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(54) **METHOD FOR CONTROLLED WINDING OF A TEXTILE PRODUCT ON A TEXTILE MACHINE, AND TEXTILE MACHINE**

(57) Warp yarns (3) are unwound from a supply unit (2) and longitudinally move towards a threads-interlacing area (8) at which a dragging roller (11) rotates to advance the textile product (9) toward a winding reel (15). A winding torque WT applied to the winding reel (15) is modulated by repeated winding adjustment cycles, to keep a target value WFtv of a winding traction force provided on the textile product (9) downstream of the dragging roller (11). Each winding adjustment cycle comprises: acquiring a winding rotation speed of the winding reel (15); acquiring a dragging rotation speed of the dragging roller (11); detecting an instant winding diameter WD of the textile product (9) in the winding reel (15); and applying an instant value of the winding torque WT calculated by the formula: WT = WFtv * WD / 2.

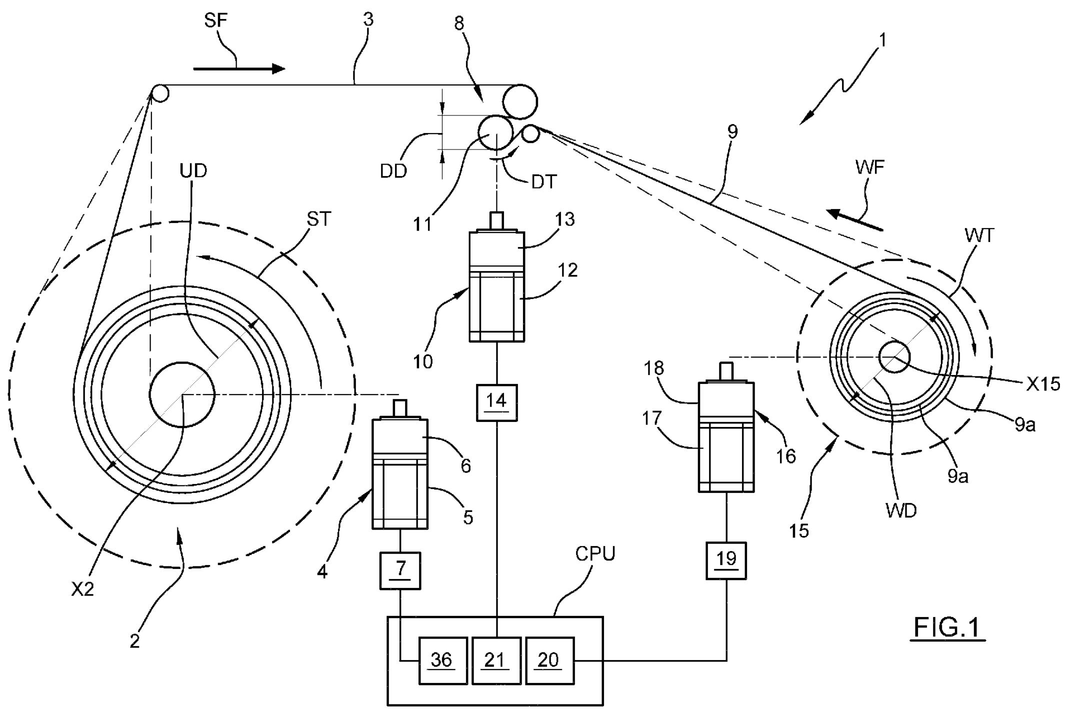


FIG.1

Description

[0001] The present invention relates to a method for controlled winding of a textile product on a textile machine, and a textile machine suitable for implementing such a method.

[0002] The invention can be conveniently applied on weaving machines, such as rapier looms, air-jet looms, water-jet looms, shuttle looms, narrow ribbon weaving machines, etc, as well as on knitting machines etc, to simplify construction and improve the quality of the product by an enhanced control of tensioning in the textile product collected on winding reel.

[0003] In the disclosure of the present invention, "reel" means a spool, reel, beam or other type of cylindrical body carrying threads or textile products wound in coils around a generally cylindrical core. By "electric motor" is meant an electric induction motor, such as a DC motor, AC motor or, preferably, a DC brushless motor.

[0004] Textile machines typically provides one or more supply unit, e.g. a supply reel from which warp threads are delivered towards a threads-interlacing area. At the threads-interlacing area, threads-interlacing devices are caused to form a textile product by interlacing the warp yarns supplied from the supply reel, possibly with insertion of weft yarns and/or other yarns depending on the type of the machine and/or required textile pattern.

[0005] A dragging drive system including a dragging roller operates on the textile product at the threads-interlacing area or immediately downstream thereof, to pull the warp yarns from the supply reels and move the textile product away from the threads-interlacing area. Downstream of the threads-interlacing area, the textile product is collected by winding into superposed coil on a winding reel.

[0006] Tensioning force of the textile product reaching the winding reel is a critical parameter to obtain a good quality in the final product. For example, a poor tensioning force during loose winding may cause wrinkling or other defects in the textile product, as well as a reduced amount of textile product for a given diameter of the reel. Likewise, excessive tensioning could cause overstretching and consequent structural defects and permanent damages on the wound textile product.

[0007] At present, attempts have been made to control the tensioning force by driving rotation of the winding reel by a mechanic transmission of the motion from the dragging drive system. Known arrangements provide a mechanical clutch operating along the mechanic transmission and equipped with an adjustable torque driving system. The adjustable torque driving system adapts the torque applied on the winding reel in order to keep a desired tensioning force along the textile product extending between the dragging roller and the winding reel. Typically, the adjustable torque driving system operates is response to a winding traction force value that is monitored by a dancer roller acting on the textile product between the dragging roller and the winding reel.

[0008] However, the known arrangements as the one disclosed above do not satisfy the increasing need in term of quality and repeatability of result, because the actual tensioning applied to the textile product is subjected to significant variance with respect to the desired value.

[0009] The known arrangements also require installation of sensors and/or mechanisms to detect the tensioning force applied and/or when the winding reel is full and needs for replacement. Indeed, two force sensors are typically required for each side of a roller, along with related electronic equipment, with consequently increased of costs.

[0010] Moreover, the known systems do not allow to easily obtain a reliable monitoring of the instant diameter of the winding reel, where desired, for example to became timely aware about the need for substitution.

[0011] Scope of the present invention is to improve the prior art, in particular by providing a method and an apparatus whereby an accurate control of the tensioning of the textile product leaving the dragging roller is attained.

[0012] A further goal of the invention is to allow an improved control of the tensioning of the warp threads leading to the dragging roller.

[0013] An additional aim of the invention is to allow the above specified accurate controls by a simplified and cheap system, which doesn't necessarily need additional sensors.

[0014] According to the invention, it has been found that an improved tensioning control of the textile product and/or warp threads respectively downstream and upstream of the dragging roller can be achieved by monitoring the rotation speed on the winding reel and/or supply unit with respect to the rotation speed of the dragging roller, and increasing or decreasing the torque applied by a motor on the winding reel and/or the supply unit, in response to variations on the ratio between such rotation speeds.

[0015] More particularly, the invention relates to a method for controlled winding of a textile product on a textile machine, wherein: warp yarns are unwound from a supply unit and longitudinally moved to reach a threads-interlacing area; a textile product including said warp yarns is formed at the threads-interlacing area; a dragging roller having an external diameter engages the textile product near the threads-interlacing area, and rotates at a dragging rotation speed n11 to advance the textile product toward at least one winding reel.

[0016] Preferably, the winding reel rotates on a winding rotation axis to wind the textile product into respectively superposed coils each according to an instant winding diameter WD; a winding torque WT is applied to the winding reel for providing a winding traction force WF on the textile product between the dragging roller and the winding reel.

[0017] The method further comprises: modulating the winding torque WT to keep the winding traction force WF at a desired target value WFtv, wherein modulating the winding torque WT includes repeated winding adjustment cycles, each comprising: acquiring a winding rotation speed n15 of the winding reel; acquiring the dragging rotation speed n11 of the dragging roller; detecting the instant winding diameter WD; and applying an instant value of the winding torque WT calculated by the formula:

$$WT = WFtv * WD / 2.$$

[0018] In a further aspect, the invention relates to a textile machine, comprising at least one supply unit configured for carrying warp yarns; threads-interlacing devices acting at a threads-interlacing area for producing a textile product by the warp yarns supplied from the supply unit; a dragging roller having an external diameter configured to engage the textile product near the threads-interlacing area, and advance it away from the threads-interlacing area; a winding reel configured to receive the textile product advanced by the dragging roller and wind it into respectively superposed coils each according to an instant winding diameter.

[0019] A winding motor is preferably provided. The winding motor is configured for applying a winding torque to the winding reel, whereby a winding traction force is applied to the textile product between the dragging roller and the winding reel.

[0020] A detector acts on the winding reel for detecting the instant winding diameter on the textile product wound on the winding reel. The detector may be conveniently implemented without the need for sensors and related additional hardware. For example, in a preferred embodiment the detector comprises a central processing unit configured to receive an input signal representative of the instant winding diameter and acting on the winding motor for modulating the winding torque as a function of the instant winding diameter, to keep the winding traction force at a predetermined target value.

[0021] It is noted that the rotation speed n11 of the dragging roller is always known, e.g. as given by the input control of the motor of the dragging roller, while the winding rotation speed n15 gradually decreases during the production process. Therefore, the ratio between the rotation speeds n11 / n15 in the algorithm used for determining the instant winding torque value is proportional to instant value of the winding diameter of the textile product on the winding reel. Consequently, any change in the winding diameter, which progressively increases as the textile product is collected on the winding reel during the manufacturing process, causes a corresponding increase in the instant winding torque value applied to the winding reel. Thus, the modulation achieved according to the invention allows an improved control of the winding traction force applied on the textile product at every stage on the production process, irrespective of any change of the winding diameter on the winding reel.

[0022] Notably, torque and rotation speed values on the single dragging roller and winding reel, as well as the supply unit if desired, are directly derivable as input and/or output data from the electronic control unit implementing the respective electric motors. Accordingly, the invention may be implemented without requiring installation of additional sensor systems on the textile machine.

[0023] The winding force control achieved by the invention timely adapt itself to the actual rotation speed n11 of the dragging roller. Thus, the rotation speed n11 of the dragging roller may be freely controlled to change according to any desired textile program or pattern, without affecting the efficiency of the winding force control.

[0024] It is also noted that the winding rotation speed n15 is proportional to the instant winding diameter, as well as a rotation speed n2 of the supply unit is proportional to the instant diameter of the supply unit. Therefore, the invention allows an ease monitoring of the diameter of the winding reel and, if desired, the supply unit, e.g. to provide warning signals for substitution when the winding reel or, if desired, the supply unit are going to be full or empty, respectively, without need for additional sensor devices.

[0025] In at least one preferred embodiment, the invention may also include one or more of the following preferred technical features.

[0026] Preferably, during one or more of said winding adjustment cycles, detection of the instant winding diameter WD is calculated by the formula:

$$WD = DD * n11 / n15.$$

[0027] Preferably, the winding motor is activated by a winding supply current 117 calculated according to the formula:

$$I17 = WT / kT17$$

wherein kT17 represents a current constant of the winding motor.

[0028] As known, the current constant is a motor specific value, typically expressed in Nm/A unit.

[0029] Preferably, the instant value of the winding torque WT is applied to the winding reel through a winding gearbox reducer which connects the winding motor to the winding reel according to a winding transmission ratio i18.

[0030] Preferably, the winding motor is activated by a winding supply current 117 calculated according to the formula:

$$I17 = WT / (kT17 * i18)$$

wherein kT17 represents the current constant of the winding motor.

[0031] The efficiency of the winding gearbox reducer can be introduced as an additional factor in the formula if a greater precision is required. Preferably, reiteration of the winding adjustment cycle occurs at a desired frequency.

[0032] Preferably, said desired frequency is comprised between 1 Hz and 10 Hz. Preferably, said desired frequency is kept constant.

[0033] Preferably, said desired frequency gradually varies during operation of the machine.

[0034] Preferably, at least 1 winding adjustment cycle is achieved for each revolution of the winding reel around the winding rotation axis. If desired, the number of these adjustment cycles may be increased, e.g. up to 5 cycles for each revolution of the winding reel, to calculate a more reliable average value.

[0035] Preferably, a controlled change in the target value WFtv of the winding traction force WF occurs during operation of the textile machine. Preferably, the winding traction force WF gradually decreases as the winding diameter WD grows, or vice-versa.

[0036] According to a different aspect of the invention, the supply unit rotates on an unwind rotation axis to unwind the warp yarns that move towards the threads-interlacing area; a supply torque ST is applied to the supply unit for providing a supply traction force SF on the warp yarns between the dragging roller and the supply unit; and a control of the supply traction force SF is achieved during operation of the textile machine to keep it at a desired target value SFtv.

[0037] Preferably, control of the supply traction force SF is achieved by modulating a supply rotation speed n2 of the supply unit to keep the supply traction force SF at the target value SFtv.

[0038] Preferably, modulating the supply rotation speed n2 includes repeated supply adjustment cycles, each comprising:

acquiring a drag supply current I12 of a drag motor;
calculating a drag torque DT applied to the dragging roller as a function of the drag supply current I12;
calculating an instant value of the supply traction force SF by the formula:

$$SF = DT * 2 / DD$$

comparing the instant value of the supply traction force SF with the target value SFtv;
increasing the supply rotation speed n2 when SF > SFtv;
decreasing the supply rotation speed n2 when SF < SFtv.

[0039] For a greater precision, the formula used for calculating the instant value of the supply traction force SF may be modified to take into consideration the winding traction force WF as follows:

$$SF = DT * 2 / DD + WF$$

[0040] However, WF may be ignored in practice since it is typically much lower than SF.

[0041] Preferably, the drag torque DT is calculated by the formula:

$$DT = I12 * kT2$$

wherein kT2 represents a current constant of the drag motor.

[0042] Preferably, the drag torque DT is applied to the dragging roller through a drag gearbox reducer which connects the drag motor to the dragging roller according to a drag transmission ratio i13.

[0043] Preferably, the drag torque DT is calculated by the formula:

$$DT = I12 * kT2 * i13$$

wherein kT2 represents the current constant of the drag motor.

[0044] The efficiency of the drag gearbox reducer can be introduced as an additional factor in the formula if a greater precision is required. Preferably, control of the supply traction force SF is achieved by modulating the supply torque ST to keep the supply traction force SF at a desired target value SFtv.

[0045] Preferably, modulating the supply torque ST includes repeated supply adjustment cycles, each comprising:

acquiring a supply rotation speed n2 of the supply unit;
acquiring the dragging rotation speed n11 of the dragging roller; and
applying to the supply unit a supply torque target value STtv calculated by the formula:

$$STtv = SFtv \times UD/2$$

[0046] Wherein UD represents an instant unwinding diameter UD on the supply unit.

[0047] Preferably, the central processing unit is configured to calculate an instant unwinding diameter UD on the supply unit basing on a supply rotation speed n2 of the supply unit and a dragging rotation speed n11 of the dragging roller, according to the formula:

$$UD = DD * n11 / n2.$$

[0048] Preferably, modulating the supply torque ST includes repeated supply adjustment cycles, each comprising:

acquiring a supply rotation speed n2 of the supply unit;
acquiring the dragging rotation speed n11 of the dragging roller; and
applying to the supply unit a supply torque target value STtv calculated by the formula:

$$STtv = SFtv * 0,5 * DD * n11 / n2.$$

[0049] Preferably, reiteration of the supply adjustment cycle occurs at a desired frequency.

[0050] Preferably, said desired frequency for the supply adjustment cycle is comprised between 1 Hz and 10 Hz.

[0051] Preferably, said desired frequency is kept constant.

[0052] Preferably, said desired frequency gradually varies during operation of the textile machine.

[0053] Preferably, at least 1 supply adjustment cycle is achieved for each revolution of the supply unit around the unwind rotation axis.

[0054] If desired, the number of these adjustment cycles may be increased, e.g. up to 5 cycles for each revolution of the supply unit, to calculate a more reliable average value.

[0055] Preferably, a controlled change in the target value SFtv of the supply traction force SF occurs during operation of the textile machine. Preferably, the detector includes a winding electronic control unit equipping the winding motor and configured for detecting a rotation speed n17 of the winding motor.

[0056] Preferably, provision is made of a winding gearbox reducer operating between the winding motor and the winding reel, and a winding controller configured for receiving the rotation speed n17 detected by the winding electronic control unit and calculating a winding rotation speed n15 of the winding reel basing on a transmission ratio i18 of the winding gearbox reducer according to the formula $n15 = n17 * i18$

[0057] Preferably, provision is made of a drag electronic control unit equipping a drag motor of the dragging roller and configured for detecting a rotation speed n12 of the drag motor.

[0058] Preferably, provision is made of a drag gearbox reducer operating between the drag motor and the dragging roller, and a drag controller configured for receiving the rotation speed n12 detected by the drag electronic control unit and calculating a dragging rotation speed of the dragging roller basing on a transmission ratio i13 of the drag gearbox reducer according to the formula $n11 = n12 * i13$

[0059] Preferably, the central processing unit is configured to calculate the instant winding diameter WD basing on a winding rotation speed n15 of the winding reel and a dragging rotation speed n11 of the dragging roller, according to the formula

$$WD = DD * n11 / n15.$$

[0060] According to a further different aspect, provision is preferably made of an unwinding drive unit configured for applying a supply torque opposing rotation of the supply unit around an unwind rotation axis, whereby a supply traction force is SF is provided on the warp yarns between the dragging roller and the supply unit.

[0061] Preferably, provision is made of a drag electronic control unit equipping a drag motor of the dragging roller and configured for acquiring a drag supply current I12 of the drag motor.

[0062] Preferably, provision is made of a drag controller configured for calculating a drag torque DT applied to the dragging roller as a function of the drag supply current I12.

[0063] Preferably, said central processing unit is further configured for calculating the supply traction force SF by the formula:

$$SF = DT * 2 / DD + WF.$$

[0064] Preferably, provision is made of a comparator configured for comparing the supply traction force SF with the target value SFtv.

[0065] Preferably, the central processing unit is further configured for:

increasing the supply rotation speed n2 when $SF > SFtv$;
decreasing the supply rotation speed n2 when $SF < SFtv$

[0066] Preferably, provision is made of a drag controller configured for receiving the drag supply current I12 detected by the drag electronic control unit and calculating the drag torque DT according to the formula:

$$T2 = I12 * kT12.$$

wherein kT12 represents the current constant of the drag motor.

[0067] Preferably, provision is made of a drag gearbox reducer operating between the drag motor and the dragging roller, and a drag controller configured for receiving the drag supply current I12 detected by the drag electronic control unit and calculating the drag torque DT basing on a transmission ratio i13 of the drag gearbox reducer according to the formula:

$$T2 = I12 * kT12 / i13.$$

wherein kT12 represents the current constant of the drag motor.

[0068] According to a further different aspect, provision is preferably made of:

an unwind electronic control unit equipping an unwind motor of the supply unit and configured for acquiring a supply rotation speed n2 of the supply unit;
a drag electronic control unit equipping the drag motor and configured for acquiring a dragging rotation speed n11 of the dragging roller 11;
wherein said central processing unit is configured for receiving input signals representative of said supply rotation speed n2 and dragging rotation speed n11, and applying to the supply unit 2 a supply torque target value STtv calculated by the formula:

$$STtv = SFtv \times UD/2$$

wherein UD represents an instant unwinding diameter on the supply unit.

[0069] Preferably, the central processing unit is configured to calculate an instant unwinding diameter UD on the supply unit basing on a supply rotation speed n2 of the supply unit and a dragging rotation speed n11 of the dragging roller, according to the formula

$$UD = DD * n11 / n2.$$

[0070] Preferably, modulating the supply torque ST includes repeated supply adjustment cycles, each comprising:

acquiring a supply rotation speed n2 of the supply unit;
acquiring the dragging rotation speed n11 of the dragging roller 11; and
applying to the supply unit a supply torque target value STtv calculated by the formula:

$$STtv = SFtv * 0{,}5 * DD * n11 / n2.$$

[0071] Preferably, the unwind motor is configured for applying a supply torque ST to the supply unit, whereby a supply traction force SF is applied to the warp yarns between the supply unit and the dragging roller.

[0072] Preferably, provision is made of an unwind electronic control unit equipping the unwind motor and configured for detecting a rotation speed n5 of the unwind motor.

[0073] Preferably, provision is made of an unwind gearbox reducer operating between the unwind motor and the supply unit, and an unwinding controller configured for receiving the rotation speed n5 detected by the unwind electronic control unit and calculating a supply rotation speed n2 of the supply unit 2 basing on a transmission ratio i6 of the unwind gearbox reducer according to the formula $n2 = n5 * i6$

[0074] Additional features and advantages will be clearer from the detailed description of a preferred but not exclusive embodiment of a method for controlled winding of a textile product on a textile machine, and a textile machine suitable for implementing such a method, in accordance with the present invention. Such description will be set forth hereinbelow with reference to the set of drawings, provided only as a non-limiting example, wherein:

- figure 1 schematically shows a side elevation sectional view of an exemplary textile machine equipped with a control system for implementing the method according to the present invention;
- figure 2 is an operation logic flowchart of the textile machine implementing the winding control method according to the invention;
- figure 3 is an operation logic flowchart of the textile machine implementing a supply traction force control upstream of dragging drive system in the textile machine.

[0075] In figure 1, a textile machine is generally indicated by reference 1. The textile machine 1 may be, for example, a rapier loom, air-jet loom, water-jet loom, shuttle loom, a narrow ribbon weaving machines, a knitting machine or other type of textile machine 1.

[0076] The textile machine1 comprises at least one supply unit 2, for example in the form of at least one supply reel or roller. A plurality of warp yarns 3 is unwound from the supply unit 2 as the supply unit 2 rotates around a respective unwind rotation axis X2, upon action of an unwinding drive unit 4. In an alternative possible solution not shown in the drawings, the supply unit 2 rotating upon control by the unwinding drive unit 4, may be configured to unwind the warp yarns 3 from respective spools carried by one or more creels.

[0077] The unwinding drive unit 4 comprises a unwind motor 5, preferably connected to the supply unit 2 through an unwind gearbox reducer 6. The unwind motor 5 is conveniently governed by an unwind electronic control unit 7, which is capable to control the rotation speed, supply current, and/or other operational parameters of the unwind motor 5. More particularly, a brushless-type motor equipped with the unwind electronic 7 control unit can be conveniently used as unwind motor 5.

[0078] The warp yarns 3 drawn from the supply unit 2 are longitudinally moved to reach a threads-interlacing area 8 (e.g. a weaving area or knitting area), wherein threads-interlacing devices (not shown) operates for producing a textile product 9 from the warp yarns 3 supplied by the supply unit 2. To this aim, the warp yarns 3 may be linked each other and/or with one or more weft yarns, and/or other additional yarns, in any known manner which is herein not disclosed as not forming part of the present invention. The threads-interlacing devices typically may include or consists of thread guiding elements cooperating with oscillating members: they are not shown as well in the drawings, as they may be realized in many different knows manners depending on the needs.

[0079] A dragging unit 10 engages the textile product 9 near the threads-interlacing area 8, i.e. at the threads-interlacing area 8 or immediately downstream of it. The dragging unit 10 comprises a dragging roller 11 acting on the textile product 9 to advance it away from the threads-interlacing area 8. The dragging roller 11 also produces a pulling action on the warp yarns 3 coming from the supply unit 2. In figure 1, DD indicates a dragging diameter defined by the dragging roller 11, at an external surface thereof acting on the textile product 9. A drag motor 12 is connected to the dragging roller 11 preferably through a drag gearbox reducer 13, to rotate the dragging roller 11 at controlled angular speed and torque. The drag motor 12 is conveniently governed by a respective drag electronic control unit 14 which is capable to control the rotation speed, supply current, and/or other operational parameters of the drag motor 12. A brushless-type motor equipped with the drag electronic control unit 14 can be conveniently used as drag motor 12.

[0080] The textile product 9 moving from the threads-interlacing area 8 is advanced towards a winding reel 15 configured to receive the textile product 9.

[0081] A winding unit 16 operates on the winding reel 15 to rotate the winding reel 15 around a winding rotation axis X15. The winding unit 16 also applies a winding torque WT to the winding reel 15, whereby a winding traction force WF is applied to the textile product 9, along a stretch thereof extending between the dragging unit 10 and the winding reel 15.

[0082] The winding unit 16 comprises a winding motor 17 preferably connected to the winding reel 15 through a winding gearbox reducer 18. The winding motor 17 is conveniently governed by a winding electronic control unit 19, which is capable to control the rotation speed, supply current, and/or other operational parameters of the winding motor 17. More particularly, a brushless-type motor equipped with the winding electronic control unit 19 can be conveniently used as winding motor 17.

[0083] Rotation of the winding reel 15 causes the textile product 9 to be wound into respectively superposed coils 9a, each according to a winding diameter WD, around the winding rotation axis X15. The thickness of the textile product 9 causes the winding diameter WD being different for each coil 9a. Indeed, the winding diameter WD progressively grows as soon as each coil 9a is formed around the winding rotation axis X15 of the winding reel 15.

[0084] Any change in the winding diameter WD would affect the value of the winding traction force WF, if the winding torque WT applied by the winding unit 16 on the winding reel 15 were kept constant. However, the invention provides for gradually modulating, i.e. adjusting, the winding torque WT while the textile product 9 is formed and wound on the winding reel 15, to keep the winding traction force WF at a desired target value WFtv. The desired target value WFtv of the winding traction force WF may be conveniently set by the user, or selected by a stored library, or provided by a job program. If desired, the target value WFtv of the winding traction force WF may be changed according to the established job program during prosecution of the job, for example being increased and/or reduced along with gradual growing of the winding diameter WD.

[0085] At least one detector 19, 20 acts on the winding reel 15 for detecting the instant winding diameter WD, or a representative parameter thereof, on the textile product 9 wound on the winding reel 15 at any moment in time. In a preferred embodiment, such detector includes the winding electronic control unit 19 equipping the winding motor 17. Indeed, as it usually occurs in control systems of brushless motors, the winding electronic control unit 19 is capable of detecting at any moment a rotation speed n17 of the winding motor 17, i.e. of a rotor thereof. The rotation speed n17 is received as an input signal by a winding controller 20, to calculate a winding rotation speed n15 of the winding reel 15 basing on the value of a winding transmission ratio i18 of the winding gearbox reducer 18 according to the formula:

$$n15 = n17 * i18.$$

[0086] The winding controller 20 may be embedded within the winding electronic control unit 19 or separated therefrom, for example as a part of a central processing unit CPU overseeing the operation of the entire textile machine 1 or a relevant part thereof as shown in figure 1.

[0087] In a similar way, the drag electronic control unit 14 is capable of detecting at any moment a rotation speed n12 of the drag motor 12, i.e. a rotor thereof. The rotation speed n12 is received as an input signal by a drag controller 21, e.g embedded within the drag electronic control unit 14 or separated therefrom, for example as a part of the central processing unit CPU, to calculate a dragging rotation speed n11 of the dragging roller 11 basing on the value of a drag transmission ratio i13 of the respective drag gearbox reducer 13 by the formula $n11 = n12 * i13$

[0088] The drag controller 21 may be embedded within the drag electronic control unit 14 or separated therefrom, for example as a part of the central processing unit CPU.

[0089] With particular reference to figure 2 modulation, i.e. adjustment, of the winding traction force WF is obtained according to the following method. Such a method may be achieved by the central processing unit CPU or other parts of the textile machine 1 which may be programmed or configured to control winding of the textile product 9 as follows.

[0090] At the start of the textile machine 1 (diagram block 22), the target value WFtv of the winding traction force WF is set (diagram block 23), e.g by the user through an input interface, or by selection from a stored menu. Such a selection may be a part of a stored job program.

[0091] As derivable from diagram block 24 in figure 2, the winding rotation speed n15 (diagram sub-block 24a) and the dragging rotation speed n11 (diagram sub-block 24b) are acquired, e.g. derived as above disclosed, from the data detected by the winding electronic control unit 19 and drag electronic control unit 14, respectively.

[0092] Basing of the acquired values of the speeds n11 and n15, the instant winding diameter WD is also detected (diagram block 25). More particularly, the instant winding diameter WD is conveniently calculated by the formula:

$$WD = DD * n11 / n15.$$

[0093] Indeed, since no significant slipping/stretching of the textile product 9 occurs on the external surfaces of the dragging roller 11 and winding reel 15, the ratio between the diameters WD / DD equals the ratio between the rotation speeds n11 / n15.

[0094] Basing on the detected value of the instant winding diameter WD, an instant value of the winding torque WT, suitable to achieve the previously set target value of the winding traction force WFtv, is then calculated (block diagram 26). More particularly, the instant value of the winding torque WT value is calculated by the formula:

$$WT = \underline{\underline{WFtv}} * WD / 2$$

[0095] The obtained instant value of the winding torque WT is then applied to the winding reel 15 through the winding motor 17 and respective winding gearbox reducer 18 (diagram block 27). For example, achievement of the desired instant value of the winding torque WT may be obtained by activating the winding motor 17, upon command of the winding electronic control unit 19, by a winding supply current I17 calculated according to the formula:

$$I17 = WT / (kT17 * i18)$$

wherein kT17 represents the current constant, i.e. a specific (nearly) constant value of the winding motor 17.

[0096] The above-described winding adjustment cycle is repeated during operation of the textile machine 1, so that the instant value of the winding torque WT may be timely updated during the gradual growing of the winding diameter WD to keep the desired target value WFtv of the winding traction force WF.

[0097] Reiteration of the winding adjustment cycle may occur at a desired frequency, preferable comprised between 1 Hz and 10 Hz. The frequency may be kept constant or gradually vary during operation of the machine, for example to achieve a fixed number, preferably at least 1 winding adjustment cycle for each revolution achieved by the winding reel 15 around the winding rotation axis X15.

[0098] If desired, any controlled change in the target value WFtv of the winding traction force WF may also be achieved during operation of the textile machine 1, e.g. according to a pre-established job program. For example, depending on the production specifications, a greater winding traction force WF may be set for the first coils 9a on the winding reel 15, when the winding diameter WD is relatively small, to gradually decrease the winding traction force WF as the winding diameter WD grows, or vice-versa. During operation of the textile machine 1, the supply unit 2 rotates upon the unwind rotation axis X2 to unwind the warp yarns 3 that move towards the threads-interlacing area 8.

[0099] The unwind motor 5 and unwind gearbox reducer 6 apply a supply torque ST to the supply unit 2. Preferably, the supply torque ST opposes rotation the supply unit 2 undergoes upon the action exerted by the dragging unit 10 on the warp yarns 3, although without preventing rotation required for unwinding the warp yarns 3. Thus, a supply traction force SF is maintained along the warp yarns 3 extending between the supply unit 2 and the dragging roller 11.

[0100] An efficient control of the supply traction force SF is critical for the correct execution of the mutual interlinking of the warp yarns 3 each other and/or with the weft yarns and/or other yarns at the threads-interlacing area 8.

[0101] At least when the supply unit 2 is in the form of a reel carrying the warp yarns 3 wound around the unwind rotation axis X2, rotation of the supply unit 2 causes the external diameter thereof, hereinafter also referred as unwinding diameter UD, to gradually decrease as the warp yarns 3 are unwound from the unwinding reel 15. Therefore, the supply traction force SF would gradually increase in response to a progressive reduction of the unwinding diameter UD during operation of the textile machine 1, if the supply torque ST were kept constant. However, according to a different and independent aspect of the invention, a positive control of the supply traction force SF is preferably achieved to keep this latter at a desired target value SFtv.

[0102] As shown in figure 3, the desired target value SFtv of the supply traction force SF may be conveniently set by in the user (see diagram block 28 in figure 3) or provided by a job program, at or just after start 22 of the textile machine 1. If desired, the target value SFtv of the supply traction force SF may be changed according to a pre-established program during operation of the textile machine 1, for example being increased and/or reduced along with prosecution of the job in response to changes in the weaving pattern executed in the threads-interlacing area 8. Indeed, for example, a pre-established weaving pattern may include a production stage wherein, e.g. due to insertion of additional yarns in the threads-interlacing area 8or for other reasons, the supply traction force SF is required to be greater or lower than a previous or subsequent production stage, for optimization of the result.

[0103] In a preferred embodiment, control of the supply traction force SF is achieved by modulating a supply rotation speed n2 of the supply unit 2 to keep the supply traction force SF at the target value SFtv. Indeed, the central processing unit CPU may be configured for achieving repeated supply adjustment cycles, each comprising calculating the instant value of the supply traction force SF basing on a drag torque DT applied to the dragging roller 11. The drag torque DT may be calculated by the drag controller 21 as a function of a drag supply current I12 of the drag motor 12. The drag supply current I12 may be acquired by the drag electronic control unit 14 (diagram block 29). Then (diagram block 30), the drag torque DT may be calculated by the formula:

$$DT = I12 * kT12 * i13$$

wherein kT12 represents the current constant of the drag motor 12.

[0104] Preferably, the instant value of the supply traction force SF is then calculated (diagram block 31) according the formula

$$SF = DT * 2 / DD + WF$$

which also considers the effect of the winding traction force WF applied to the textile product 9.

[0105] A comparator (not shown), e.g. embedded within the central processing unit CPU or separated therefrom, may be provided for comparing the instant value of the supply traction force SF with the target value SFtv thereof. If the instant value of the supply traction force SF equals the target value SFtv (diagram block 32), a new supply adjustment cycle is achieved.

[0106] Otherwise (diagram block 33), the comparator determines if the instant supply traction force SF is smaller than the target value SFtv In the affirmative the central processing unit CPU drives the unwind motor 5 to increase the supply rotation speed n2 (diagram block 34). Otherwise, the supply rotation speed n2 is decreased (diagram block 35).

[0107] Increasing and decreasing the rotation speed n2 causes a corresponding decreasing and increasing, respectively, of the supply traction force SF toward the target value SFtv

[0108] Any adjustment in the supply rotation speed n2 triggers a new supply adjustment cycle as shown in figure 3. Reiteration of the supply adjustment cycle may occur at a desired frequency, preferably comprised between 1 Hz and 10 Hz. The frequency may be kept constant or gradually vary during operation of the machine, for example to achieve a pre-determined number, preferably at least 1 supply adjustment cycle for each revolution achieved by the supply unit 2 around the unwind rotation axis X2.

[0109] In a possible alternative embodiment, control of the supply traction force SF may be achieved by modulating the supply torque ST, instead of the supply rotation speed n2, to keep the supply traction force SF at the desired target value SFtv. In this case, each supply adjustment cycle will include acquiring the dragging rotation speed n11 of the dragging roller 11 and acquiring the supply rotation speed n2 of the supply unit 2. These acquiring steps may be respectively achieved by the drag controller 21, and by an unwinding controller 36. The unwinding controller 36 receives a rotation speed n5 of the unwind motor 5, i.e. of a rotor thereof, as an input signals, and may be configured for calculating the supply rotation speed n2 of the supply unit 2 basing on a transmission ratio i6 of the unwind gearbox reducer 6 according to the formula:

$$n2 = n5 * i6.$$

[0110] The unwinding controller 36 may be embedded within the unwind electronic control unit 7 or separated therefrom, for example as a part of the central processing unit CPU. The central processing unit CPU may be configured to receive input signals representative of the acquired values, and to command the unwind motor 5 for applying to the supply unit 2 a target torque value STtv calculated by the formula:

$$STtv = SFtv * 0{,}5 * DD * n11 / n2.$$

[0111] As additional or alternative measure, the central processing unit CPU may be configured to calculate an instant unwinding diameter UD on the supply unit 2 basing on the supply rotation speed n2 and the dragging rotation speed n11 of the dragging roller 11, according to the formula

$$UD = DD * n11 / n2.$$

[0112] The target torque value STtv may be accordingly calculated by the formula:

$$STtv = SFtv \times UD/2.$$

Claims

1. Method for controlled winding of a textile product (9) on a textile machine, wherein:

 warp yarns (3) are unwound from a supply unit

(2) and longitudinally moved to reach a threads-interlacing area (8);
a textile product (9) including said warp yarns (3) is formed at the threads-interlacing area (8);
a dragging roller (11) having an external diameter DD engages the textile product (9) near the threads-interlacing area (8), and rotates at a dragging rotation speed n11 to advance the textile product (9) toward at least one winding reel (15);
the winding reel (15) rotates on a winding rotation axis (X15) to wind the textile product (9) into respectively superposed coils (9a) each according to an instant winding diameter WD;
a winding torque WT is applied to the winding reel (15) for providing a winding traction force WF on the textile product (9) between the dragging roller (11) and the winding reel (15);
the method further comprising:

modulating the winding torque WT to keep the winding traction force WF at a desired target value WFtv,
wherein modulating the winding torque WT includes repeated winding adjustment cycles, each comprising:

acquiring a winding rotation speed n15 of the winding reel (15);
acquiring the dragging rotation speed n11 of the dragging roller (11);
detecting the instant winding diameter WD; and
applying an instant value of the winding torque WT calculated by the formula:

$$WT = WFtv * WD / 2.$$

2. Method according to claim 2, wherein during one or more of said winding adjustment cycles, detection of the instant winding diameter WD is made by calculating the instant winding diameter WD by the formula:

$$WD = DD * n11 / n15.$$

3. Method according to claim 1 or 2, wherein reiteration of the winding adjustment cycle occurs at a frequency comprised between 1 Hz and 10 Hz.

4. Method according to one or more of the preceding claims, wherein at least 1 winding adjustment cycle is achieved for each revolution of the winding reel (15) around the winding rotation axis (X15).

5. Method according to one or more of the preceding claims, wherein a controlled change in the target value WFtv of the winding traction force WF occurs during operation of the textile machine (1).

6. Method according to one or more of the preceding claims, wherein the winding traction force WF gradually decreases as the winding diameter WD grows, or vice-versa.

7. Method according to one or more of the preceding claims, wherein:

the supply unit (2) rotates on an unwind rotation axis (X2) to unwind the warp yarns (3) that move towards the threads-interlacing area (8);
a supply torque ST is applied to the supply unit (2) for providing a supply traction force SF on the warp yarns (3) between the dragging roller (11) and the supply unit (2); and
a control of the supply traction force SF is achieved during operation of the textile machine (1) to keep it at a desired target value SFtv.

8. Method according to claim 7, wherein control of the supply traction force SF is achieved by modulating a supply rotation speed n2 of the supply unit (2) to keep the supply traction force SF at the target value SFtv.

9. Method according to claim 8, wherein modulating the supply rotation speed n2 includes repeated supply adjustment cycles, each comprising:

acquiring a drag supply current I12 of the drag motor (12);
calculating a drag torque DT applied to the dragging roller (11) as a function of the drag supply current I12;
calculating an instant value of the supply traction force SF by the formula:

$$SF = DT * 2 / DD;$$

comparing the instant value of the supply traction force SF with the target value SFtv;
increasing the supply rotation speed n2 when SF > SFtv;
decreasing the supply rotation speed n2 when SF < SFtv.

10. Method according to one or more of claims 7 to 9, wherein a controlled change in the target value SFtv of the supply traction force SF occurs during operation of the textile machine (1).

11. Textile machine, comprising

at least one supply unit (2) configured for carrying warp yarns (3);
threads-interlacing devices acting at a threads-interlacing area (8) for producing a textile product (9) by the warp yarns (3) supplied from the supply unit (2);
a dragging roller (11) having an external diameter DD configured to engage the textile product (9) near the threads-interlacing area (8), and advance it away from the threads-interlacing area (8);
a winding reel (15) configured to receive the textile product (9) advanced by the dragging roller (11) and wind it into respectively superposed coils (9a) each according to an instant winding diameter WD;
a winding motor (17) configured for applying a winding torque WT to the winding reel (15), whereby a winding traction force WF is applied to the textile product (9) between the dragging roller (11) and the winding reel (15);
a detector acting on the winding reel (15) for detecting the instant winding diameter WD on the textile product (9) wound on the winding reel (15);
wherein the detector comprises a central processing unit (CPU) configured to receive an input signal representative of the instant winding diameter WD and acting on the winding motor (17) for modulating the winding torque WT as a function of the instant winding diameter WD, to keep the winding traction force WF at a predetermined target value WFtv.

12. Textile machine according to claim 11, wherein the central processing unit (CPU) is configured to calculate the instant winding diameter WD basing on a winding rotation speed n15 of the winding reel (15) and a dragging rotation speed n11 of the dragging roller (11), according to the formula:

$$WD = DD * n11 / n15.$$

13. Textile machine according to claim 11 or 12, further comprising an unwinding drive unit (4) configured for applying a supply torque opposing rotation of the supply unit (2) around an unwind rotation axis (X2), whereby a supply traction force is SF is provided on the warp yarns (3) between the dragging roller (11) and the supply unit (2).

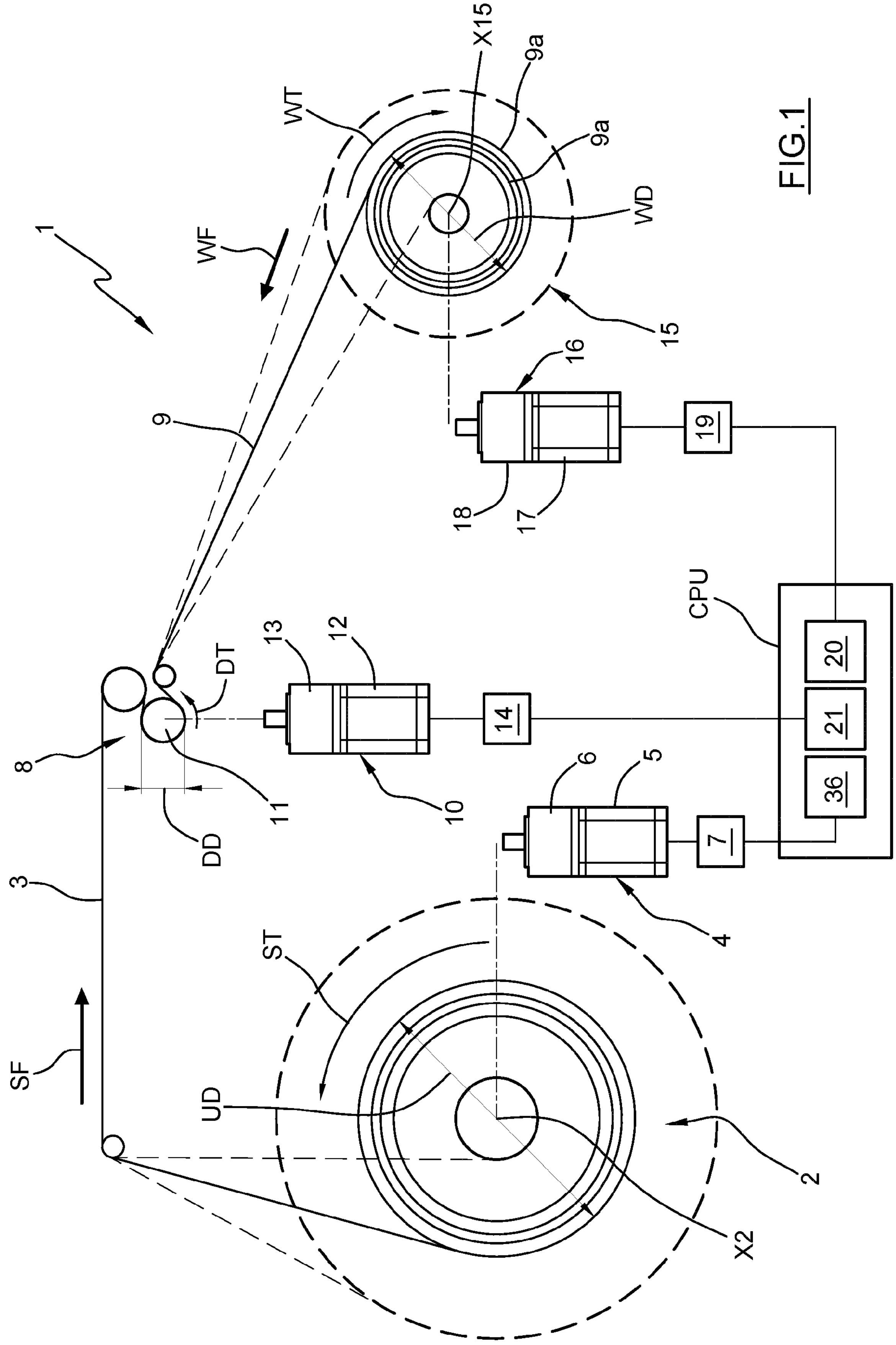
14. Textile machine according to claim 13, further comprising:

a drag electronic control unit (14) equipping a drag motor (12) of the dragging roller (11) and configured for acquiring a drag supply current I12 of the drag motor (12);
a drag controller (21) configured for calculating a drag torque DT applied to the dragging roller (11) as a function of the drag supply current I12;
wherein said central processing unit (CPU) is further configured for calculating the supply traction force SF by the formula:

$$SF = DT * 2 / DD.$$

15. Textile machine according to claim 13 or 14, further comprising a comparator configured for comparing the supply traction force SF with a target value SFtv of the supply traction force SF, wherein the central processing unit (CPU) is further configured for:

increasing the supply rotation speed n2 when SF > SFtv;
decreasing the supply rotation speed n2 when SF < SFtv.


1
WF
9
9a
9a
X15
WT
WD
15
16
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CPU
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21
36
14
13
12
10
DT
8
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DD
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SF
ST
UD
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X2
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FIG.1

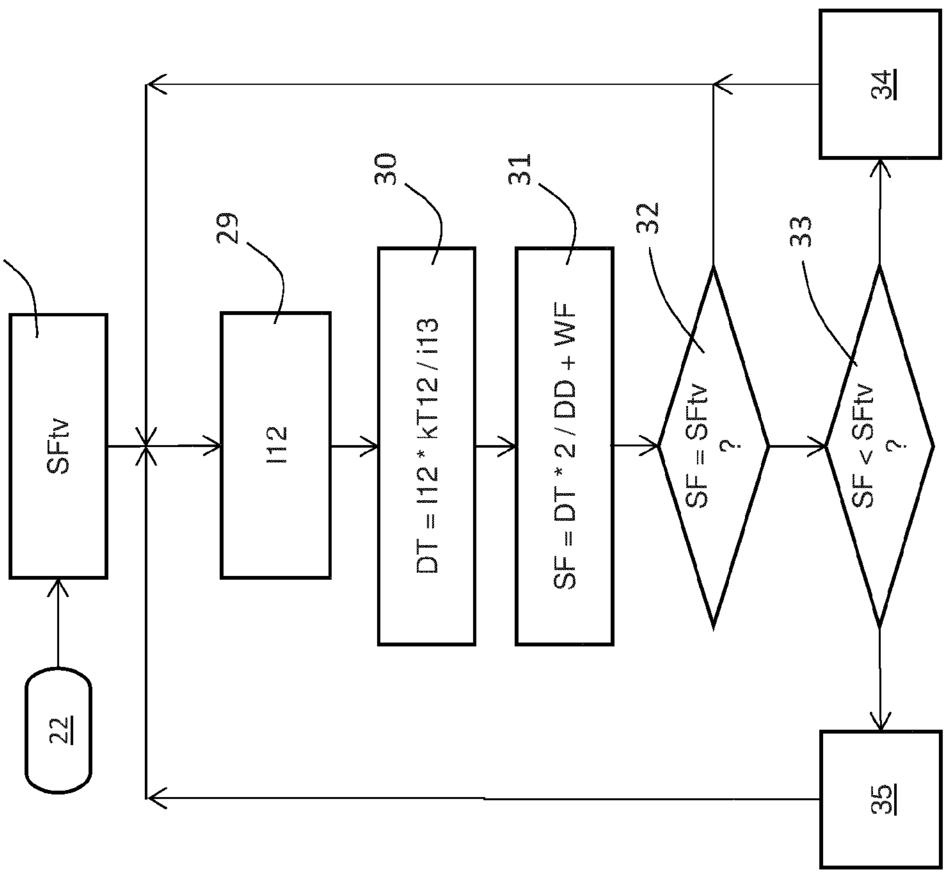
28
29
30
31
32
33
22
SFtv
I12
DT = I12 * kT12 / i13
SF = DT * 2 / DD + WF
SF = SFtv ?
SF < SFtv ?
34
35

FIG. 3

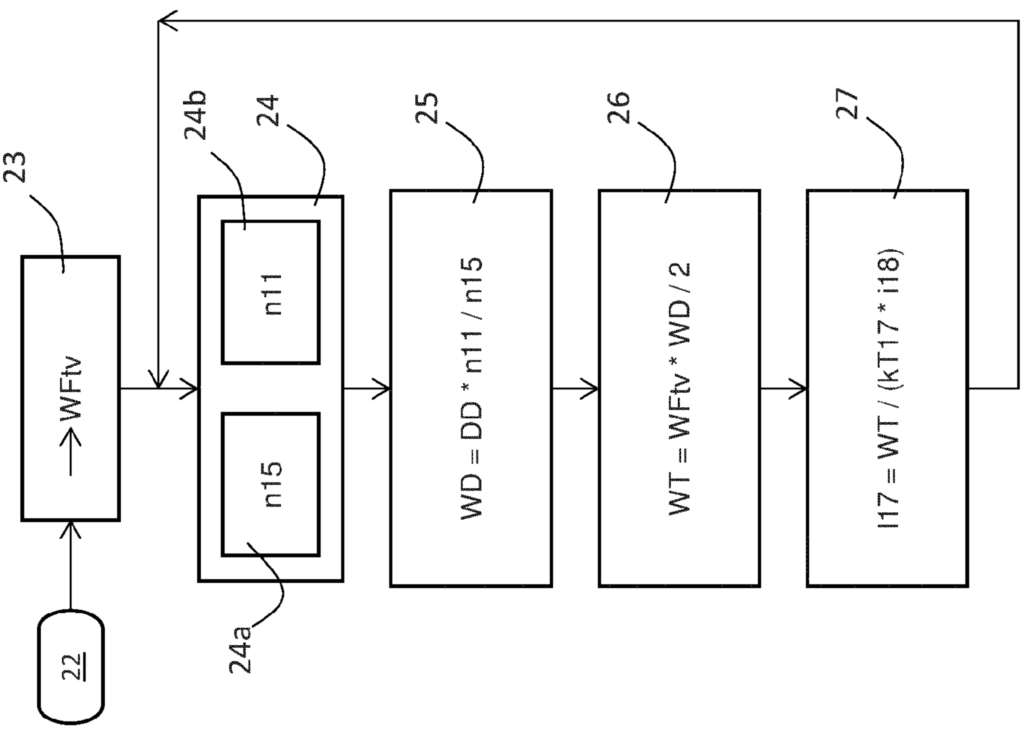
23
24b
24
25
26
27
22
WFtv
n15
n11
24a
WD = DD * n11 / n15
WT = WFtv * WD / 2
I17 = WT / (kT17 * i18)

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 2429

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			D03D D04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 December 2023	Louter, Petrus

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