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(2) Sliver regularity after the comber when most if not all the fibre hooks have been removed.

For optimum combing conditions it is preferable to ensure that the majority of fibres should have leading hooks when presented to the comber cylinder needles which means that an even number of machines should be used for the comber preparation. An ideal technological process has three passages of drawing followed by a lap former, but this involves too many machines. The general process arrangement is to use only one passage of pre-comber drawing providing a draft range of 8 to 24.

The most economic system would be to comb card sliver by direct sliver feed to the combing heads. The major objection to this system is that the pre-comber draft is too low and poor combing results, also if card cans from high production cards are used in the comber creel, machine space becomes very great. These points may not be easily overcome and a two-machine sequence between card and comber may be the shortest practical process for comber preparation.

It would also be of benefit if the combed sliver could be fed direct to a speed frame because fibre hooks are not important enough at this stage in the system to adversely affect roving or yarn quality.

To test these proposals, a comber was installed in the automated plant as shown in Figure 7.

The experience gained with this equipment proved to be satisfactory and subsequently a new machine was developed with the following features:

(a) Large can creel holding 550 kg (1200 lb.) of cotton.
(b) High speed combing unit of 8 heads.
(c) Drawbox sliver with an Uster value of 1.5 to 2.0 % mean deviation.
(d) Automatic can indexing.
(e) Automatic waste removal.

To emphasise the importance of these items one only has to analyse the work elements on combing to realise that operative work may be divided as follows:

Creeling and doffing	17 %
Cleaning	28 %
Maintenance	10 %
Interference	25 %
Faults	20 %

These values vary according to individual mill conditions and machines, but are fairly typical. On this kind of basis a machine of the type embodying the above features would be capable of higher machine productivity, require less direct labour and possibly some of the work which is normally dealt with by the comber operative could be transferred onto an indirect labour force.

For the process to be applied for conventional processing, it is necessary to guarantee combed sliver regularity to the specified level. Therefore it was necessary that the comber drawbox should be fitted with a sliver autolevelling device. Such a unit was fitted and developed by Zellweger Ltd., Uster/Switzerland, in association with T.M.M. (Research) Ltd.

The creel supply was prepared by using a double passage of drawing, whereby the first passage was a standard machine, whereas the second drawframe in the process was a bi-coil machine, coiling two slivers into one can. In this way it was possible to reduce the creel size to five cans to each combing head provided with a 10-sliver feed, and a machine creel containing up to 550 kg (1200 lb.) of material. This large amount of material is 3 to 4 times that for conventional combers and piecing of ends and creeling of new cans may be done with the machine processing.

Two machines of this type were produced; one was used for mill trials and the other for laboratory work. Figure 11 shows typical sliver regularity figures from our technological work on the mill plant. Subsequent laboratory work is not yet available for publication.

Fig. 11 Combed Sliver Irregularity

Sample	U %	Saco-Lowell Mean R %	Saco-Lowell Max. R %	Can Weight % Variation
Autolevelled combed drawbox sliver	1.9	21.3	32.3	± 2
Non-autolevelled combed drawbox sliver	3.2	30.0	41.0	± 5
2nd Pass. Post comber DF sliver from unlevelled combed drawbox sliver	2.1	21.0	30.6	

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An analysis of drafting behaviour of worsted slivers with particular reference to the automatic control of drafting irregularities

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Abstract

An analytical and experimental study has been made of the frequency response behaviour of a simple roller drafting system. It is shown, analytically, that closed loop automatic control of short term drafting irregularities is basically more stable when based on a measurement of drafting tension than when based on the measurement of sliver thickness. An analysis of such a control system, which includes a non-ideal drafting system, is then given. It shows that such a system has a characteristic resonant frequency which has been confirmed by experimental determinations of the open loop frequency response. Such determinations are difficult especially at high frequency due to the presence of a large amount of noise in the drafting tension signals and two methods for eliminating this noise are discussed. In conclusion the deviations, between the experimental results obtained here and (a) those obtained by other authors and (b) those obtained by analytical methods, are then discussed.

Zusammenfassung

Das Verhalten eines einfachen Walzenstreckwerksystems wurde hinsichtlich des Frequenzganges analytisch und experimentell untersucht. Es wird analytisch aufgezeigt, dass eine auf Messungen der Streckspannung basierende automatische geschlossene Regelkreiskontrolle von kurzfristigen Streckunregelmässigkeiten im Grunde konstanter ist als eine, die auf Messungen der Banddicke beruht. Es folgt eine Analyse eines solchen Kontrollsystems, das ein unvollkommenes Streckwerksystem einschliesst. Sie zeigt, dass ein derartiges System eine charakteristische Resonanzfrequenz aufweist, was auch durch eine experimentelle Feststellung des offenen Frequenzganges bestätigt wurde. Solche Fest-

stellungen sind besonders bei hohen Frequenzen auf Grund des dabei vorhandenen grossen Geräuschumfangs in den Streckspannungssignalen schwierig, und zwei Methoden, diese Geräusche auszuschalten, werden besprochen. Schliesslich werden die Abweichungen zwischen den hier experimentell erhaltenen, den von anderen Autoren sowie den durch analytische Methoden erworbenen Ergebnissen besprochen.

1. Introduction

The dynamic response of an automatically controlled drafting system is governed by the mechanical or electrical response of the controller and the controlling mechanism as well as the basic response of the drafting system. The present paper is concerned with the basic response of the drafting system only. In other words, we shall be concerned with the response of a simple roller drafting system to changes in the drafting ratio. Two cases will first be considered analytically, namely, (i) the response of an ideal drafting system and (ii) the response of one of the many possible non-ideal drafting models. In conclusion the experimentally determined frequency response will be compared with these analytical predictions.

2. The response of an ideal drafting system

An ideal drafting system is one in which all fibres move at back roller speed until they are gripped by the front rollers. A change in the draft ratio of such a system produces an instantaneous change in the density of leading fibre ends leaving the system. This change is never measured and cannot, therefore, be used to produce a direct control of the fibre end density and hence of the sliver thickness. It is usual practice to measure the thickness of the sliver either leaving the drafting system (closed loop control) or entering it (open loop control). Several analyses of the frequency response of such an ideal drafting system are available[1 2 3 4] Davies[2] deals with both open and closed loop systems, while the other references deal with closed loop systems only. Davies' analysis, as well as other more approximate analyses of open loop systems, have shown that open loop systems are incapable of reducing the short-term irregularity of the product, if these are due to input irregularities, if the wave length of the irregularity is less than the draft times the mean fibre length. It is also basically incapable of altering in any way the irregularities introduced by the drafting system itself. This paper will therefore concern itself exclusively with the problems of closed loop drafting systems.

The connection between the leading fibre end density of the fibres at a point x in front of the front roller nip at a time t, n(x, t) and the thickness of the sliver at the nip at time t, N(t), is given by

$$N(t) = \int_0^L n(x, t)\, dx \qquad (1)$$

for a sliver in which all the fibres are length L. It can readily be shown (1) that as a result the frequency response of the thickness of such a sliver issuing from an ideal drafting system when the front roller speed is varying sinusoidally, at a frequency of ω radians per unit time, is given by

$$\text{Amplitude gain} = \sqrt{2 - 2\cos\beta} / \beta \qquad (2)$$

$$\text{Phase lag} = \arctan\,(1 - \cos\beta) / \sin\beta \qquad (3)$$

where $\beta = \omega L/v$, v being the average speed of the front rollers. Figure 1 shows this frequency response plotted as a Bode diagram.

It can be seen that very large lags occur at what are quite moderate frequencies for short term controlling action. It is therefore difficult to obtain any very great improvement in the short term irregularity of slivers by using a closed loop control based on a measurement of thickness of the output sliver. The Bode diagram in Fig. 1 can, in fact, be approximated to by a system consisting of a simple exponential lag

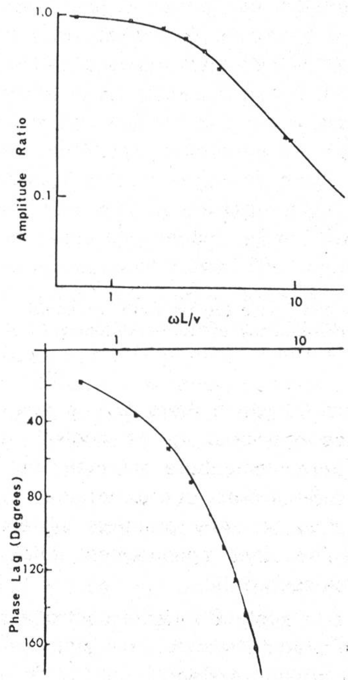

Fig. 1 Changes in the amplitude and phase lag of sliver-thickness variation with changes in frequency of fibre-end-density variations.

plus a measurement lag equal to the time taken for half the mean fibre length to pass through the front rollers. The difficulty of controlling high frequency fluctuations when a measurement lag is present is well known.

An alternative approach to closed loop control of short term irregularities is to measure the drafting force instead of the sliver thickness at the front rollers. The drafting force, T, is very largely determined by the leading fibre end density. For reasonably large drafts it is approximately given by (1)

$$T = k_1 \int_0^L (L - x)\, n(x, t)\, dx \qquad (4)$$

From this relationship it can be shown that the frequency response of the tension to changes in draft is given by

$$\text{Amplitude gain} = \sqrt{(8 + 4\beta^2 - 8\cos\beta - 8\sin\beta)} / \beta^4 \qquad (5)$$

$$\text{Phase lag} = \arctan\,(\beta - \sin\beta) / (1 - \cos\beta) \qquad (6)$$

Figure 2 shows this frequency response plotted as a Bode diagram. It can be seen that the phase lags in this system never exceed 90° and it therefore becomes possible to use the tension measurement as the basis of a short term irregularity controller. A more detailed comparison of the behaviour of closed loop systems based on thickness and tension measurements are given in reference (2) where the advantages of using tension measurements are clearly demonstrated.

Before concluding, however, that the problem of closed loop automatic control of short term irregularities has been solved two very different factors must be considered.

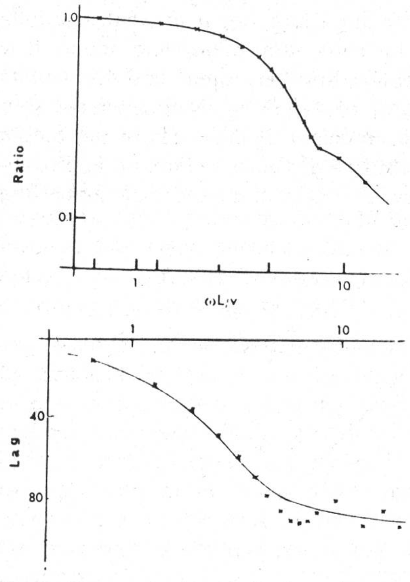

Fig. 2 Changes in the amplitude and phase lag of drafting-tension variations with changes in frequency of fibre-end-density variations.

(a) The use of such a system (of which there are no commercial examples) will be restricted to the control of short term irregularities only, since there are many factors which can produce serious drifts due to variation in the constant k_1 in equation (4). Any practical system must therefore rely on some other measurement, thickness for example, to check such drift.

(b) It is a very simple matter to apply a suitable controlling network to such an ideal drafting system. Is it still possible to apply it to a real drafting system?

In the following section one possible cause of non-ideal drafting behaviour will be analysed. In section 3 we assume that the fibre speed in the drafting zone is determined by the sliver speed until the leading fibre ends reach the front roller nip. The sliver speed being determined by the back roller speed modified by the elastic stretching of the sliver in the drafting zone (5, 6, 7).

3. The response to drafting changes of a non-ideal drafting system

The sliver speed can very readily be found by noting that an increase in drafting force, dT, extends the sliver as it is about to enter the nip of the front rollers by an amount dx, where

$$dx = k_2 \, dT$$

Here k_2 is a constant of proportionality dependent on the modulus of elasticity of the sliver.

Let $n_1(t)$ denote the number of leading fibre ends immediately behind the nip, $n_2(t)$ the number immediately in front of the nip at time t, and v_1 and v_2 the back and front roller surface speeds. Then by the continuity of flow condition:

$$n_1(t)\,[v_1 + dx/dt] = n_2(t)\, v_2,$$

or

$$n_1(t)\,[v_1 + k_2\, dT/dt] = n_2(t)\, v_2 \qquad (7)$$

As has previously been noted T can be assumed to be directly proportional to the total length of front held fibres so that for a constant fibre length

$$T = k_1 \int_0^l n(t - x/v_2)\,(l - x)\, dx,$$

while for varying fibre length:

$$T = k_1 \int_0^{l\,max} f(l) \int_0^l n_2(t - x/v_2)\,(l - x)\, dx\, dl, \qquad (8)$$

where f(l)dl is the fractional frequency of fibres of length l, l_{max} is the length of the longest fibre, and k_2 is a constant depending on the interfibre friction, pressure, etc.

If v_1 is varying sinusoidally it can be written as $\overline{v_1}$ (1 + a exp iωt) where $\overline{v_1}$ is the average value of the back roller velocity, ωλ the frequency (in radians per unit time) of the variation, and a the fractional amplitude of the variation. Under these circumstances $n_1(t)$ remains the input number of leading fibre ends per unit length which can be written as n_1 (1 + ε_1) where n_1 is the average value of $n_1(t)$ and ε_1 is a random variable. It also follows that $n_2(t)$ now becomes n_2 (1 + φ a exp iωt + ε_2), where φ is some complex number and ε_2 is a random variable. Hence by substituting equation (8) into equation (7) and inserting these functions for $n_1(t)$, $n_2(t)$ and v_1 into equation (7) an equation is obtained from which φ can be found.

To obtain this equation in a closed form it is necessary to know the form of the function f(l). For simplicity it will be assumed that the fibre length distribution is normal. (This is not a good fit for most fibre length distributions but the final result is not sensitive to the type of distribution chosen). Hence we have:

$$f(l) = \exp\,[-(l - L)^2/2\sigma^2]\;\sqrt{2}\,\pi\,\sigma,$$

where L is the numerical mean fibre length and σ the standard deviation of fibre length.

With these substitutions equation (7) becomes:

$$1 + a \exp i\omega t + \frac{k_1 k_2}{v_1}\frac{d}{dt}\int_0^L\int_0^l f(l) n_2\,[1 + \varphi\, a \exp i\omega\,(t - \frac{x}{v_2} + \varepsilon)]\, x\,(l - x)\, dx\, dl$$

$$= (1 + \varphi\, a \exp i\omega t + \varepsilon_2)\; v_2 n_2\,(1 + \varepsilon_1)\; v_1 n_1$$

$$= 1 + \varphi\, a \exp i\omega t + \varepsilon_2 - \varepsilon_1$$

since φ a exp iωt, ε_2 and ε_1 are all small in comparison with unity and $v_2 n_2 = v_1 n_1$. Hence substituting the proposed function for f(l) and manipulating we have:

$$\varphi = \frac{1 - K + (K/\beta)\sin\beta\exp(-\beta^2c^2/2) + i\,(K/\beta)\,[1 - \cos\beta\exp(-\beta^2c^2/2)]}{[1 - K + (K/\beta)\sin\beta\exp(-\beta^2c^2/2)]^2 + (K/\beta)^2\,[1 - \cos\beta\exp(-\beta^2c^2/2)]^2}$$

where $K = k_1 k_2 n_1 L$, $\beta = \omega L/v_2$ and $c = \sigma/L$.

φ can be written in the form |φ| exp iϑ where ϑ is the phase difference between the speed variation and fibre end density variation and |φ| the amplitude ratio of these two variations. By algebraic manipulation:

$$(|\varphi|)^{-1} = [1 - K + (K/\beta)\sin\beta\exp(-\beta^2c^2/2)]^2 + (K/\beta)^2\,[1 - \cos\beta\exp(-\beta^2c^2/2)]^2 \quad \tan\vartheta = (K/\beta)\,[1 - \cos\beta\exp(-\beta^2c^2/2)]\;[1 - K + (K/\beta)\sin\beta\exp(-\beta^2c^2/2)] \qquad (9)$$

The values of |φ| and tan ϑ calculated from equation (9) are shown as functions of β (= ωL/v) on Figure 3 for a coefficient of variation of fibre length of 35 %. These graphs are plotted for different values of K between 0.2 and 0.8. K is a dimensionless constant which depends on the relative elasticity of the sliver in the drafting zone.

A similar relationship is obtained from the use of a different model of the drafting system which is due Foster[8]. In this model he assumed that all fibres move at back roller speed till they reach a point a short distance from the nip of the front rollers. Here they accelerate, almost instantaneously, to front roller speed. This changeover point, as it was called, is not a fixed point, and Foster assumed moreover that the distance of this point from the front roller nip is proportional to the length of the fibres held by the front rollers and pro-

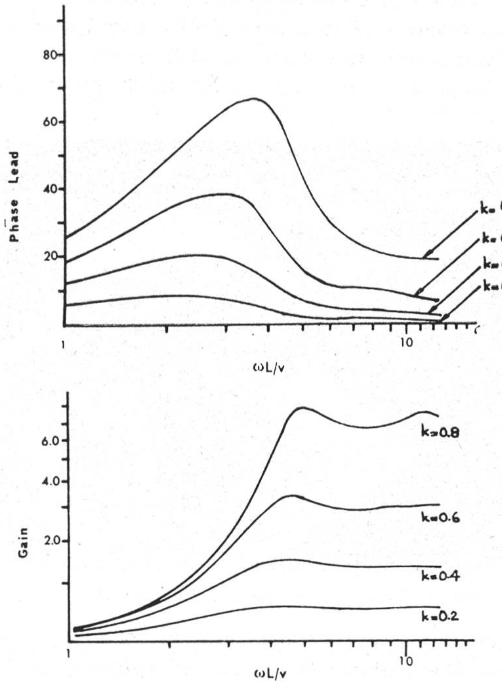

Fig. 3 Changes in the amplitude and phase lag of fibre-end-density variations with changes in frequency of drafting ratio variations under conditions of sliver elasticity with coefficient of variation of fibre length = 35 %.

jecting into the drafting zone. This mathematical model results in the same equations connecting $n_1(t)$ and $n_2(t)$ as given above in equations (7) and (8), but the constants k_2 and K now have no physical meaning. This model also involves a picture of the fibre movements which contradicts the experimental evidence that the majority of the fibres do not achieve front roller speeds until they are actually gripped by the front rollers. In the stretching model, however, it is quite simple to show that K is equal to twice the draft times the ratio of the sliver extension at the average drafting force to the mean fibre length. It should be noted that when K equals unity $|\varphi|$ becomes infinite for large values of β and hence it follows that under such conditions continuous drafting is impossible. This can be shown by making v_1 constant, and replacing $n_1(t)$ by its Fourier components. It then follows that $n_2(t) \leqslant O$ for $K = 1$ and large β, implying a breakdown in continuous drafting. For values of K less than unity $|\varphi|$ is always greater than unity showing that it is probable that the drafting system itself will resonate at some frequency. To show that this is so we multiply the value of $|\varphi|$ given in Figure 2 by those given in Figure 3 and also add the phase lags given in Figures 2 and 3. The resulting graph will show the variations in drafting tension behaviour accompanying sinusoidal changes in roller speeds at different frequencies. Figure 7 shows such a typical graph for the frequency response, for a K value of 0.7 and c = 35 %.

It can be seen on this graph that the phase lags are never very large and if real drafting systems behave in this way a reasonable automatic control could be fitted to this system. It can also be noticed that a peak occurs in the amplitude response at a value of $\omega L/v_2$ equal to 4.5, where the amplitude is twice as large as for low frequency changes, showing that at this frequency the drafting system is resonating. This frequency is considerably higher than that usually associated with the so-called drafting wave. The drafting wave has a wavelength of 2.5 to 3 times the fibre length in the output material, while this frequency is equivalent to a wavelength of 1.2 times the fibre length. It is therefore now necessary to determine experimentally whether these predictions are in fact valid for real drafting systems.

4. Experimental procedure

(i) General

Two pairs of drafting rollers were constructed, each pair being driven by a variable speed motor. A 24-dram roving of 64's Australian warp quality wool in oil was fed to the slower pair of rollers and the drafted material was removed from the faster set of rollers by suction. One of the two variable speed motors had its speed varied sinusoidally by means of an electrical circuit described in the next section; the speed of the other motor was kept constant throughout any particular experiment but was varied whenever it was necessary to change the draft ratio. The drafting tension was measured by moving the sliver, which was being drafted, out of the line connecting the two nip points by means of a spring mounted probe. The displacement of this probe thus registered the drafting force, and this displacement was measured by means of a set of capacitance plates attached to a Fielden proximity meter. The frequency of variation of the roller speeds was varied between 0.3 c/s and 2.0 c/s in a series of experiments. The tension variations, together with the variations in the basic sine wave which was fed to the motor were recorded by use of an oscilloscope with camera attachment. To obtain the phase lags and amplification changes that take place with variation in frequency it is necessary (i) to know the speed variations at each frequency and their phase lags with respect to the basic signal fed to the motor. (This was determined by means of a separate experiment using a tachogenerator to determine the front roller speed. The speed variations at each frequency were found to be nearly constant for all frequencies and the phase lags were small); (ii) to separate the sinusoidal component of tension variation from the random or noise components. This was difficult to do by filtering or other simple electronic technique and was finally achieved by means of a technique based on a simple calculation. The tension trace was divided into a set of complete cycles, each cycle representing a cycle in change of roller speed. Each of these cycles was then divided into 20 parts. The value of the tension in each part, say part 2, was read off and its value added to the value of the tension in part 2 of the next

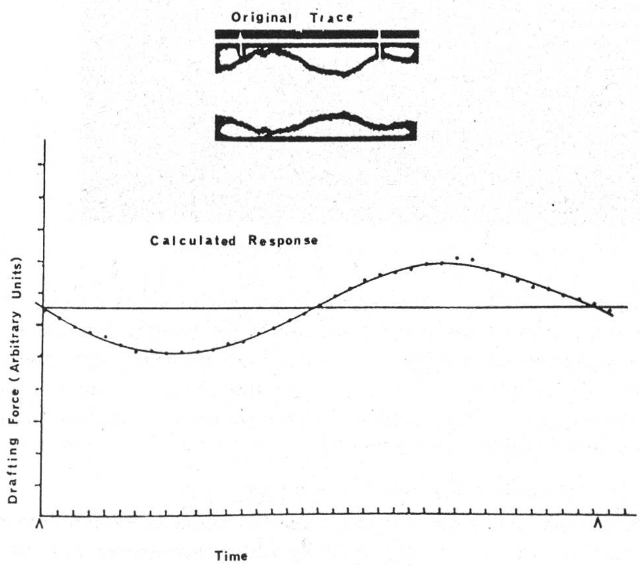

Fig. 4 Original and calculated tension traces.

cycle, and so on. By this means the average tension variation over a cycle was determined with the effect of noise eliminated. The upper diagram in Figure 4 shows a typical tension trace while the lower diagram shows the sinusoidal component obtained in this way. By measuring the range in tension that accompanied a very slow change in roller speed between the two limiting values used, the gain in amplification of tension at all higher frequencies could readily be determined. The phase lag was obtained by finding the difference – expressed as an angle – between the point where the sinusoidal tension trace crossed the mean tension (point A on Figure 4b) and the same point on the input signal to the roller drive.

This numerical method for removing the noise from the signal is perfectly satisfactory but lengthy. An analogue computer which accomplishes the same result more rapidly was therefore constructed as follows. The basic sine wave is obtained mechanically, as described in the next section, from a rotating cam. Two banks of 32 rotary switches were mounted so that their central switch shaft was gear driven directly from the cam shaft. The drafting tension signal was fed to the input of one of these banks of switches. An R-C integrator circuit was connected to each of the separate switches of this bank. As a result the voltage in each of these 32 integrator circuits represented the average voltage, over a fixed part of the basic sine wave signal of the original tension signal. These voltages were then fed out in the correct order to the second bank of switches and the re-

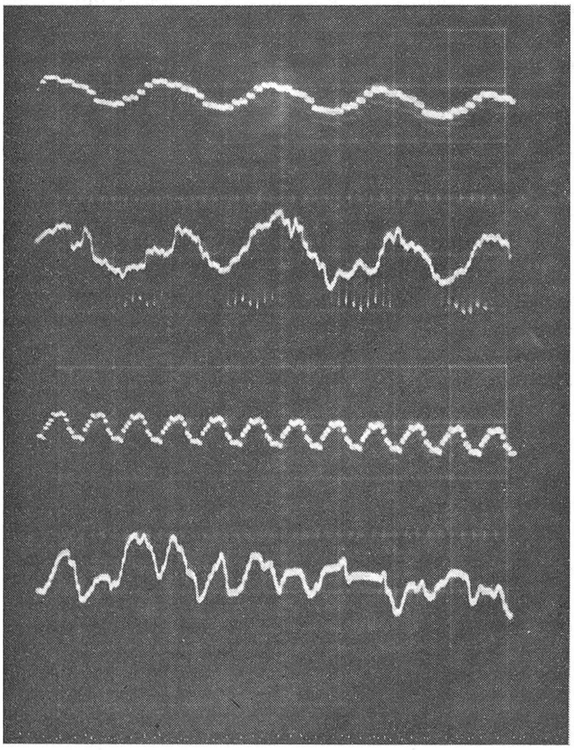

Fig. 5 "Integrated" and original tension traces.

constituted sine wave was then read out on an oscilloscope. Figure 5 shows the basic trace fed to the bank of integrators together with the sine wave component read out from them. It can be seen that even though the noise component of this signal was very large the sine wave component has been obtained without any difficulty.

(ii) The sinusoidal drive to the motor

The motor used was a d.c. servomotor made by Evershed and Vignoles (type FBR 104 A/31/B) which possessed a linear relationship between speed and applied voltage. The basic signal to the motor was obtained from the sine wave generator shown in Figure 6. This consisted of a cam driven by a variable speed motor via a Kopp variable speed gear. By using both available sources of speed variations it was

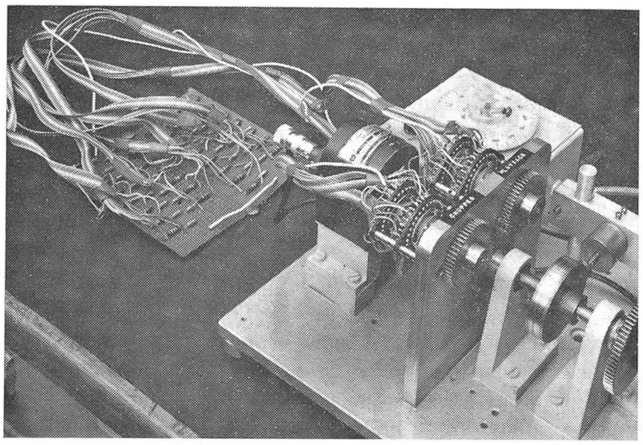

Fig. 6 General view of sine wave generator and integrator.

possible to rotate the cam at any constant speed between 0.2 and 30 c/s. The cam consisted of an eccentrically mounted cylinder which raised and lowered the core of a linear variable differential transformer. The a.c. signal from this transformer was fed to a bridge, amplified and converted into a slowly varying sinusoidal signal which provided a suitable low frequency signal for controlling the motor speed.

To amplify this signal it was fed to a West Viscount standard controller which had been modified so that the higher frequency signals were not attenuated. This amplifier supplied a sinusoidally varying voltage of about 200 volts d.c. which was fed directly to the d.c. servomotor. By using an amplifier based on transistorised circuits and S.C.R. units, together with a motor with an armature of very low moment of inertia, a system was obtained which gave a speed response of the motor almost identical with the input signal up to frequencies greater than 5 c/s.

5. Discussion

It was found that on the whole the behaviour of the tension during dynamic testing of the simple drafting system followed the predictions made in the theoretical section. Figure 7 shows the amplitude gain and phase lags obtained experimentally for a draft of 7. The experimental points are shown as plotted points, together with the calculated theoretical line. It can be seen that reasonable agreement has been obtained although the phase lags found experimentally are rather larger than expected at high frequencies. The measurement of these phase lags is, however, experimentally difficult and it is probable though not certain that these differences are real.

Further work is now underway to determine whether these differences are real by using the more accurate integrator technique previously described. The value of K chosen, viz. 0.7, was that which gave the best agreement between experimental results and theoretical predictions. K can also be found by direct determination but with the relatively thin slivers used in these experiments these determinations are rather approximate. The best direct estimate for K was 0.5 which is reasonably close to the value required to explain the experimental findings.

The experimentally determined frequency response is not particularly suitable for control purposes due to the lags, but calculation has shown that it should still be possible to halve the short-term irregularities by means of a simple pro-

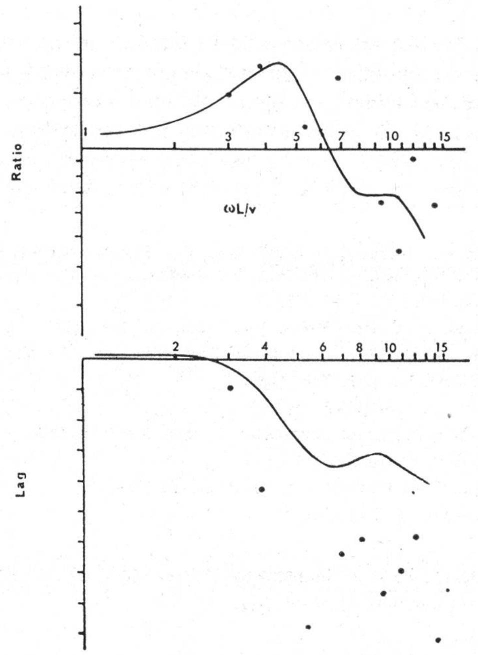

Fig. 7 Changes in the amplitude and phase lag of drafting-tension variations with changes in frequency of drafting-ratio variations. D = 5.

portional controller. Such a controller was therefore fitted and the coefficient of variation of 1 cm lengths of sliver was in fact halved by the introduction of such a control system.

Similar results were obtained at drafts of 5 and 9 but an interesting phenomenon was observed when higher drafts were used. Figure 8 shows the same plots as on Figure 7 but for a draft of 11. The amplitude trace shows a second

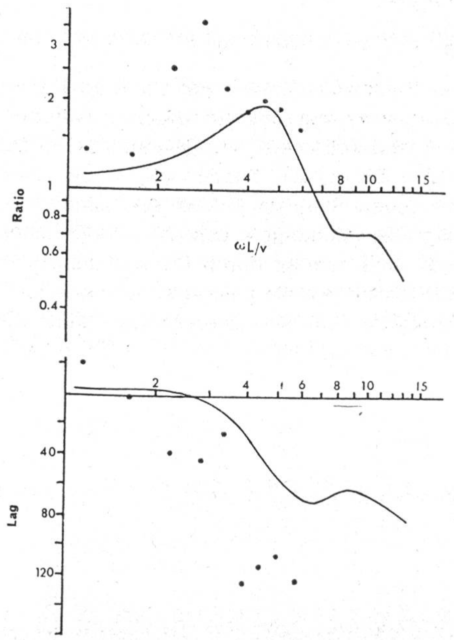

Fig. 8 Changes in the amplitude and phase lag of drafting-tension variations with changes in frequency of drafting-ratio variations. D = 11.

peak this time at a lower frequency, somewhere around ωl/v equals 2.6. This frequency corresponds to an output wavelength of about 2½ fibre lengths. It seems probable, therefore, that this corresponds to the wavelength reported to be present in many cotton (9) and some worsted (10) rovings. It is interesting to note that such a wavelength will result when K approaches unity. Under these conditions it has already been noted that drafting continuity breaks down and the output sliver will therefore consist of a series of tufts. Foster[8] has shown that under such circumstances the output sliver profile will contain a wavelength approximately equal to 2½ times the mean fibre length. The value of K which gives the best fit on Figure 8, however, is only 0.7. The reason for the breakdown in the continuity of drafting may be that the sliver does not necessarily stretch as a whole. A section of the sliver may have a higher K value and, if it can move independently, beakdown in drafting may occur over such a section of the sliver, resulting in the same output wavelength but of reduced amplitude. This possibility, although in a modified form, has also been suggested by Foster and is being examined experimentally.

The experimental findings given in this paper are in general agreement with those obtained by Ihara and Sato[3]. For example they also found that the assumption of ideal drafting could not explain the dynamic response of their drafting system. In addition they obtained a peak in their frequency gain curve but their peak occurred at a lower frequency than that predicted and found experimentally in this work. Their results, however, are not directly comparable as they measured the response in sliver thickness to front roller speed changes in a gill box. In addition they made no attempt to remove the noise component from their traces and at high frequencies their results are open to considerable doubt.

6. Conclusions

At the drafts usually encountered in worsted drawing the response of the drafting system cannot be predicted from an assumption of ideal drafting. In fact a resonant frequency, equivalent to a wavelength of 1.2 times the mean fibre length in the output sliver, occurs which is not predicted by the equations for an ideal drafting system. Such a resonance can be obtained theoretically by assuming either the stretching mechanism of drafting or Foster's change-over point hypothesis. The stretching mechanism is preferred since it

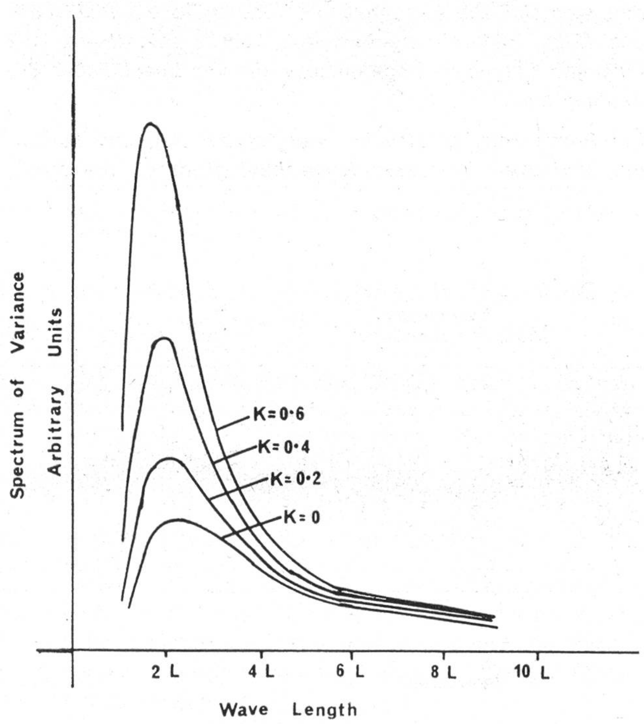

Fig. 9 Spectrum of yarn thickness.

is more nearly in agreement with other experimental findings and because the constants predicted by it are of the right order of magnitude. There is no way of predicting the same constants from Foster's hypothesis. The phase lags obtained experimentally differ somewhat from those predicted and further work is needed to clarify this point. It is not to be expected that a roving produced under constant drafting conditions will have a variation of the resonant wavelength present. This is the result of the spreading of fibre end density irregularity by the fibre length. In fact the method used to obtain equation (7) can also be used to obtain the spectrum of the thickness irregularity of a sliver produced in a drafting system where the stretching mechanism occurs and in which the input speed v_1 is constant and the input fibre end density $n_1(t)$ is a purely random variable. Figure 9 illustrates the spectrum predicted in this way, and shows that the peak of the spectrum lies between 2.5 and 2.0 times the mean fibre length, depending on the K value of the sliver. This smooth type of spectrum is a feature of the spectra found with worsted yarns and slivers and provides further confirmation of the importance of the stretching mechanism in worsted drawing.

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References

1 Balasubramanian, H., Grosberg, P. and Turkes, Y., "Studies in Modern Yarn Production", The Textile Institute p. 169 (1968).
2 Davies, I., J. Text. Inst., 58, T10 (1968).
3 Ihara, M. and Sato, B., J. Text. Mach. Soc. Japan, 13, 119 (1967).
4 Fujino, K. and Kawabata, S., J. Text. Mach. Soc. Japan, 8., 12 (1962).
5 Grosberg, P., J. Text. Inst., 49, T493 (1958).
6 Grosberg, P., ibid, 52, T91 (1961).
7 Grosberg, P., Smith, P. A. and Yoshikawa, I., ibid, 53, T553 (1962).
8 Foster, G. A. R., ibid, 42, T335 (1951).
9 Foster, G. A. R. and Martindale, J. C., ibid, 37, T1 (1946).
10 Goodings, A. C., ibid, 22, T1 (1931).

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Grenzen der Regelung von Strecken der Baumwollspinnerei

Obering. E. Felix, Uster

Zusammenfassung

Geregelten Strecken der Baumwollspinnerei wird normalerweise ein Faserband zugeführt, das im Mittel gegen 10 000 Fasern im Querschnitt aufweist. Unvollkommenheiten der Vorprozesse zur Erzeugung dieses Faserbandes können durch geregeltes Verstecken des Faserbandes teilweise ausgeglichen werden. Das Strecken von Faserbändern kann aber nicht mit dem Verziehen plastischer Medien verglichen werden, weil sich die Einzelfaser im Verzugsprozess nicht dehnen lässt. Dadurch ergeben sich bereits rein theoretisch Einschränkungen im Regelprozess, die von beachtlicher Bedeutung sind.

Die Praxis setzt zusätzliche Grenzen der Regelmöglichkeiten, und zwar im wesentlichen bedingt durch die Messmethoden zur Bestimmung des Bandquerschnittes, mechanisch bedingte Einschränkungen sowie Unzulänglichkeiten in der Verzugszone.

Mit Kombination von Regelungen und Steuerungen gelingt es, einen wesentlichen Teil der mittel- und kurzperiodischen Schwankungen zu eliminieren. Stets tritt aber das grundsätzliche Problem des Verstreckens eines Faserbandes wesentlich in den Vordergrund.

1. Problemstellung

Eine Strecke in der Baumwollspinnerei hat zur Aufgabe, ein Band aus Textilfasern etwa vier- bis sechsfach zu verstrekken. Ein solches Faserband weist im Querschnitt in der Grössenordnung 1000 bis 10 000 Fasern von 2 bis 3 cm Länge auf. Der Bandquerschnitt ist jedoch keinesfalls konstant, sondern zeigt Abweichungen von 20 % und mehr. Diese Abweichungen sind bedingt durch Unzulänglichkeiten in den Vorprozessen. In der Praxis gelingt es in günstigsten Fällen, Variationskoeffizienten des Querschnittverlaufs von

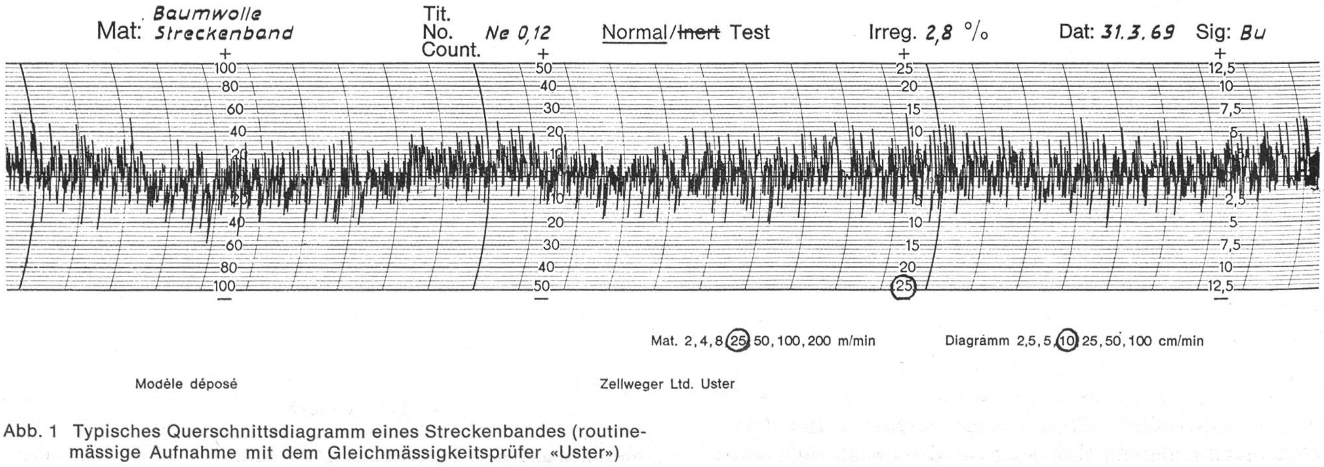

Abb. 1 Typisches Querschnittsdiagramm eines Streckenbandes (routinemässige Aufnahme mit dem Gleichmässigkeitsprüfer «Uster»)