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(54) CONTROL OF THE FILLING LEVEL OF SLIVER RESERVOIRS IN THE TEXTILE INDUSTRY

(71) We, ZELLWEGER USTER LTD., formerly known as Zellweger Limited, Uster Factories for Apparatus and Machines, of 8610 Uster, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the control of the filling level of sliver reservoirs in the textile industry.

Sliver reservoirs are commonly used for storage between the delivery of an intermediate product from one production machine and the pickup of this intermediate product by the following machine. When both machines are adjusted to the same output, the sliver reservoirs need only contain a relatively small sliver reserve, whereas in the case of production lines with highly fluctuating production, these sliver reservoirs have to be kept suitably filled.

However, it is not only between different production stages that the interposition of sliver reservoirs is called for, as there are also types of machine in which storage to allow for fluctuations in internal production and consumption is necessary at one or more places to guarantee uninterrupted production. One example of a machine of this kind is an adjustable card which incorporates two types of regulating system, namely a first for eliminating prolonged fluctuations in the feed to or the take out from the reservoir in the form of a controlled variable rotational speed of the feed roller, and a second for standardising short-term fluctuations which acts on the card sliver in the form of a draft means. For example, a sliver reservoir is required between a front roller of the draft means with variable speed for regulating purposes and the feed means delivering the sliver to the can stock which is driven at a constant speed, to provide for the fluctuations in production of the card sliver due to the regulation. To this end, the sliver reservoir requires a

monitoring means which prevents excessive filling or excessive removal of sliver. Since the effect of the sliver reservoir is intended to be satisfactory under all the working conditions occurring, the average filling level has to be so high that, in even the most unfavourable case, complete emptying never occurs. However, a sliver reservoir is attended by the serious disadvantage that if the sliver reservoir is overfull the sliver to be removed from the reservoir has to be withdrawn with a relatively thick layer of sliver piled on top so that due to its loose cohesion the sliver is readily damaged or torn.

An object of the present invention is to obviate these disadvantages. The invention accordingly provides a method of controlling the filling level of a sliver reservoir, comprising monitoring the filling level by means of sensors at at least one level, and controlling the quantity of sliver delivered to the reservoir on the basis of the signals produced by the sensors, wherein the filling level of the reservoir is rendered dependent on the size of variations in the cross-section of the sliver.

The invention also provides an apparatus for carrying out the above method, comprising at least one sensor for detecting a predetermined filling level in the sliver reservoir, delivery means for controlling the quantity of sliver delivered to the sliver reservoir on the basis of the signal generated by the sensor, and a drafting arrangement, the draft of which is controlled on the basis of the size of variations in the cross-section of the sliver.

The sensor or sensors may be photocells, electro-mechanical probes, capacitive detectors, heat-sensitive detectors, or any combination thereof.

In the accompanying drawings:

Figure 1 is a graph of a number of statistical distributions.

Figure 2 is another graph of statistical distributions in another arrangement.

Figure 3 diagrammatically illustrates the

(11) principle of a sliver reservoir with a sensor for the filling level.

Figure 4 is a graph illustrating a controlled filling level.

Figure 5 is a block diagram illustrating the connection of the sensor to the regulating mechanism.

Figure 6 is an enlarged detail from a graph illustrating a statistical distribution.

Figure 7 diagrammatically illustrates the principle of a sliver reservoir with a sensor for the filling level and a safety device, and

Figure 8 is a block diagram illustrating the connection of another sensor to the regulating mechanism.

Figure 1 is a frequency diagram illustrating the distribution of the filling of a sliver reservoir in a regulated spinning machine, for example a card. In the event of regulation, this frequency follows very closely a normal distribution so that the laws of statistics applying to the normal distribution can be applied at least approximately to this frequency. The references 1, 2 and 3 denote different coefficients of variation of the filling, curve 1 embodying a large coefficient of variation, curve 2 an average coefficient and curve 3 a very small coefficient of variation. All three can occur in one and the same machine. In the absence of an arrangement according to the invention, the average filling level of the sliver reservoir would have to be fixed at such a value that, in the case of highly irregular material (curve 1), the state of complete emptying occurs so rarely that it can still be borne in practice. In the case of curve 1, this average filling level would be the value M. In the processing of a material with relatively small fluctuations in filling, for example according to curve 2 or even curve 3, complete emptying of the sliver reservoir would never occur in practice and the sliver would always have to be removed from an unnecessarily large quantity of sliver.

However, if the average length of sliver present in the sliver reservoir could be selected to be smaller, the better the uniformity of the filling or the smaller its variation coefficient. Accordingly, it would always be possible to work with a minimum permissible filling if the variation coefficient of the filling were known, diminishing the problem of withdrawing the further-transported sliver under one or more layers of stored sliver.

This is also shown in the graph according to Figure 2, in which the middle lines M of the distribution curves 1, 2, 3 are displaced along the abscissa. The displacements have taken place to such an extent that the ordinate axis x is situated at a tolerable frequency value 11, for example one per cent of the total frequency. This percentage can be chosen to any value,

whereby a limit of 10% would represent the highest value for reasonable operation. This produces the frequency curve 1' with its central axis M1 for a large variation coefficient, the frequency curve 2' with its central axis M2 for an average variation coefficient and the frequency curve 3' with its central axis M3 for a small variation coefficient of the filling level of the sliver reservoir.

The fluctuations in the filling level under consideration are a function of time. Accordingly, it is also permissible to express the remaining frequencies 11 as a time fraction of a predetermined, sufficiently large representative time interval.

Figure 3 shows a first embodiment of the invention for controlling the filling level of a sliver reservoir. The references 14, 15 and 16, 17 denote paired rollers of a drafting arrangement for a card sliver 10 whose draft is controlled, as known *per se*, on the basis of a measuring signal formed from the cross-section of the card sliver in a measuring unit 18. The card sliver 10 is deposited in the actual sliver reservoir, the container 20, by a pair of transporting rollers 19. A second pair of transporting rollers 21 removes the card sliver 10 from the container 20 and delivers it for example to a so-called can stock of which one pair of rollers 22 is diagrammatically illustrated, filling the card sliver into spinning cans. The sliver reservoir 20 can always be arranged either (as shown in Figure 3) behind the drafting arrangement 14-17 and in front of the can stock or after a sliver funnel forming the card sliver and in front of the drafting arrangement 14-17. The location of the sliver reservoir is not of crucial significance to the control of the filling level of the sliver reservoir.

Inside the sliver reservoir 20 there is a first sensor 23 which always releases a certain electrical signal when, after leaving the pair of transporting rollers 19, the card sliver 10 falls downwards under its own weight. This function can be performed for example by a photocell arrangement known *per se*. If then the filling of the sliver reservoir 20 decreases (for a reason to be explained further on) to such an extent that the card sliver 10 no longer covers the bottom of the container 20, but passes with a free sag 10" from the pair of rollers 19 to the pair of rollers 21, the sensor 23 will respond. In this case, increased follow-up of card sliver is necessary and can be achieved by increasing the delivery of material to the input end of the card through the control system so that the follow-up of card sliver is also increased by the then necessary higher draft in the drafting arrangement 14-17. After a while therefore the sag 10" will become greater and the

card sliver 10' will begin to be re-deposited on the bottom of the container 20 so that the sensor 23 will no longer respond, stopping the increased delivery of material.

After a certain time, therefore, a condition will prevail in which the sagging sliver 10'' will cover the sensor 23 for a certain time interval and expose it for another, on average, longer, time interval.

In this connection, it is desirable that the sliver reservoir should on average be emptied to a very slight extent, i.e. that the quantity of sliver removed should be somewhat greater than the quantity of sliver introduced. Accordingly, after a certain period of time, the sliver reservoir will of necessity be increasingly emptied, giving rise to the increased delivery of sliver in accordance with the cycle described earlier on. Figure 4 shows the path followed by the filling level as a function of time. At the time $t_1, t_2, t_3, \dots$, the sliver reservoir is empty to such an extent that the sensor 23 releases a signal. This in turn releases the increased flow of material until the flow of material returns to normal through disappearance of the signal at times t_2, t_4 , and t_6 . When the gradual emptying which begins again leads to release of the signal, the cycle is repeated in the manner described.

If the card sliver 10 shows pronounced irregularities, the filling in the sliver reservoir 20 will also be subjected to considerable fluctuations. The frequency of certain fillings will substantially follow the curve 1 in Figure 1.

In the event of minor fluctuations in the cross-section of the card sliver 10, the supply of material controlled by the periodic response of the sensor 23 will also deposit a certain supply of sliver in the reservoir and use it up again at shorter time intervals. Accordingly, the average filling level remains low.

Figure 5 is a diagrammatic plan view of a card with a feed roller 31 and its controlled drive 32, the pairs 14-17 of drafting rollers with a rotational-speed control 33, and a control unit 34 which converts the signals of the sensor 23 into control commands for the controllable drives 32 and 33.

Since the filling level of the sliver reservoir 20, is, as already mentioned, largely subject to the laws of normal distribution and since as required a small fraction of the fillings of the sliver reservoir or an inadequate delivery occurs during a fraction of a sufficiently long time interval, it can happen as a so-called "rare occurrence" that the supply of card sliver in the sliver reservoir 20 is completely used up and the sag is less than the permitted limit. Figure 6 shows the beginning of the branch of a normal distribution curve, that part of the filling which occurs in less than 1% of the random

tests according to the filling level (or in less than 1% of a certain sufficiently long time interval) being limited to the abscissa σ .

If a condition such as this (filling level dropping below a permitted minimum) occurs, the card sliver will tear in the absence of special measures because the offtake over the pair of rollers 21 is greater than the follow-up supplied by the pair of rollers 19.

Initially, however, the sag in the card sliver 10'' (Figure 3) will be further reduced where permitted by the cohesive force of the fibrous material.

Accordingly, the limit 0 is not identical with the limit at which the sliver would tear, instead it is even further to the left. At the same time, the probability value also falls appreciably, for example from 1% to 0.1%.

If this condition of a minimum permitted sag 100 is detected by a second sensor 24 (Figure 7) and on the basis of this detection acts on those parts of the machine responsible for follow-up of the sliver in the sense that more sliver is supplied, for example by interrupting or limiting regulation of the rotational speeds of the rollers, the danger of the card sliver tearing through inadequate capacity of the sliver reservoir is eliminated. The objection that some of the card sliver is processed with unregulated draft in this way, can be overcome on the grounds that this condition occurs on average for only 0.1% of the working time and the disadvantage of a sliver regulated to a limited extent in regard to its cross-section over a limited length is less serious than tearing of the sliver in the sliver reservoir.

Accordingly, the arrangement according to the invention functions in a balanced condition in such a way that the card sliver 10 issuing from the pair of rollers 19 passes between at least one sensor 23 and/or 24 and is run off by the pair of rollers 21.

These sensors are arranged in such a way that the first sensor 23 is influenced in the event of excessive sag of the card sliver 10 whilst the second, 24, is influenced in the event of excessive tension in the card sliver and releases a signal. The signal released by the first sensor 23 regulates the delivery of fibrous material at the input 31 and hence a maximum filling of the sliver reservoir 20 through the cross-sectional measurement of the card sliver 10 produced and the control of draft derived therefrom in the drafting arrangement 14-17. The second sensor 24 acts as a limiting or safety means in those cases where the filling level would theoretically fall below a permitted minimum in order to avoid any interruption in the flow of material.

Figure 8 is a diagrammatic plan view of a card followed by a regulated drafting arrangement, a sliver reservoir and a can

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stock. The second sensor 24 acts on the controllable drive 33 through the control unit 35. This influence on draft regulation in the case of response of the second sensor 24 has to take place without any delay because the sensor only comes into operation after the last sliver reserve has been used up and no more material is available in the reservoir.

Any type of sensor can be used for the sensors 23 and 24, for example mechanical sensors which are deflected by the card sliver, or photocells which have the advantage of being able to function as sensors in the absence of any contact. Capacitive sensors can also be used.

WHAT WE CLAIM IS:—

1. A method of controlling the filling level of a sliver reservoir, comprising monitoring the filling level by means of sensors at at least one level, and controlling the quantity of sliver delivered to the reservoir on the basis of the signals produced by the sensors, wherein the filling level of the reservoir is rendered dependent on the size of the variations in the cross-section of the sliver.

2. A method as claimed in Claim 1, wherein control of the filling level is superimposed upon a control for gradually emptying the sliver reservoir and comparatively quickly replenishing it when a minimum filling level is reached.

3. A method as claimed in Claim 1 or 2, wherein a first sensor responds and releases a signal when the filling level of the sliver reservoir has not reached the minimum permitted level.

4. A method as claimed in Claim 3, wherein another sensor responds and releases a signal when the minimum permitted filling level is reached.

5. A method as claimed in Claim 4, wherein the signal of the second sensor is used for limiting and/or interrupting the draft regulation of a drafting arrangement controlling the filling level of the sliver reservoir.

6. A method of controlling the filling level of a sliver reservoir substantially as described with reference to the accompanying drawings.

7. An arrangement for carrying out the method as claimed in Claim 1, comprising at least one sensor for detecting a predetermined filling level in the sliver reser-

voir, delivery means for controlling the quantity of sliver delivered to the sliver reservoir on the basis of the signal generated by the sensor, and a drafting arrangement, the draft of which is controlled on the basis of the size of variations in the cross-section of the sliver.

8. An apparatus as claimed in Claim 7, wherein the delivery means for controlling the quantity of sliver delivered to the sliver reservoir respond when the filling level reaches a minimum value.

9. An apparatus as claimed in Claim 8, wherein the predetermined minimum of the filling level comprises a safety reserve of sliver length, and wherein another sensor responding to the beginning consumption of this safety reserve is provided.

10. An apparatus as claimed in any one of Claims 7 to 9, wherein the delivery means comprises delivery rollers at the input end of the apparatus.

11. An apparatus as claimed in Claim 9, wherein the signals produced by the second sensor act through control means on the rotational speed control of the drafting arrangement in such a way that the regulating effect of the drafting arrangement is periodically eliminated or reduced.

12. An apparatus as claimed in any one of Claims 7 to 11, wherein the sensor or sensors are optico-electrical photocells.

13. An apparatus as claimed in any one of Claims 7 to 11, wherein the sensor or sensors are electromechanical probes.

14. An apparatus as claimed in any one of Claims 7 to 11, wherein the sensor or sensors are capacitive detectors.

15. An apparatus as claimed in any one of Claims 7 to 11, wherein the sensor or sensors are heat-sensitive detectors.

16. An apparatus as claimed in any one of Claims 12 to 15, comprising a combination of different types of sensors as the first and second sensor.

17. An apparatus for controlling the filling level of sliver reservoirs substantially as described with reference to the accompanying drawings.

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2. A method as claimed in Claim 1, wherein control of the filling level is superimposed upon a control for gradually emptying the sliver reservoir and comparatively quickly replenishing it when a minimum filling level is reached.

3. A method as claimed in Claim 1 or 2, wherein a first sensor responds and releases a signal when the filling level of the sliver reservoir has not reached the minimum permitted level.

4. A method as claimed in Claim 3, wherein another sensor responds and releases a signal when the minimum permitted filling level is reached.

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6. A method of controlling the filling level of a sliver reservoir substantially as described with reference to the accompanying drawings.

7. An arrangement for carrying out the method as claimed in Claim 1, comprising at least one sensor for detecting a predetermined filling level in the sliver reservoir,

delivery means for controlling the quantity of sliver delivered to the sliver reservoir on the basis of the signal generated by the sensor, and a drafting arrangement, the draft of which is controlled on the basis of the size of variations in the cross-section of the sliver.

8. An apparatus as claimed in Claim 7, wherein the delivery means for controlling the quantity of sliver delivered to the sliver reservoir respond when the filling level reaches a minimum value.

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