autoleveller, undergoes a process of relaxation. This phenomenon takes place only in the case of regulated sliver. Unregulated slivers passing through a leveller operating with constant draft show few relaxing properties. One reason why autolevelled card sliver has such relaxing properties may be the variation of the drafting force caused by the continually changing draft. The performance of the short-term card autoleveller cannot be unequivocally evaluated. The main difficulty lies in the time span between levelling and measurement, during which the sliver undergoes relaxation. How quickly the autolevelled card sliver is fed to the next machine in the yarn manufacturing process is therefore important, because in the intervening time the initial irregularity of the product may undergo uncontrolled changes.

Key words:

Spectral analysis, evenness of mass, short-term autoleveller, spinning machine.

1. Introduction

Until recently, the reduction of weight irregularity of spinning products was mainly effected by doubling and drafting of the sliver or roving on drawing frames, roving frames, and spinning frames.

In the 1930s, as many as about 3 500 doublings were usual in the manufacturing process of 20 ÷ 25 tex yarn. The number fell to 800 ÷ 900 following the introduction of one-process pickers, and was further reduced to 144 upon elimination of the third passage in drawing. In modern spinning systems, the number of doublings may be less than 10. Consequently, doubling has ceased to be the fundamental operation for reducing the weight irregularity of spinning halfproducts, which is decisive for the quality of the yarn. Its role has now been taken over by the general use of autolevellers.

2. The object of analysis

The most important part of an autolevelling system is the measuring unit. Its function is to compress the fibre stream, determine what process value corresponds to the linear density of the stream, and transmit a suitable electric (or mechanical) signal to the next parts of the system. Any error in either determining the process value or changing the latter into an electric value (voltage) will affect the accuracy of operation of the system and cannot be corrected. From the literature [1,2], patents, and his own experience [3,4], the author knows of about 14 physically possible measuring systems, of which only the following three have any practical value:

a) the mechanical system (Figure 1),
b) the passive pneumatic system (Figure 2),
c) the active pneumatic system (Figure 3).

In the mechanical system, a sensor records the linear changes of position of a floating roll which is displaced up and down proportionally to the variation in the linear density (thickness) of the sliver, and appropriate electric control signals are generated.

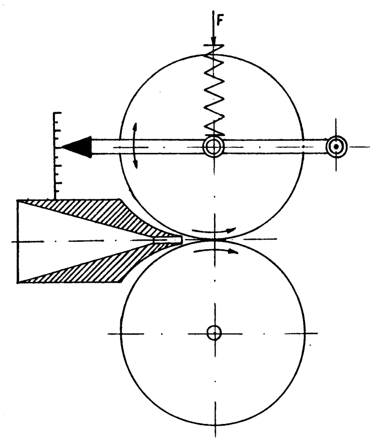

Figure 1. A diagram of the mechanical measurement system.

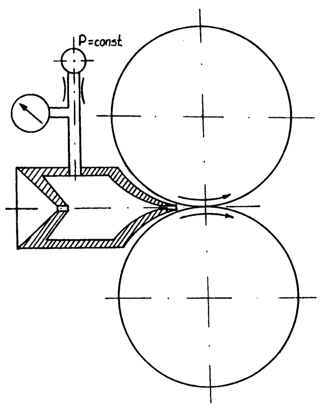

Figure 2. A diagram of the passive pneumatic measurement system.

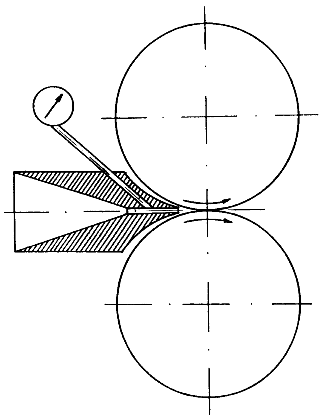

Figure 3. A diagram of the active pneumatic measurement system.

In the passive pneumatic system, the sliver passes through two chokes where it is subjected to a constant air pressure. In proportion to the variation in linear density of the sliver, the resistance to air flow varies, with such resistance being recorded and transformed into control signals.

In the active pneumatic system, the air enclosed in the sliver is displaced and the resultant overpressure is recorded.

Each of the three methods is dependent on the parameters described by the following relations [1]:

- Mechanical

$$\frac{\Delta T}{T} = 0{,}11\frac{\Delta M}{M} - 0{,}04\frac{\Delta V}{V} + 0{,}37\frac{\Delta K}{K} \quad (1)$$

- Pneumatic, passive

$$\frac{\Delta T}{T} = 0{,}75\frac{\Delta M}{M} + 0{,}03\frac{\Delta V}{V} + 0{,}21\frac{\Delta p}{p} \quad (2)$$

- Pneumatic, active

$$\frac{\Delta T}{T} = 0{,}50\frac{\Delta M}{M} - 0{,}45\frac{\Delta V}{V} \quad (3)$$

where:

T - linear density of the measured sliver [ktex],
M - Micronaire index [g/sq in],
V - sliver speed [m/s],
K - weighting of the roll in the mechanical measurement [N],
p - air pressure in the so-called passive funnel [mbar].

The above preliminary empirical relations suggest that:

1. The control signal is largely dependent on fibre diameter in pneumatic measurement and on the speed of the sliver in active measurement .

2. In the passive pneumatic measurement, it is important that the pneumatic pressure at feeding is kept constant.

3. The mechanical method seems to be the best compromise between spinning art and measurement. It is less dependent on the type of the fibre processed (Micronaire), and is practically independent of sliver speed. It is important, however, that weighting of the floating rolls is kept constant (Figure 4).

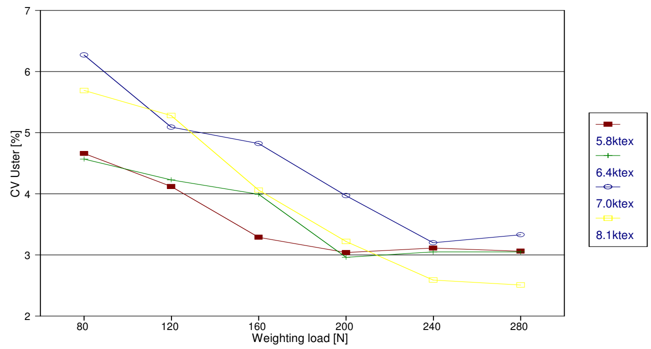

Figure 4. Autolevelled card sliver irregularity as a function of weighting load applied to the measuring roll.

The controlling principle should be based on an equation that would represent the relationship between draft and variation of the linear density (thickness) of the sliver as recorded by the measuring unit.

In order to control the thickness of the sliver it is necessary not only to measure the irregularity of the thickness but also to determine how the fibre ends are distributed in the sliver, as this determines the structure of the latter.

$$n_1(t) = n_1\left[1 + a\cos\left(\frac{2\pi v_1}{\lambda_1}\right)t\right] \quad (4)$$

where:

n_1 - average number of fibre fore ends;
a - oscillation amplitude of the number of fibre fore ends;
λ_1- wavelength of oscillation of the number of fibre fore ends,
$n_1(t)$ - number of fibre fore ends at any time *t*.

And analogically for the delivery rollers:

$$n_2(t) = \frac{n_1}{R}\left[1 + a\cos\left(\frac{2\pi v_2}{\lambda_2}\right)t\right] \quad (5)$$

where:

R - mean draft;
λ_2 - wavelength of number of fibre fore ends at delivery rollers.

In order to have a constant number of fibre fore ends in the delivered sliver it is necessary to change draft *R(t)* proportionally to the number of fibre fore ends in the sliver entering the feed rollers.

$$n_2 = \frac{n_1}{R} = \frac{n_1(L;t)}{R(t)} \quad (6)$$

Hence:

$$R(t) = \frac{R}{n_1}n_1(L;t) \quad \text{- the regularity control equation} \quad (7)$$

where:

L - length of draft zone.

The regularity control equation describes draft change as a function of density of the fibre fore ends in the feeding sliver. Assuming that wavelength λ_1 is $6\bar{l}$ or more,

$$R(t) = \frac{R}{m_1} m_1 [Q;(t - t_z)] \tag{8}$$

where:

m_1 - number of fibres in the sliver in the measuring unit (i.e. number within cross-section Q),

t_z - delay time.

Practically speaking, the autoleveller is capable of levelling an irregular mass distribution of wavelength λ_1 equal to or greater than $6\bar{l}$. Wavelengths shorter than $2\bar{l}$ cannot be levelled only on the basis of information about the cross-section irregularity. It is also necessary to know how the fibre ends are distributed in the sliver.

In order to analyse the levelling process, or more accurately its effect, card sliver down the delivery rollers of a short-term card autoleveller was examined. It was found that irregularity of the sliver as measured by CV Uster was growing in the subsequent layers in the can (Figure 5). It seemed at first that the autoleveller was to blame, so in the next attempt the sequence was reversed and the sliver was analysed starting from the bottom of the can. A similar tendency was observed however (Figure 6), which ruled out instability in the autoleveller operation and led to the conclusion that the reason for the rising irregularity should be sought not in the location of the sliver in the can but in the time elapsed between levelling and the moment when the measurement was performed. The correctness of this assumption was confirmed by a subsequent test (Figure 7). Thus it appears that card sliver that has been through an autoleveller changes its structure directly following the short-term levelling process and only after about 3 hours does its structure reach stability.

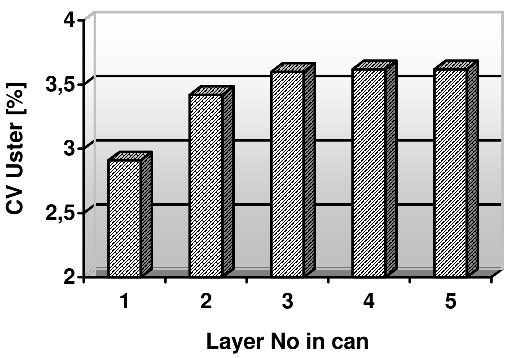

Figure 5. CV Uster (%) of "autolevelled" card sliver in the successive layers in the can (numbered from the top of the can).

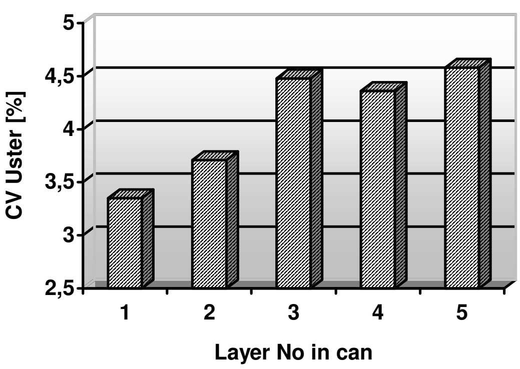

Figure 6. CV Uster (%) of "autolevelled" card sliver in the successive layers in the can (numbered from bottom of the can).

By comparison, Figure 8 shows the changes in irregularity of a sliver that has been through a leveller operating with constant draft. The sliver shows practically no tendency to change its irregularity after leaving the leveller.

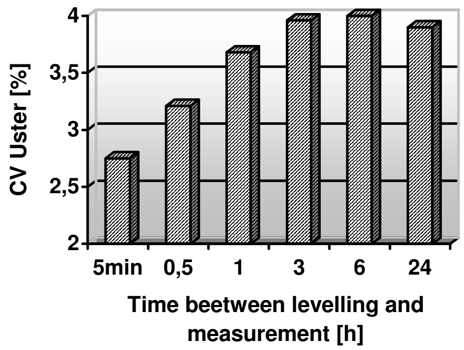

Figure 7. CV Uster (%) of "autolevelled" card sliver determined at various times after levelling.

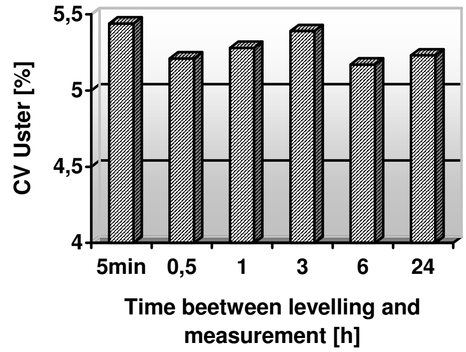

Figure 8. CV Uster (%) of "unautolevelled" card sliver determined at various times after passing through a leveller.

One reason why the autolevelled card sliver has this relaxing property may be the variation of the drafting force caused by the continually changing draft. Drafting force value has been theoretically defined by Kowner. A diagram of the drafting force at various values of sliver draft is presented in Figure 9. The character of the curve in the levelling process investigated will surely be slightly different, but the tendency will remain the same.

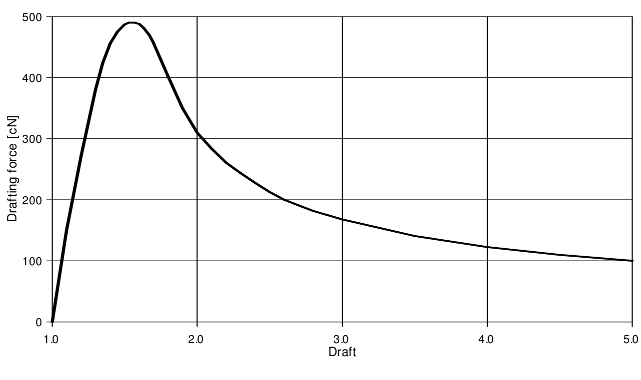

Figure 9. Drafting force at various values of draft.

The card short-term autolevellers are usually operated at a draft below 1.5. The autoleveller used in the present work operated at a draft of 1.35. With variation of sliver linear density within ±25%, the draft oscillated between 1.01 and 1.69 and the drafting force varied accordingly from 0 to 500 cN. Within the limits of stable operation of the autoleveller (R = 1.2 to R = 1.8) the lowest variation of the drafting force is at a draft of 1.55

(in accordance with Kowner's curve). It was experimentally confirmed that at that draft the tendency toward relaxation was the lowest. However, such a draft cannot be recommended because of the higher values of irregularity of the sliver.

The total friction force across the drafting zone is given by the equation:

$$T = \alpha_f f(x,t)\, g[f(x,t)t]\, \Phi\left[\beta_f \frac{\delta \upsilon(x,t)}{\delta x}\right] \quad (9)$$

where:

T - friction force in drafting zone,
α_f - total number of inter-fibre contacts in an investigated fibre stream cross-section,
f(x,t) - number of fibres in an investigated fibre stream cross-section,
g[f(x,t)t] - average inter-fibre pressure being a function of thickness of the product,
$\upsilon(x,t)$ - average speed of fibres in an investigated cross-section,
β_f - coefficient dependent on lengths of fibres located in the vicinity of an investigated cross-section,
$\Phi\left[\beta_f \frac{\delta \upsilon(x,t)}{\delta x}\right] = \mu$ - coefficient of inter-fibre friction.

If inertion of the fibres is disregarded, then the friction force is equal and oppositely directed to the external force which pulls the fibres out of the drafting zone. The equation is often referred to as the principal equation of draft, and it is the basic equation in calculating the so-called spectral characteristics of the drafting zone.

Displacement of the fibres in the drafting zone is possible only if the natural resistance of the fibres has been overcome. It is therefore necessary to apply an appropriate external force. This force effects the drafting, and is referred to as the drafting force.

The value of draft at which the drafting force is maximal and the maximum value of the drafting force are dependent on the drafting conditions, especially on the types of fibres, linear density and twist of the product, length of the fibres, distance between the nip points of the drafting rollers, and other parameters of minor significance. The higher the irregularity of the product, the greater the variation of the drafting force that is recorded.

The value of the drafting force is also dependent on the degree to which the fibres have been straightened. Drafting force for a sliver after a third drawing passage is nearly four times lower than that for card sliver.

In the drafting process, straightening of the fibres is proportional to the increasing value of draft. Upon leaving the drafting system, when the drafting and straightening forces have ceased to operate, the fibres attempt to regain their former configurations. However, they always retain some of the deformations acquired in the drafting process. This behaviour of a fibre can be accounted for by the high elasticity inherent in its structure causing the fibre to resist the straightening force and to attempt to regain its original shape once the straightening force has ceased.

Conclusion

In conclusion, it must be admitted that the performance of the short-term card autoleveller cannot be unequivocally evaluated. The main difficulty lies in the time span between levelling and measurement, during which the sliver undergoes relaxation. How soon the autolevelled card sliver is fed to the next machine in the yarn manufacturing process is therefore important, because in the intervening time the initial irregularity of the product may undergo uncontrolled changes.

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