



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.04.2023 Bulletin 2023/14

(51) International Patent Classification (IPC):
B65H 59/38 ^(2006.01) **D04B 15/44** ^(2006.01)

(21) Application number: **22198457.8**

(52) Cooperative Patent Classification (CPC):
D04B 15/44; B65H 59/388; B65H 2701/31

(22) Date of filing: **28.09.2022**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **RUGGERI, Mirko**
24026 LEFFE BG (IT)
• **BERTOCCHI, Giorgio**
24026 LEFFE BG (IT)
• **PREVITALI, Davide**
24048 TREVILO BG (IT)
• **PREVIDI, Fabio**
24100 BERGAMO (IT)

(30) Priority: **30.09.2021 IT 202100025076**

(71) Applicants:
• **L.G.L. Electronics S.p.A.**
24024 Gandino (Bergamo) (IT)
• **Università degli studi di Bergamo**
24129 Bergamo (IT)

(74) Representative: **Modiano, Micaela Nadia**
Modiano & Partners
Via Meravigli, 16
20123 Milano (IT)

(54) **METHOD FOR CONTROLLING YARN TENSION FOR MOTORIZED POSITIVE YARN FEEDERS**

(57) A yarn (Y) is wound on the motorized reel (12) of a feeder which draws the yarn (Y) from a spool (S) and feeds it to a knitting machine (KM). A control unit (CU) adjusts the rotation rate of the reel (12) by closed loop on the basis of the signal received from a tension sensor (14), in order to stabilize the tension of the yarn (Y) on a desired value (Tdes). The tension (T) measured by the tension sensor (14) is compared with the desired value (Tdes) in order to obtain an error (Terr) which, by means

of a proportional-integral-derivative regulator (PID), generates a reference angular speed (ω_{Rref}) to be sent to a reel speed control loop (RSL). The proportional-integral-derivative regulator (PID) has an integrative constant K_I which is updated iteratively by means of a self-calibration procedure (18) adapted to minimize a performance index of the signal generated by the tension sensor (14).

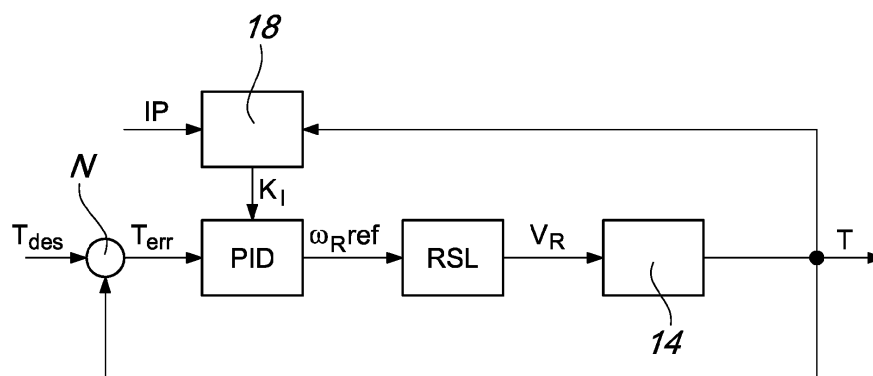


Fig. 2

YTL

Description

[0001] The present invention relates to a method for controlling yarn tension for motorized positive yarn feeders.

[0002] As is known, in a generic weaving process, a yarn can be fed toward a downstream textile machine, such as in particular a knitting machine, by a motorized yarn feeder of what is called the "positive" type.

[0003] This type of feeder is provided with a motorized reel on which the yarn is wound repeatedly (for example, 3 or 4 turns) so that it adheres thereto by friction. By turning the reel, the yarn unwinds from an upstream spool and is fed to the downstream knitting machine.

[0004] During work, a control unit modulates the rotation rate of the reel by closed loop on the basis of the signal received from a tension sensor, in order to stabilize the tension of the yarn fed to the knitting machine at a fixed value or at a profile set by the user.

[0005] One of the factors that most affects yarn tension is the difference between the speed at which the yarn exits from the feeder and the speed at which it is drawn by the knitting machine.

[0006] Therefore, in order to improve the performance of the control loop, for certain applications it is known to transmit the speed information of the knitting machine to the feeder during work.

[0007] Other factors that affect yarn tension are the stiffness of the yarn and the distance between the feeder and the knitting machine.

[0008] Therefore, again in order to improve the performance of the control loop, in some cases the control unit makes it possible to select manually some adjustment parameters as a function of the type of yarn and, indirectly, of the distance between the feeder and the knitting machine.

[0009] The abovementioned solutions for optimizing the control loop performance complicate line setup considerably, since they require manual entry of the operating parameters on all feeders and/or to electronically connect the knitting machine to the feeders in order to transmit the speed information. This last solution, moreover, is not always feasible, since many knitting machines, particularly the less recent ones that are however still widely used, are not equipped to transmit their speed signal externally.

[0010] Therefore, the aim of the present invention is to provide a method that makes it possible to control the tension of the yarn in a manner that is more precise and more reliable than known solutions, optimizing automatically the performance during work in relation to the various factors involved, particularly the type of yarn, the speed variations of the knitting machine and the distance between the feeder and the knitting machine.

[0011] This aim and these and other objects which will become more apparent from the continuation of the description are achieved by a method for adjusting yarn tension having the characteristics described in claim 1, while the dependent claims define other advantageous, albeit secondary, characteristics of the invention.

[0012] The invention is now described in greater detail with reference to a preferred but not exclusive embodiment thereof, illustrated by way of nonlimiting example in the accompanying drawings, wherein:

Figure 1 is a schematic view of a motorized positive yarn feeder which feeds a yarn to a knitting machine;

Figure 2 is a block diagram view of the method according to the invention;

Figure 3 is a combined chart which plots the effects of the variation of some process parameters in the method according to the invention;

Figure 4 is a chart of an example of yarn drawing speed profile by a generic knitting machine.

Figure 1 is a schematic view of a motorized positive yarn feeder 10 which feeds a yarn Y to a textile machine, particularly a knitting machine KM.

[0013] The feeder 10 comprises a motorized reel 12 on which the yarn Y is wound repeatedly (for example, 3 or 4 turns) so that it adheres to the reel by friction. By turning the reel 12, the yarn Y unwinds from an upstream spool S and is fed to the downstream knitting machine KM.

[0014] A control unit CU, which can be integrated in the feeder 10, is connected to adjust the rotation speed of the reel 12 by closed loop on the basis of the signal received from a tension sensor 14 (also, optionally, integrated in the feeder 10), so as to stabilize the tension of the yarn fed to the machine on a fixed value or on a profile set by the user.

[0015] The feeder 10 is also provided with means (not shown) for measuring the angular speed ω_R of the reel 12, which can generally comprise an encoder, a series of Hall sensors, or other similar known devices.

[0016] As the person skilled in the art will easily understand, the release speed V_R of the yarn Y can be assumed to be equal to the product of the angular speed ω_R of the reel 12 and the radius of the reel 12.

[0017] The feeder 10 is arranged at a distance L from the knitting machine KM, which draws yarn at a drawing speed V_{KM} . In relation to the present invention, the distance L and the drawing speed V_{KM} are assumed to be unknown, as are the mechanical characteristics (in particular the stiffness) of the yarn Y.

[0018] As is known, the drawing speed V_{KM} can vary widely, for example during the provision of a design. The closed loop control system has the purpose of limiting the tension variations of the yarn Y which result from said variations in

the drawing speed V_{KM} by the knitting machine.

[0019] Figure 2 shows the architecture of the closed loop control system.

[0020] In a manner known per se, the control system comprises generally a yarn tension control loop YTL, a reel speed control loop RSL, and a control loop of the current that crosses the electric motor (not shown), which is contained within the speed control loop RSL.

[0021] The speed control loop RSL and the current control loop are preferably controlled in a conventional manner by means of constant parameter linear regulators, so as to receive in input a reference angular speed ω_{Rref} and return in output the release speed V_R . As mentioned earlier, the difference between the release speed V_R and the drawing speed V_{KM} generates a tension T on the yarn Y . The tension T is measured by the tension sensor 14 and compared with a desired tension T_{des} in a subtractor node N of the tension control loop YTL, so as to generate a tension error T_{err} . The desired tension T_{des} can have a constant value or a profile that is variable over time.

[0022] According to the invention, the reference angular speed ω_{Rref} is generated by a proportional-integral-derivative regulator PID which receives in input the tension error T_{err} and has an integrative constant K_I that is not constant but is instead updated iteratively through a self-calibration procedure 18 adapted to minimize a performance index (or cost function) of the signal generated by the tension sensor 14.

[0023] In the preferred embodiment described hereinafter, the variance of the tension signal is used as performance index.

[0024] Preferably, the self-calibration procedure comprises the following steps:

- calculating the variance $V(K_I)$ on a preset number of samples N of the tension signal T by applying the current integrative constant K_I ,
- selecting a new integrative constant K_I' by means of a *black-box* optimization algorithm,
- if the new integrative constant K_I' falls within an interval comprised between a minimum safeguard value K_{Imin} and a maximum safeguard value K_{Imax} which are predetermined, repeating the procedure using the new integrative constant K_I' , otherwise repeating the procedure using the current integrative constant K_I .

[0025] According to the aim and objects of the present invention, it has been found also in practice that the proportional-integral-derivative regulator PID with integrative constant which is updated iteratively in the abovementioned manner has the effect of minimizing the magnitude of the tension peaks caused by the speed changes of the knitting machine and at the same time of avoiding excessive oscillations of the tension signal.

[0026] As the person skilled in the art can easily understand, these two purposes are usually conflicting, since an "aggressive" or "fast" adjustment entails a rapid reduction of the tension peaks but possible steady-state oscillations due to tension measurement noise. Vice versa, a "robust" or "slow" adjustment yields more regular trends of the tension signal but high peak magnitudes.

[0027] It has been found experimentally as well that the sample variance of the tension signal in the self-calibration procedure described above is a reliable indicator of system performance in relation to the above purposes.

[0028] Since the variance is calculated over a predetermined time interval, the described self-calibration procedure is particularly effective in the system described here because, as is known, knitting machines conventionally have periodic speed profiles, therefore making the comparison between variances obtained with different successive integrative constants significant.

[0029] In relation to this, it is appropriate that the variance be calculated over a time interval that has a longer duration than the period of the knitting machine.

[0030] In order to compensate for the use of an incorrect interval and take into account the noise of the voltage signal, in a constructive variation it is possible to consider the mean variance $E[Var(K_I)]$ of the tension signal over a preset number of consecutive intervals M as a performance indicator instead of the point value $Var(K_I)$ of the variance.

[0031] Figure 3 shows an example of the trend of the mean variance $E[Var(K_I)]$ as the integrative constant K_I varies for an intermediate yarn at a certain working point, as well as the trend of the tension T and of the release speed V_R at the minimum value K_{Imin} and at the maximum value K_{Imax} of the integrative constant within the domain portion considered, and also the value that minimizes the mean variance $E[Var(K_I)]$.

[0032] The trend of the drawing speed V_{KM} by the knitting machine KM , which generated the charts of Figure 3, is shown in Figure 4.

[0033] It is evident that the calibration of the integrative constant K_I that maximizes the performance in the terms mentioned above is the one that minimizes the mean variance of the tension signal $E[Var(K_I)]$.

[0034] The minimum safeguard value K_{Imin} and the maximum safeguard value K_{Imax} are defined based on the threshold values that can be represented by the control unit CU , considering also the fact that the integrative constant K_I can assume only negative values in order to prevent the system from becoming unstable.

[0035] For the sake of greater clarity and simplicity of exposition, hereinafter reference shall be made again to the variance $Var(K_I)$ instead of the mean variance $E[Var(K_I)]$, although, as mentioned, the use of the latter is preferable as

it is more reliable.

[0036] As is well-known to the person skilled in the art, conventional *black-box* optimization algorithms for minimizing a performance index (in the specific case, the variance $\text{Var}(K_I)$) that is unknown (meaning that in this case the mathematical relationship between the calibration of the integrative constant K_I and the variance $\text{Var}(K_I)$ of the tension signal T is not known), have some drawbacks; in particular:

- they are computationally costly and therefore difficult to implement on a microcontroller;
- they normally do not provide safeguard limits on the extent of the variation of the integrative constant K_I between one iteration and the subsequent one, with the risk of abrupt changes in the calibration of the proportional-integral-derivative regulator PID during work, which in turn might generate transients of considerable magnitude with consequent breaking of the yarn;
- they are designed to solve optimization problems with more complex cost functions than the variance $\text{Var}(K_I)$, which is usually a function suitable for the adoption of simpler algorithms.

[0037] For this reason, preferably, the black-box optimization algorithm used in the method according to the invention provides for:

- performing a first test, which can be defined as "passive" and in which the control loop of the tension TL works with a current integrative constant K_I which is fixed for a predetermined time interval and then the variance of the tension signal in this time interval is calculated,
- calculating the minimum step δK_I of the integrative constant K_I according to the formula

$$\delta K_I = \frac{|K_I|}{\gamma_{\minstep}}$$

where $\gamma_{\minstep}$ is an experimentally determined minimum step coefficient, typically comprised between 5 and 50,

- performing a second passive test, in which the tension control loop TL works with an increased integrative constant which is equal to $K_I + \delta K_I$ for the same time interval and then the variance is calculated on the preset number of samples N of the tension signal T in this time interval,
- performing a third passive test, in which the tension control loop TL works with a reduced integrative constant which is equal to $K_I - \delta K_I$ for the same time interval and then the variance is calculated on the preset number of samples N of the tension signal T in this time interval.

[0038] The passive tests are performed by closed loop without ever interrupting tension adjustment.

[0039] Advantageously, at this point, it is possible to use a modified version of Newton's algorithm that approximates the cost function at a certain point with a quadratic model and chooses as the next point to be tested the one that reduces to zero the first derivative of this simplified model. The second derivative must be positive and different from zero in order to have a minimum of the quadratic model, otherwise it is necessary to apply safeguards. In particular, if the second derivative were equal to zero it would not be possible to calculate the direction of descent, whereas if it were negative the direction of descent would lead toward a local maximum.

[0040] In greater detail, the first derivative and the second derivative can be calculated, for example, by means of what is called the central difference formula:

$$\frac{dV(K_I)}{dK_I} = \frac{V(K_I + \delta K_I) - V(K_I - \delta K_I)}{2 \cdot \delta K_I}$$

$$\frac{d^2 V(K_I)}{dK_I^2} = \frac{V(K_I + \delta K_I) - 2V(K_I) + V(K_I - \delta K_I)}{(\delta K_I)^2}$$

[0041] On the basis of the first and second derivatives, the algorithm calculates the direction of the movement p, checking whether one between $V(K_I + \delta K_I) - V(K_I)$ or $V(K_I - \delta K_I) - V(K_I)$ returns a result < 0 . In the first case, in the chart of Figure 3 the value is to the left of the minimum of the variance and, therefore, with a sufficiently short "positive" step it is possible to approach the minimum value; in the second case, the value is to the right of the minimum of the variance

and with a sufficiently short "negative" step it is possible to approach the minimum value.

[0042] If one of the two differences gives a result <0 , the safeguard check is applied and then one chooses the extent of the step α so as to improve the variance and the new integrative constant K_I' is applied to the tension control loop YTL according to the formula $K_I' = K_I + \alpha p$.

[0043] By way of example, in the case of a positive second derivative, the direction of the movement p is given by the negative ratio between the first derivative and the second derivative (Newton direction).

[0044] The extent of the step α can be derived by a procedure known as *line search*. In particular, if the Newton direction is used, one can simply perform what is called a backtracking line search in which one starts from $\alpha = 1$ and checks whether the variance improves for $K_I + p$. If it does not, one repeats the check by halving α and so forth for a predetermined number of steps.

[0045] If neither of the two differences yields a result <0 , the procedure is repeated using the same integrative constant K_I without performing any step. Under ideal conditions of no measurement noise, this would mean that the variance is already very close to the minimum value, and therefore a step in any direction would offer a worse result. In the presence of noise (or because of numerical accuracy problems), the procedure may be unable to derive a movement direction. In that case, the optimization step, i.e., the three tests for the variances, is repeated.

[0046] Advantageously, in order to avoid excessively abrupt transitions, in addition to the safeguard criterion already mentioned on the value of K_I , which must be comprised between a minimum value K_{Imin} and a maximum value K_{Imax} , an additional safeguard criterion is applied according to which

$$\delta K_I \leq \alpha |p| \leq \Delta K_I$$

where

$$\Delta K_I = \frac{|KI|}{\gamma_{maxstep}},$$

$\gamma_{maxstep}$ being an experimentally determined maximum step coefficient, which can be comprised typically between 1 and 5.

[0047] As the person skilled in the art may appreciate, the algorithm is never interrupted during work. Once the calibration of K_I that guarantees the minimum variance has been reached, the algorithm oscillates around it, so as to provide a genuine adaptive control: in case of changes in the working conditions (change of yarn, changes in the speed profile of the knitting machine, change in the distance between the feeder and the knitting machine) the procedure resumes the search for the minimum.

[0048] The starting integrative coefficient, K_I , the number of samples N to be used in calculating the variance (given the sampling rate, this is equivalent to defining the time interval to be considered), the number of intervals M over which to calculate the mean variance, as well as the coefficients for calculating the minimum step and the maximum step, $\gamma_{minstep}$ and $\gamma_{maxstep}$, respectively, can be determined on the basis of experimental tests.

[0049] As an alternative, as regards the starting integrative coefficient, K_I , it is possible to perform a preset number of iterations of the procedure according to the invention under controlled conditions (i.e., with known yarn, knitting machine speed profile, and distance between the feeder and knitting machine), so as to obtain initial calibrations for a small number of yarn types. These initial calibrations can be used as a starting point during work in order to speed up the convergence to the variance minimum $V(K_I)$.

[0050] Preferably, the variance calculation can be performed incrementally in order to avoid the need to store a number N of samples, so as to limit the memory capacity required to perform the self-calibration procedure.

[0051] Preferably, the time constant of the integral part T_I and the time constant of the derivative part T_D of the proportional-integral-derivative regulator PID are kept constant and calibrated starting from an estimated model for the speed control loop.

[0052] Preferably, the reel speed control loop RSL includes a Kalman filter for estimating the angular rotation rate of the motor, which is performed starting from the measurement of the angular position. As mentioned earlier, this estimate can be exploited advantageously by a proportional-integral controller in order to control the angular speed ω_R of the reel.

[0053] In practice, it has been found that the Kalman filter allows to improve the performance of the speed control loop RSL and, accordingly, of the entire adjustment procedure, simplifying the implementation of the tension adjustment loop YTL.

[0054] Some preferred embodiments of the invention have been described, but the person skilled in the art will naturally be able to make various modifications and variations within the scope of the claims.

[0055] In particular, the variance (or the mean variance) has been used as performance index. However, as the person skilled in the art will easily understand, it will be possible to use other performance indices calculated directly from the

measured value (as in the case of the variance) or from the error (difference between setpoint and measured value). Some examples of alternative performance indices are the Mean Squared Error (MSE), the Root Mean Squared Error (RMSE), or Integral Performance Indices such as the Integral Squared Error (ISE), the Integral Absolute Error (IAE), the Integral of the Time weighted Absolute Error (ITAE), or even the Integral of the Time weighted Squared Error (ITSE).

[0056] Other possible performance indices are normalized versions or various combinations of those defined above. Each performance index substantially defines a different trade-off between peak rejection and oscillations and must be calculated over a certain measurement period.

[0057] All of the above cited performance indices have "zero" as the ideal minimum value.

[0058] The disclosures in Italian Patent Application No. 102021000025076 from which this application claims priority are incorporated herein by reference.

[0059] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A method for controlling yarn tension in a yarn feeder of the type provided with a reel (12) which is adapted to carry a yarn (Y) wound thereon and is driven to rotate by a motor in order to draw said yarn (Y) from a spool (S) and feed it to a knitting machine (KM), wherein a control unit (CU) adjusts the rotation rate of the reel (12) by closed loop on the basis of the signal received from a tension sensor (14), in order to stabilize the tension of the yarn (Y) at a desired value (Tdes) which is fixed or variable over time according to a preset profile, wherein the tension (T) measured by said tension sensor (14) is compared with said desired value (Tdes) in order to obtain an error (Terr) which, by means of a proportional-integral-derivative regulator (PID), generates a reference angular speed (ω_{Rref}) to be sent to a reel speed control loop (RSL), **characterized in that** said proportional-integral-derivative regulator (PID) has an integrative constant K_I which is updated iteratively by means of a self-calibration procedure (18) adapted to minimize a performance index of the signal generated by said tension sensor (14).

2. The method according to claim 1, **characterized in that** said performance index is the variance $V(K_I)$ of the tension signal.

3. The method according to claim 1, **characterized in that** said performance index is the mean variance $E[Var(K_I)]$ of the tension signal, calculated over a preset number of consecutive intervals (M).

4. The method according to one or more of claims 1-3, **characterized in that** said self-calibration procedure comprises the following steps:

- calculating said performance index on a preset number of samples (N) of the tension signal (T) by applying the current integrative constant K_I ,
- selecting a new integrative constant K_I' by means of a *black-box* optimization algorithm,
- if the new integrative constant K_I' falls within a safeguard interval comprised between a minimum safeguard value K_{Imin} and a maximum safeguard value K_{Imax} which are predetermined, repeating the procedure using the new integrative constant K_I' , otherwise repeating the procedure using the current integrative constant K_I .

5. The method according to claim 4, **characterized in that** said *black-box* optimization algorithm comprises the following steps:

- performing a first passive test, in which a fixed current integrative constant K_I is used for a predetermined time interval and then the performance index of the tension signal in this time interval is calculated,
- calculating the minimum step δK_I of the current integrative constant K_I according to the formula

$$\delta K_I = \frac{|KI|}{\gamma_{minstep}}$$

where $\gamma_{minstep}$ is an experimentally determined minimum step coefficient,

- performing a second passive test, in which an increased integrative constant is used which is equal to $K_I + \delta K_I$ for the same time interval and then the performance index is calculated on the preset number of samples

(N) of the tension signal (T) in this time interval,

- performing a third passive test, in which a reduced integrative constant is used which is equal to $K_I - \delta K_I$ for the same time interval and then the performance index is calculated on the preset number (N) of samples of the tension signal (T) in this time interval,

5 said passive tests being performed in a closed loop without ever interrupting the tension adjustment,

- calculating the first derivative and the second derivative according to the following formula:

$$10 \quad \frac{dV(K_I)}{dK_I} = \frac{V(K_I + \delta K_I) - V(K_I - \delta K_I)}{2 \cdot \delta K_I}$$

$$15 \quad \frac{d^2 V(K_I)}{dK_I^2} = \frac{V(K_I + \delta K_I) - 2V(K_I) + V(K_I - \delta K_I)}{(\delta K_I)^2}$$

- calculating the direction of the movement p, checking whether one of $V(K_I + \delta K_I) - V(K_I)$ or $V(K_I - \delta K_I) - V(K_I)$ returns a result < 0 and,

20 - if it does, after applying a safeguard check, choosing the extent of the step α so as to improve the variance and applying the new integrative constant K_I' to the tension control loop (YTL) according to the formula $K_I' = K_I + \alpha p$,

- if it does not, repeating the procedure by using the current integrative constant K_I without performing any step.

25 **6.** The method according to claim 5, **characterized in that** said minimum step coefficient $\gamma_{\minstep}$ is comprised between 5 and 50.

7. The method according to claim 5 or 6, **characterized in that** the extent of the step α is determined by means of a backtracking line search procedure.

30 **8.** The method according to one or more of claims 4-7, **characterized in that** a further safeguard criterion is applied according to which

$$35 \quad \delta K_I \leq \alpha |p| \leq \Delta K_I$$

where

$$40 \quad \Delta K_I = \frac{|KI|}{\gamma_{\maxstep}},$$

$\gamma_{\maxstep}$ being an experimentally determined maximum step coefficient.

45 **9.** The method according to claim 8, **characterized in that** said maximum step coefficient $\gamma_{\maxstep}$ is comprised between 1 and 5.

10. The method according to one or more of claims 1-9, **characterized in that** the calculation of the performance index is performed incrementally in order to limit the memory capacity required to execute the self-calibration procedure.

11. The method according to one or more of claims 1-10, **characterized in that** a time constant of an integral part T_I and a time constant of a derivative part T_D of said proportional-integral-derivative regulator (PID) are kept constant and calibrated starting from an estimated model for the reel speed control loop (RSL).

55 **12.** The method according to one or more of claims 1-11, **characterized in that** the reel speed control loop (RSL) includes a Kalman filter for the estimate of the angular rotation speed of the motor, which is performed starting from the measurement of the angular position.

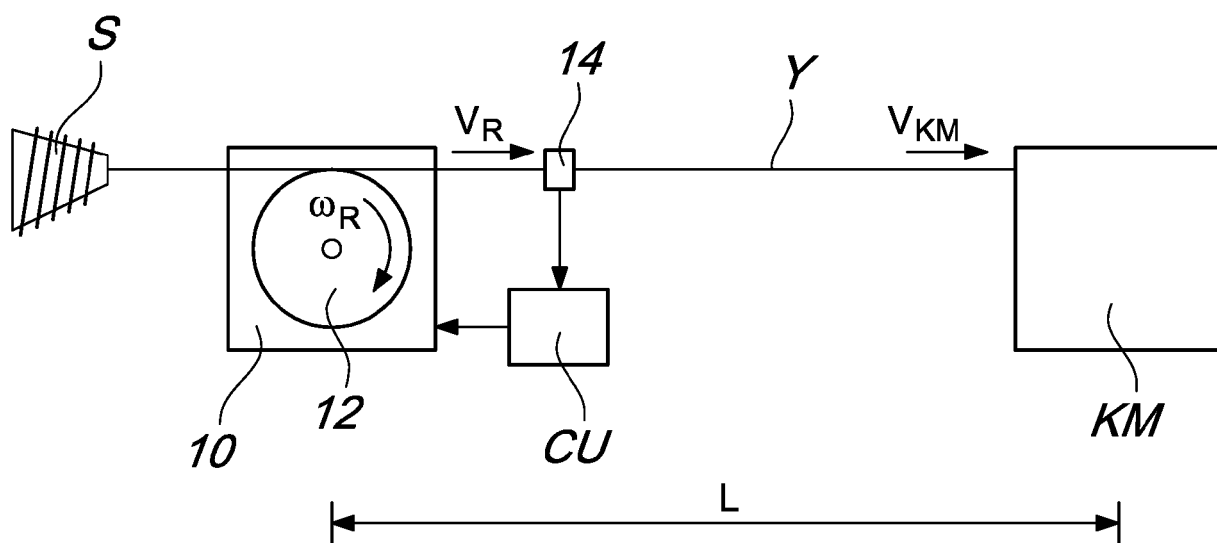


Fig. 1

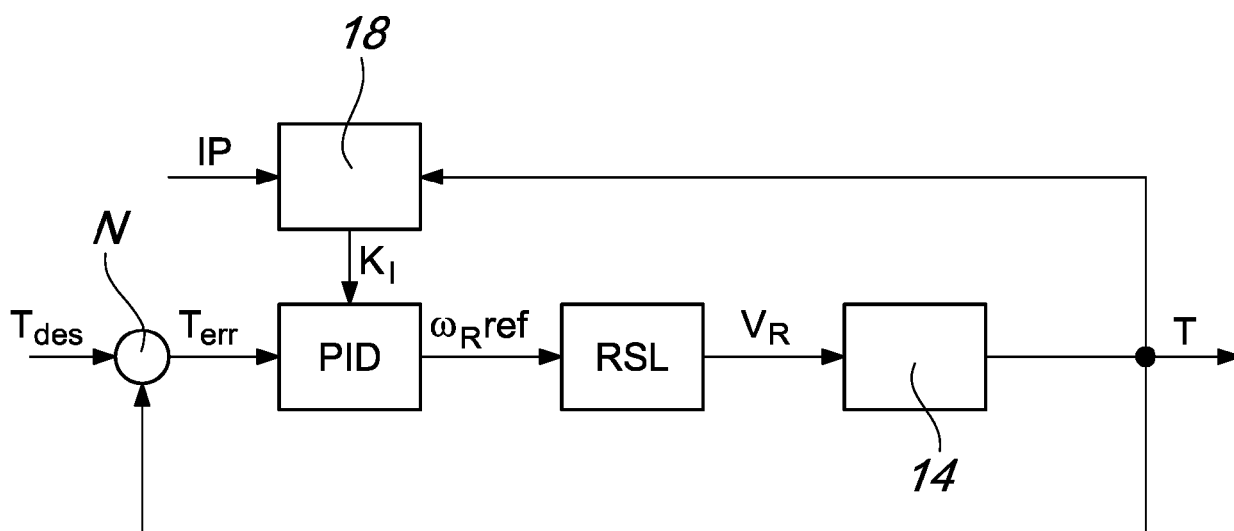


Fig. 2

YTL

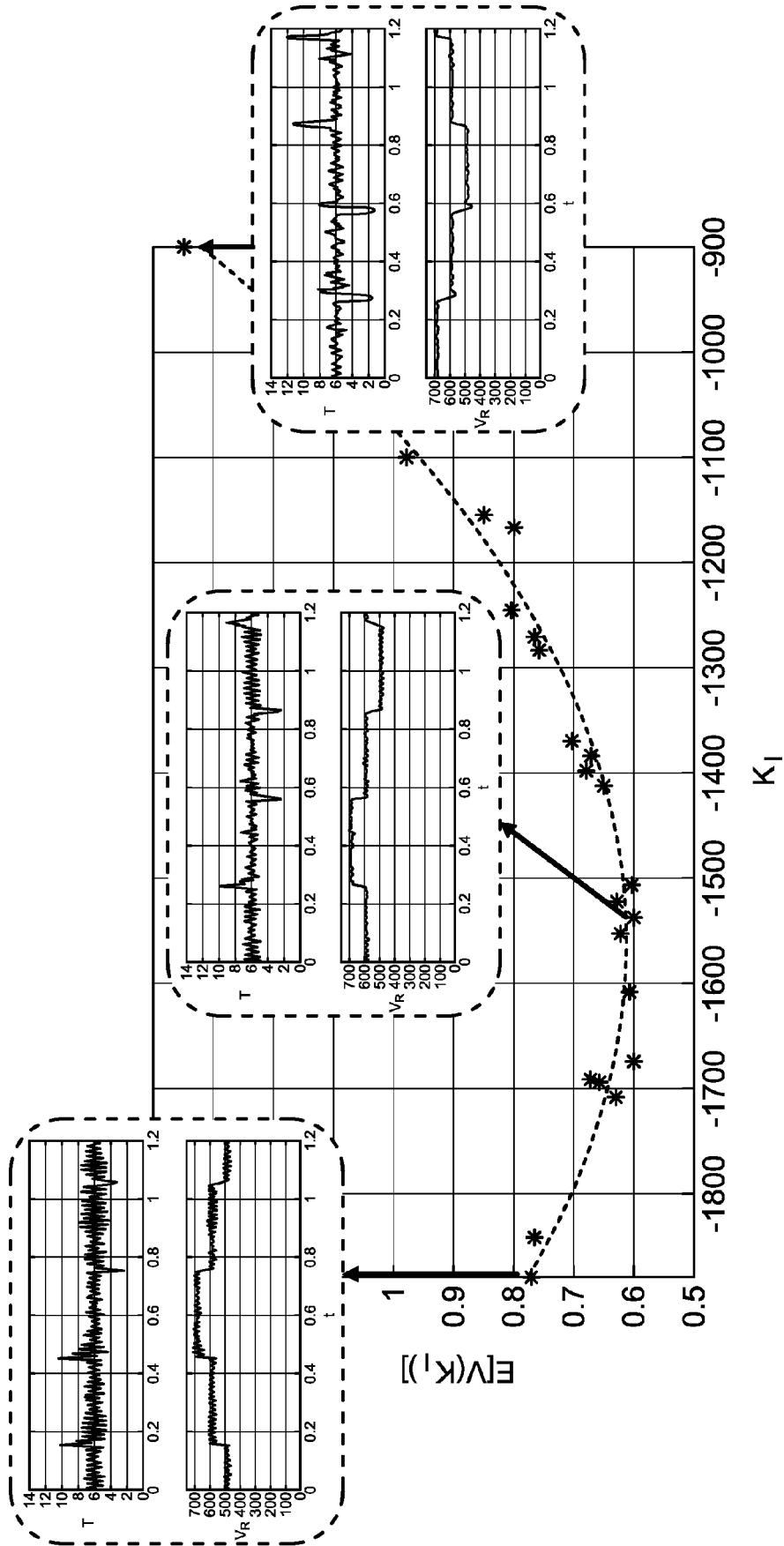
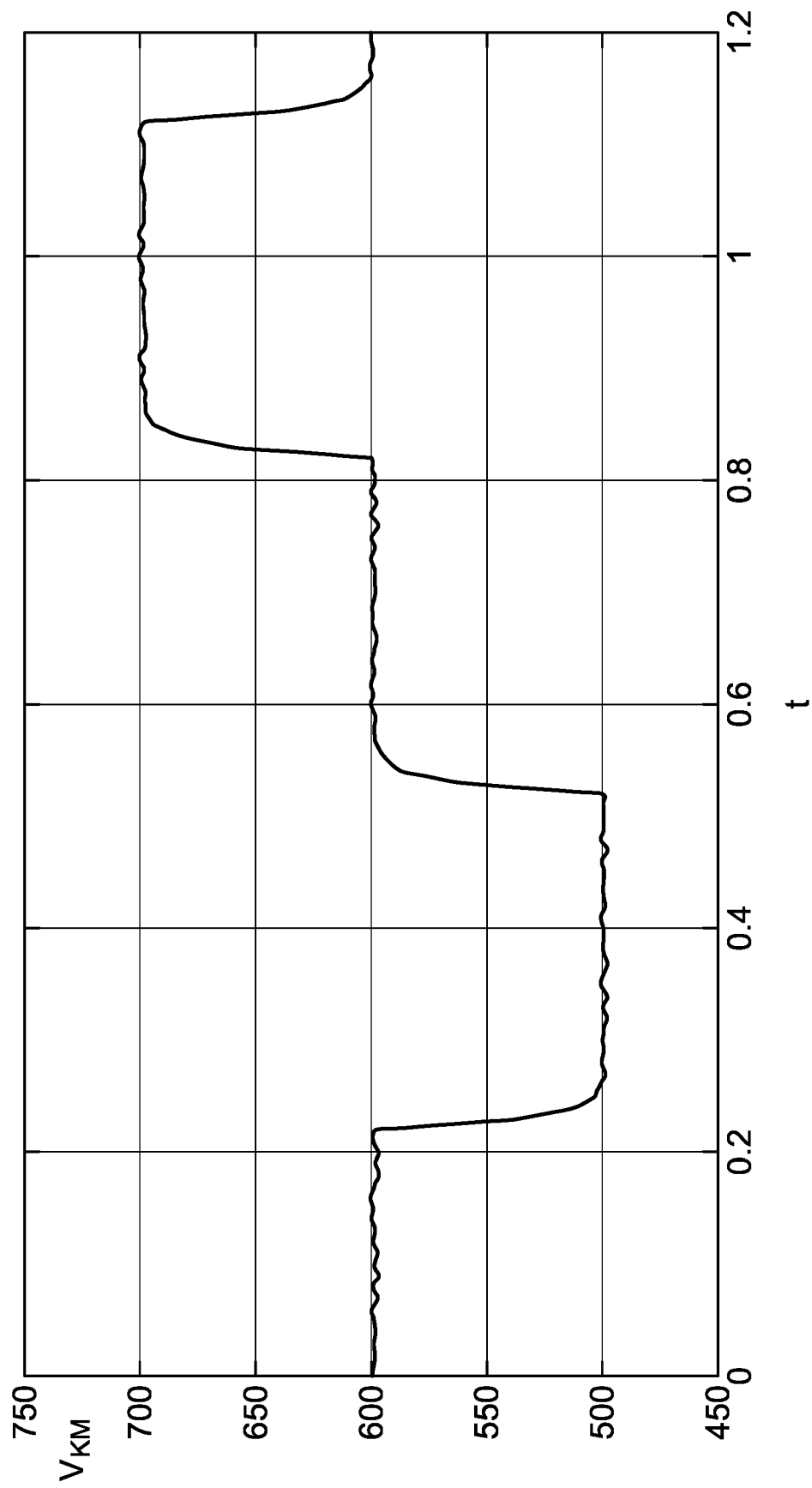


Fig. 3

*Fig. 4*



EUROPEAN SEARCH REPORT

Application Number

EP 22 19 8457

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 079 656 A (SCHMODDE HERMANN [DE] ET AL) 27 June 2000 (2000-06-27)	1-3, 10-12	INV. B65H59/38
Y	* (col.6, 1.31-36; col.6, 1.64 - col.7, 1.10)	4	D04B15/44
A	col.4, 1.57-1.67; figures 1-2 *	5-9	
Y	ZHAO HAI XIA ET AL: "Application of Fuzzy PID Control in Yarn Tension Control System", APPLIED MECHANICS AND MATERIALS, vol. 321-324, 1 June 2013 (2013-06-01), pages 1748-1752, XP055927091, DOI: 10.4028/www.scientific.net/AMM.321-324.1748 * tension control system, B c. Fuzzy reasoning arithmetic; B Design of Fuzzy PID controller; figure 4 *	4	
			TECHNICAL FIELDS SEARCHED (IPC)
			B65H D04B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 January 2023	Examiner Messai, Sonia
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 22 19 8457

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-01-2023

10	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
15	US 6079656 A	27-06-2000	AR 003796 A1	09-09-1998
			AU 7618696 A	30-04-1997
			BR 9610786 A	13-07-1999
			CA 2233647 A1	17-04-1997
			CN 1202940 A	23-12-1998
			CO 4600009 A1	08-05-1998
			CZ 287339 B6	11-10-2000
			DE 19537215 A1	10-04-1997
			EA 199800269 A1	24-12-1998
			EP 0853696 A1	22-07-1998
			ES 2156301 T3	16-06-2001
			GR 3035884 T3	31-08-2001
			HK 1015835 A1	22-10-1999
			IL 123953 A	08-08-2001
			JP H11500499 A	12-01-1999
			KR 19990063971 A	26-07-1999
			TR 199800639 T1	22-06-1998
			TW 421682 B	11-02-2001
			UA 49851 C2	15-10-2002
			US 6079656 A	27-06-2000
			UY 24342 A1	01-11-1996
			WO 9713907 A1	17-04-1997

35				
40				
45				
50				
55				

ORM P0459

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- IT 102021000025076 [0058]