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(54) METHOD OF OPERATING A WEAVING MACHINE

(57) A method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles, the weaving machine comprising at least one weft thread inserting means with an inserting rapier for inserting a weft thread and a receiving rapier for receiving the weft thread inserted by the inserting rapier, the weaving machine further comprising a weft thread tension sensor for outputting a weft thread tension signal indicative of a weft thread tension of a weft thread inserted by the at least one weft thread inserting means, comprises the steps of A) providing a plurality of consecutive weft thread tension values (V_T) within a weaving cycle on the basis of the weft thread tension signal, B) using at least a part of the weft thread tension values (V_T) of the plurality of consecutive weft thread tension values (V_T) for determining a variability parameter indicative of the variability of the weft thread tension values (V_T), and C) determining whether a weft thread (14) has moved during the weaving cycle on the basis of the variability parameter.

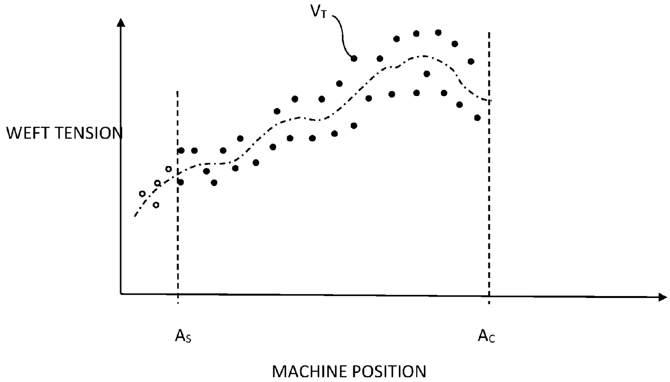

Fig. 5

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Description

[0001] For inserting weft threads into sheds that, during each weaving cycle, are formed between the warp threads extending in the warp direction within a rapier weaving machine, weft thread inserting means comprising an inserting rapier for inserting a weft thread into a shed from one side of the shed and a receiving rapier for receiving the weft thread approximately in the center of the shed in the weft direction from the inserting rapier and moving the weft thread transferred to the receiving rapier to the other side of the shed are provided.

[0002] WO 2019/082 222 A1 discloses a gripper assembly with a bringer gripper acting as an inserting rapier and a taker gripper acting as a receiving rapier of a passive weft inserting means, also known as a negative weft inserting means. The weft thread inserted by the bringer gripper is directly transferred from the bringer gripper to the taker gripper, when both grippers are in a mutually overlapping positioning such that, upon a reverse movement of the bringer gripper, the taker gripper grips the weft thread and, upon a reverse movement of the taker gripper, moves the gripped weft thread to the other end of the shed. In active weft inserting means, also known as positive weft inserting means, active means to operate the clamps of the rapier, that hold the weft, such as blades, hooks or cams for example, are used for actuating the closing or the opening of these clamps in order to transfer the weft thread from the inserting rapier to the receiving rapier in the middle of the shed.

[0003] In a weaving process, it is essential to know whether a weft error has occurred. To be able to recognize a weft error information about the movement of a weft thread during the consecutive weaving cycles of a weaving process can be provided. For providing this information about the movement of a weft thread, weft detectors are associated with the weft threads that, by means of the weft insertion means, are moved into and through the sheds formed between the warp threads. Such weft detectors may be positioned between a weft feeder and the edge of a shed, generally between a weft brake and a weft recuperator or a weft selector provided for presenting a weft thread to be inserted into a shed to the weft insertion means.

[0004] It is the object of the present invention to provide a method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles providing information about a movement of a weft thread in an easy manner.

[0005] For achieving this object, the present invention provides a method of operating a weaving machine for inserting weft threads into sheds formed between warp threads during weaving cycles, the weaving machine comprising at least one weft thread inserting means with an inserting rapier for inserting a weft thread and a receiving rapier for receiving the weft thread inserted by the inserting rapier, the weaving machine further comprising a weft thread tension sensor for outputting a weft thread tension signal indicative of a weft thread tension of a weft thread inserted by the at least one weft thread inserting means.

[0006] The method comprises the steps of:

A) providing a plurality of consecutive weft thread tension values within a weaving cycle based on the weft thread tension signal,

B) using at least a part of the weft thread tension values of the plurality of consecutive weft thread tension values for determining a variability parameter indicative of the variability of the weft thread tension values,

C) determining whether a weft thread has moved during the weaving cycle based on the variability parameter.

[0007] The present invention is based on the fact that the movement of a weft thread is reflected in the weft thread tension signal. It has been recognized that the variability of the weft thread tension within a weaving cycle is clearly linked to the movement of a weft thread. Therefore, by determining the variability parameter, information about the movement can be provided in an easy manner without requiring the use of a weft detector.

[0008] For providing information about the movement of a weft thread throughout a weaving cycle, the variability parameter may be determined repeatedly during the weaving cycle.

[0009] Each weaving cycle may correspond to a predetermined angular range of rotation of a weaving machine main shaft and, in step B), the variability parameter may be determined only for angles of rotation of the weaving machine main shaft that are within a determination angular range of rotation within the predetermined angular range of rotation.

[0010] For considering only phases within a weaving cycle in which a movement of the weft thread can be expected and, therefore, can be reflected in the weft thread tension signal, the determination angular range of rotation is an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft in which, throughout the entire determination angular range of rotation, an expected weft thread speed is above a weft thread speed threshold value.

[0011] For increasing the interval within the predetermined angular range of rotation of the weaving machine main shaft during which a movement of a weft thread can be detected, the determination angular range of rotation may be an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft starting at an angle of rotation at which an expected weft thread speed exceeds a first weft thread speed threshold value for the first time and ending at an angle of rotation at which the expected weft thread speed falls below a second weft thread speed threshold value for the last time. Therefore, the movement detection can also be carried out in phases in which the expected speed of the weft thread and, therefore, the actual speed of the weft thread, falls below an associated threshold value for a short period within a weaving cycle.

[0012] The first weft thread speed threshold value may correspond to the second weft thread speed threshold value.

[0013] In an alternative embodiment, the determination angular range of rotation may be an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft in which, throughout the entire determination angular range of rotation, an expected weft thread tension or a detected weft thread tension is above a weft thread tension threshold value.

[0014] For increasing the interval within each weaving cycle during which the movement of the weft thread can be detected, the determination angular range of rotation may be an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft starting at an angle of rotation at which an expected weft thread tension or a detected weft thread tension exceeds a first weft thread tension threshold value for the first time and ending at an angle of rotation at which the expected weft thread tension or the detected weft thread tension falls below a second weft thread tension threshold value for the last time.

[0015] Again, the first weft thread tension threshold value may correspond to the second weft thread tension threshold value.

[0016] For increasing the reliability of the weft thread movement detection, in step B) only weft thread tension values of the plurality of consecutive weft thread tension values associated with the determination angular range of rotation may be used for determining the variability parameter.

[0017] For reducing the calculating work necessary for repeatedly determining the variability parameter, a predetermined number of weft thread tension values of the plurality of consecutive weft thread tension values may be used for determining the variability parameter. This is of particular advantage if, for example, a high sampling frequency is used for generating the weft thread tension values on the basis of the weft thread tension signal and, therefore, a high number of weft thread tension values is provided during each weaving cycle.

[0018] For using a well-known mathematical operation, in step B) the variability parameter may be determined on the basis of a variance of the weft thread tension values used for determining the variability parameter.

[0019] For example, in step B) the variability parameter may be determined as the standard deviation of the weft thread tension values used for determining the variability parameter.

[0020] As it has been recognized that the movement of a weft thread influences the variability of the weft thread tension in such a manner that the variability parameter is higher, when the weft thread moves, in step C) it may be determined that the weft thread moves, if the variability parameter is above a variability parameter threshold value. A too low variability parameter can be considered as an indicator for a non-moving weft thread.

[0021] The present invention will now be explained with reference to the enclosed drawings in which:

Fig. 1 is a schematic representation of a weaving machine and weft insertion means associated therewith;

Fig. 2 shows the position of an inserting rapier, a receiving rapier and a weft thread transferred therebetween during one weaving cycle;

Fig. 3 shows the speed of a weft thread during one weaving cycle;

Fig. 4 shows the weft thread tension during one weaving cycle;

Fig. 5 shows a plurality of weft thread tension values indicative of the weft thread tension for a portion of a weaving cycle;

Fig. 6 shows, for a weaving cycle without a weft thread error, the weft thread tension, a variability parameter and a weft thread error detection signal;

Fig. 7 shows, for a weaving cycle with a weft thread error, the weft thread tension, the variability parameter and the weft thread error detection signal.

[0022] Fig. 1 shows, in a schematic manner, a loom or weaving machine 10. The weaving machine 10 has a weft insertion means 12 for inserting a weft thread 14 into a shed formed between non-shown warp threads extending in a warp direction of the weaving machine 10. The weft insertion means 12 comprises an inserting rapier 16 and a receiving rapier 18 that, in Fig. 1, are shown in a retracted position in which these rapiers 16, 18 are withdrawn from the shed formed between the warp threads, and are shown in an advanced position in which respective gripper portions of these rapiers 16, 18 inserted into the shed are positioned such as to overlap each other in the area of a center C of the shed in a weft direction W for transferring the weft thread 14 inserted into the shed by the inserting rapier 16 to the receiving rapier 18. In the preferred embodiment shown in Fig. 1, the weft insertion means 12 is embodied as a passive or negative weft insertion means arranged for directly transferring the weft thread 14 from the inserting rapier 16 to the receiving rapier 18 without using active means to open or to close the clamps of the rapiers for clamping the weft.

[0023] For forwarding the weft thread 14 to the inserting rapier, a bobbin 20 for providing the weft thread 14 and a feeder 22 buffering a portion of the weft thread 14 are provided. If required, a knot detector 24 can be provided or can be integrated into the feeder 22. Following to the feeder 22, a weft brake 26 arranged for applying a braking force to the weft thread 14, a weft tension sensor 28 for outputting a weft thread tension signal indicative of the tension of the weft thread 14 between the weft brake 26 and the one of the rapiers 16, 18 by means of which the weft thread 14 is gripped, a weft thread recuperator 30 as well as a weft selector 32 are provided in the weaving machine 10. If a plurality of different weft threads 14 are provided for generating specific weft thread patterns, such a weft selector 32 is used for offering the one weft thread that is to be used in a specific weaving cycle to the inserting rapier 16. Further, a weft scissor 34 is provided for cutting the weft thread 14 after a portion thereof has been inserted into a shed and for clamping the weft thread 14 and presenting it to the inserting rapier before its next portion will be inserted into the next shed formed between the warp threads.

[0024] Further, a weft release actuator 36 is associated with the receiving rapier 18 for releasing the weft thread 14 from the receiving rapier 18 after the receiving rapier 18 has approached its retracted position and the weft thread 14 has been inserted into the shed.

[0025] It is to be noted that the weaving machine 10 may comprise a plurality of such weft insertion means 12 for simultaneously inserting a plurality of weft threads into a plurality of sheds formed between the warp threads and/or for inserting a plurality of weft threads at different levels, for example, if the weaving machine 10 is a face-to-face carpet weaving machine. Each such weft insertion means 12 may comprise an inserting rapier 16 and a receiving rapier 18 and, if the weft insertion means 12 is an active or positive weft insertion means, additionally may comprise active means for transferring the weft thread from the inserting rapier to the receiving rapier.

[0026] The braking force applied by the weft brake 26 to the weft thread 14 during each weaving cycle of a weaving process can be controlled based on the weft tension signal output by the weft tension sensor 28 to a weft machine controller 38. The weft machine controller 38 that, for example, provides a sampling of the weft tension signal continuously output by the weft tension sensor 28 with a desired sampling frequency of some hundreds or thousands hertz, controls the weft brake 26 by outputting a control signal for adjusting the braking force applied during each weaving cycle for adapting the braking force applied to the weft thread 14 to the movement of the inserting rapier 16 and the receiving rapier 18, respectively.

[0027] Fig. 2 shows the movement of the inserting rapier 16, the receiving rapier 18 and the weft thread 14 transferred therebetween during one weaving cycle. It is to be noted that, normally, such a weaving cycle is defined by one complete rotation of a main shaft of the weaving machine 10. If the weaving machine 10 is a carpet weaving machine, the weaving shaft of the weaving machine 10 makes about 130 to 200 or even up to 250 rotations per minute, which means that, per minute, a corresponding number of weft thread insertion operations are carried out by the weft insertion means 12. As the width of a carpet to be woven by such a carpet weaving machine may be up to about 5.3 meters, during each weft thread inserting operation, the weft thread 14 is moved by the inserting rapier 16 and the receiving rapier 18 through the shed having a corresponding extension of up to more than 5 meters in the weft direction W.

[0028] Fig. 3 shows a curve that, for one weaving cycle, reflects the speed of the front end of the weft thread 14. This speed of the weft thread 14 substantially corresponds to the speed of the one of the rapiers by means of which the weft thread 14 has been gripped and is moved during the weaving cycle. Fig. 3 shows that, upon having been gripped by the inserting rapier 16, the speed of the weft thread 14 increases to a first maximum value and then decreases due to the deceleration of the inserting rapier 16 upon approaching the transfer position. After having been gripped by the receiving rapier 18, the speed of the weft thread 14 increases again and, following to a second maximum value, decreases due to the deceleration of the receiving rapier 18 upon approaching the retracted position thereof.

[0029] Fig. 4 shows the weft thread tension signal indicative of the tension of the weft thread 14 detected by the weft tension sensor 28. It can be seen in Fig. 4 that, after the inserting rapier 16 has started moving together with the gripped weft thread 14 with an increasing speed of the weft thread 14, the tension of the weft thread 14 increases while, in a phase in which the inserting rapier 16 approaches the area of the center C of the shed and decelerates for transferring the weft thread 14 to the also decelerating receiving rapier 18, the tension of the weft thread 14 decreases.

[0030] Once the weft thread 14 has been transferred to the receiving rapier 18 and the receiving rapier 18 has started accelerating for pulling the weft thread 14 toward the other end of the shed, there is a sharp increase of the tension of the weft thread 14 that is reflected in the weft thread tension signal in the area of a machine position between 180° and 200° of the rotation of the weaving machine main shaft within the shown weaving cycle. After this transfer peak of the weft thread tension has occurred, there is a corresponding sharp decrease of the weft thread tension and, thereafter, the tension of the weft thread 14 increases with the increasing speed of the receiving rapier 18 and, upon approaching the other end of the shed, decreases with the decreasing speed of the receiving rapier 18.

[0031] The weft thread tension signal shown in Fig. 4 shows a clear linkage between the fluctuation thereof and the speed of the weft thread 14. As long as the speed is rather low or the weft thread 14 does not move, the fluctuation range of the weft thread tension signal is rather narrow while, with an increasing speed of the weft thread 14, this fluctuation range increases. This means that the movement of the weft thread 14 is reflected in the weft thread tension signal what, in turn, means that, by appropriately evaluating the weft thread tension signal, information about the movement of the weft thread can be provided. In the following, a method for determining the status of the movement of the weft thread 14 during a weaving cycle will be explained with reference to Fig. 3 to 5.

[0032] Fig. 5 shows, for a small portion of a weaving cycle, i.e. for a small portion of one full rotation of a weaving machine main shaft, a plurality of consecutive weft thread tension values V_T that, for example, can be provided by the weft machine controller 38 by sampling the continuously output weft thread tension signal. The fluctuation of the weft thread tension signal is represented by the deviation of the various weft thread tension values V_T from a mean value of the weft thread tension. The number of these consecutive weft thread tension values V_T within a weaving cycle is defined by the sampling frequency.

[0033] As indicated in Fig. 3, a determination angular range of rotation A_D is determined in association with the weaving cycle that, in turn, corresponds to a predetermined angular range of rotation of the weaving machine main shaft. As stated above, normally this predetermined angular range of rotation of the weaving main shaft corresponding to one weaving cycle is 360°. The determination angular range of rotation A_D, for example, may be defined as an angular range of rotation within the weaving cycle in which the speed that the weft thread 14 is expected to have during the weaving cycle is above an associated weft thread speed threshold value Vs.

[0034] Because, during the transfer of the weft thread 14 from the inserting rapier 16 to the receiving rapier 18, the weft thread 14 comes to a stand still, the expected speed thereof falls below the weft thread speed threshold value Vs in the area of the transfer position. This means that, in this embodiment, the determination angular range of rotation A_D comprises two regions, each one of these regions corresponding to those phases of the weaving cycle in which the weft thread 14 moves together with one of the rapiers.

[0035] In an alternative embodiment, the determination angular range of rotation A_D may be determined as the interval between an angle of rotation As of the weaving machine main shaft at which the expected speed of the weft thread 14 exceeds the weft thread speed threshold value Vs in the weaving cycle for the first time, and the angle of rotation A_E of the weaving machine main shaft at which the expected speed of the weft thread 14 falls below the weft thread speed threshold value Vs for the last time. By considering the expected speed of the weft thread 14 that, for example, can be known from an evaluation of a plurality of previous weaving cycles or from a theoretical model of the movement of the weft thread 14, a defined angular range of rotation of the weaving machine main shaft can be provided in which the status of the movement of the weft thread 14 can be evaluated with a high reliability.

[0036] According to the principles of the present invention, the status of the movement of the weft thread 14 is determined within the determination angular range of rotation A_D by calculating a variability parameter based on the weft thread tension values V_T shown in Fig. 5. Supposing that, for example, at a machine position of the weaving machine 10 corresponding to an angle of rotation Ac of the weaving machine main shaft the status of the movement of the weft thread 14 has to be determined, the variability parameter can be determined as the standard deviation of the weft thread tension values V_T corresponding to the square root of the variance thereof. For enhancing the reliability of this determination, only those weft thread tension values V_T that, up to reaching the machine position corresponding to the angle Ac, have been generated and that are within the determination angular range of rotation A_D will be considered when calculating the standard deviation.

[0037] At the point of time within a weaving cycle corresponding to the angle of rotation Ac, all the weft thread tension values V_T that, within this weaving cycle, have been provided since the start of the determination angular range of rotation A_D at the angle of rotation As may be considered for calculating the variability parameter. If, due to a rather high sampling frequency, a corresponding high number of such weft thread tension values V_T is available for determining the variability parameter, only a predetermined number thereof, for example, some ten or some hundred weft thread tension values V_T can be used for determining the variability parameter for keeping the amount of calculation work at a low level and, thereby, allowing the variability parameter to be provided substantially without delay.

[0038] After having determined the variability parameter, for example, by having calculated the standard deviation of the weft thread tension values V_T in association with the angle of rotation Ac, this variability parameter is compared to an associated variability parameter threshold value. If the variability parameter determined in association with the machine position corresponding the angle of rotation Ac is at or above the variability parameter threshold value, it can be determined that the weft thread 14 has been moving at this specific point of time. If the variability parameter determined in association with the angle of rotation Ac is not above the variability parameter threshold value, it can be determined that, at this specific point of time, the weft thread 14 has not been moving, what might be due to a weft error. For example, the weft thread may have broken or may have not been gripped by one of the rapiers appropriately. If it is determined that the weft thread 14 has not been moving in a phase within a weaving cycle in which it normally should have been moving, the weaving machine can be stopped and the weaving process can be interrupted for allowing a supervisor to check which kind of error this is. After having identified the weft error, the appropriate measures can be taken for allowing the weaving process to be restarted again.

[0039] Fig. 4 shows that, in a further alternative embodiment, instead of determining the determination angular range of rotation A_D on the basis of the expected speed of the weft thread 14, the weft thread tension that is expected to be generated during a weaving cycle may be used as the basis for determining the determination angular range of rotation A_D. Again, this determination angular range of rotation A_D can be determined as being such an angular range of rotation in which the expected weft thread tension is above a weft thread tension threshold value Ts.

[0040] In a further alternative embodiment, the determination angular range of rotation A_D can be determined on the basis of the angles of rotation As and A_E being those angles at which the expected weft thread tension exceeds the weft thread tension reference value Ts for the first time and falls below the weft thread tension reference value Ts for the last time within one weaving cycle.

[0041] In a further embodiment, the determination angular range of rotation A_D within which, in each weaving cycle, the variability parameter can be determined repeatedly for determining the status of the movement of the weft thread 14, can be determined based on the weft thread tension signal reflecting the actually measured weft thread tension. Only if the actually measured weft thread tension represented by the weft thread tension values V_T is above the weft thread tension threshold value Ts, the variability parameter is determined on the basis of those weft thread tension values V_T that have been provided prior to reaching the angle of rotation Ac for which the status of the movement of the weft thread 14 has to be determined.

[0042] By repeatedly determining the variability parameter of the weft thread tension values, for example, in association with each degree of the rotation of the weaving machine main shaft and comparing each one of these variability parameters to the associated variability parameter threshold value, reliable information about the movement of a weft thread during a weaving cycle can be provided. As, in an advantageous embodiment of the method of the present invention, this determination of the movement is only carried out in phases in which, based on the knowledge about the normal movement of a weft thread during a weaving cycle or even based on the detected weft thread tension, it can be expected that the movement of the weft thread is fast enough to be clearly reflected in the weft thread tension signal, an incorrect judgement of the status of the movement of a weft thread can be avoided with a high probability.

[0043] Fig. 6 shows, for a weaving circle without a weft thread error, the weft tension signal (upper diagram), the standard deviation of the weft tension signal representing the variability parameter determined on the basis of the weft thread tension values V_T obtained by sampling the weft thread tension signal (middle diagram), and an error detection signal indicating whether, within the determination angular range of rotation represented by the two grey areas, a weft thread error has occurred. As can be seen in the middle diagram of Fig. 6, the standard deviation is above the associated variability parameter threshold value that is shown by a dashed line throughout the entire determination angular range of rotation. Therefore, the error detection signal is at 0 throughout the entire weaving cycle indicating that no weft thread error has occurred.

[0044] Fig. 7 shows the same diagrams for a weaving cycle in which, during the first part of the determination angular range of rotation, a weft thread error has occurred and, therefore, the weft thread tension has dropped to a value close to 0. Due to this sharp decrease of the weft thread tension, the variability parameter represented by the standard deviation also shows a sharp decrease and falls below the variability parameter threshold value shown by the dashed line. As soon as this happens, the error detection signal jumps to a higher value indicating that a weft thread error has occurred. As this weft thread error still exists in the second part of the determination angular range of rotation, the error detection signal is at the higher level throughout this second part of the determination angular range of rotation.

[0045] While, in association with the above embodiments a weaving cycle is represented by one complete revolution of a weaving machine main shaft and the transfer occurrence parameter defining the position of the transfer of weft thread within such a weaving cycle is referred to as being an angular position of the weaving machine main shaft within the value range of 0° to 360°, such a weaving cycle can be defined in an other manner. For example, the rotation or movement of an other component of a weaving machine that, as is the case with the weaving machine main shaft, repeats with each weaving cycle can be used as the basis for defining the weaving cycle and for defining the position of the transfer of a weft thread within a value range associated with such a repeated movement. A weaving cycle can also be determining in a time based manner. If, for example, a weaving machine is operated with a speed of 200 weaving cycles per minute, each weaving cycle takes 300 ms. The start of each weaving cycle may be triggered by a start command of the weaving machine controller, and the transfer occurrence parameter can be defined as being a particular point of time within the value range of 0 ms corresponding to the start of the weaving cycle and 300 ms corresponding to the end of the weaving cycle.

Claims

1. A method of operating a weaving machine (10) for inserting weft threads (14) into sheds formed between warp threads during weaving cycles, the weaving machine (10) comprising at least one weft thread inserting means (12) with an inserting rapier

(16) for inserting a weft thread (14) and a receiving rapier (18) for receiving the weft thread (14) inserted by the inserting rapier (16), the weaving machine (10) further comprising a weft thread tension sensor (28) for outputting a weft thread tension signal indicative of a weft thread tension of a weft thread (14) inserted by the at least one weft thread inserting means (12),
the method comprising the steps of:

A) providing a plurality of consecutive weft thread tension values (V_T) within a weaving cycle on the basis of the weft thread tension signal,
B) using at least a part of the weft thread tension values (V_T) of the plurality of consecutive weft thread tension values (V_T) for determining a variability parameter indicative of the variability of the weft thread tension values (V_T),
C) determining whether a weft thread (14) has moved during the weaving cycle based on the variability parameter.

2. The method of claim 1, wherein the variability parameter is determined repeatedly during the weaving cycle.

3. The method of one of claims 1 or 2, wherein each weaving cycle corresponds to a predetermined angular range of rotation of a weaving machine main shaft, and wherein, in step B), the variability parameter is determined only for angles of rotation of the weaving machine main shaft that are within a determination angular range of rotation (A_D) within the predetermined angular range of rotation.

4. The method of claim 3, wherein the determination angular range of rotation (A_D) is an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft in which, throughout the entire determination angular range of rotation (A_D), an expected weft thread speed is above a weft thread speed threshold value (Vs).

5. The method of claim 3, wherein the determination angular range of rotation (A_D) is an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft starting at an angle of rotation (As) at which an expected weft thread speed exceeds a first weft thread speed threshold value (Vs) for the first time and ending at an angle of rotation (A_E) at which the expected weft thread speed falls below a second weft thread speed threshold value (Vs) for the last time.

6. The method of claim 5, wherein the first weft thread speed threshold value (Vs) corresponds to the second weft thread speed threshold value (Vs).

7. The method of claim 3, wherein the determination angular range of rotation (A_D) is an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft in which, throughout the entire determination angular range of rotation (A_D), an expected weft thread tension or a detected weft thread tension is above a weft thread tension threshold value (Ts).

8. The method of claim 3, wherein the determination angular range of rotation (A_D) is an angular range of rotation within the predetermined angular range of rotation of the weaving machine main shaft starting at an angle of rotation (As) at which an expected weft thread tension or a detected weft thread tension exceeds a first weft thread tension threshold value (Ts) for the first time and ending at an angle of rotation (A_E) at which the expected weft thread tension or the detected weft thread tension falls below a second weft thread tension threshold value (Ts) for the last time.

9. The method of claim 8, wherein the first weft thread tension threshold value (Ts) corresponds to the second weft thread tension threshold value (Ts).

10. The method of one of claims 3 to 9, wherein, in step B), only weft thread tension values (V_T) of the plurality of consecutive weft thread tension values (V_T) associated with the determination angular range of rotation (A_D) are used for determining the variability parameter.

11. The method of one of claims 1 to 10, wherein, in step B), a predetermined number of weft thread tension values (V_T) of the plurality of consecutive weft thread tension values (V_T) is used for determining the variability parameter.

12. The method of one of claims 1 to 11, wherein, in step B), the variability parameter is determined based on a variance of the weft thread tension values (V_T) used for determining the variability parameter.

13. The method of claim 12, wherein, in step B), the variability parameter is determined as the standard deviation of the weft thread tension values (V_T) used for determining the variability parameter.

14. The method of one of claims 1 to 13, wherein, in step C), it is determined that the weft thread (14) moves, if the variability parameter is above a variability parameter threshold value.

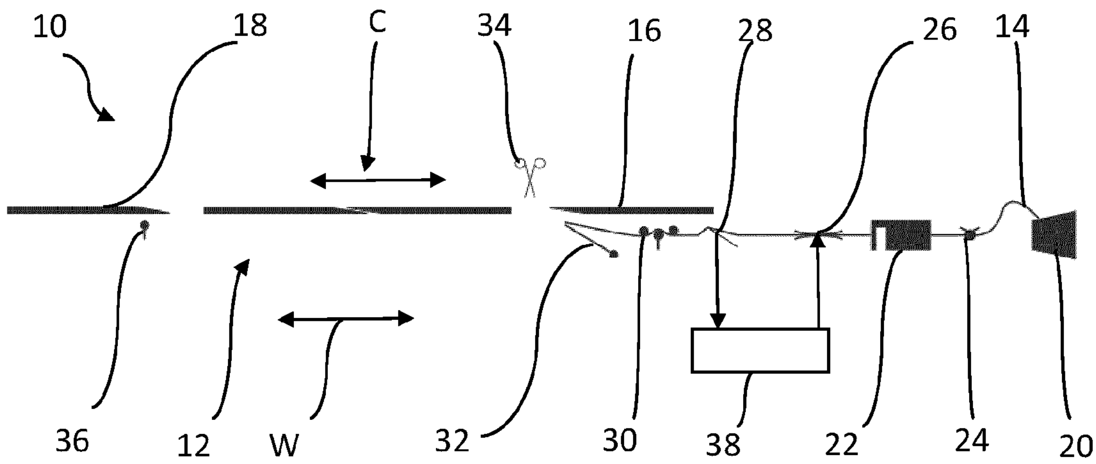
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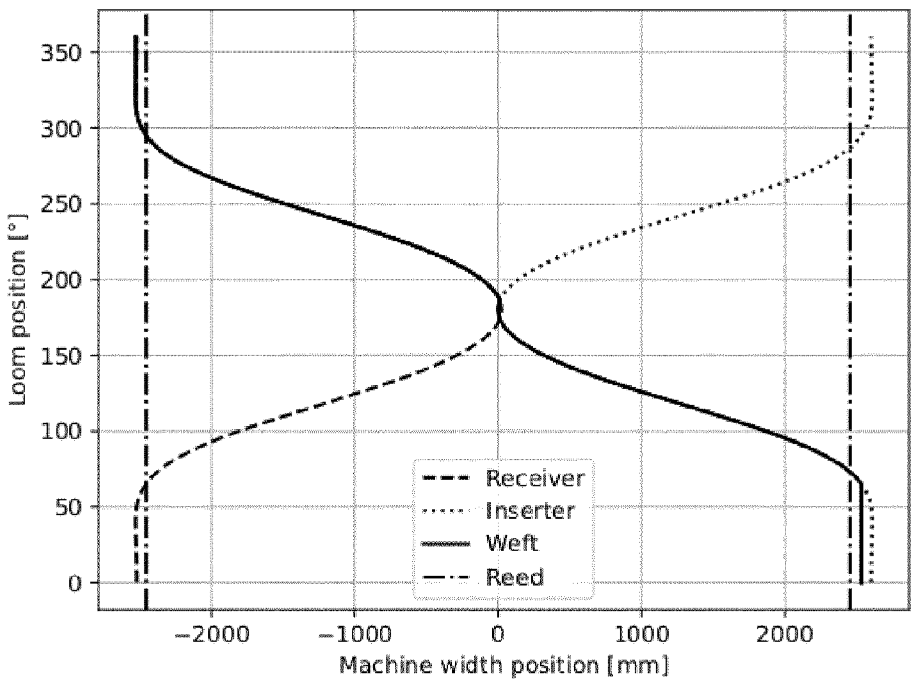
Fig. 1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350
300
250
200
150
100
50
0
−2000
−1000
0
1000
2000
Machine width position [mm]
Receiver
Inserter
Weft
Reed

Fig. 2

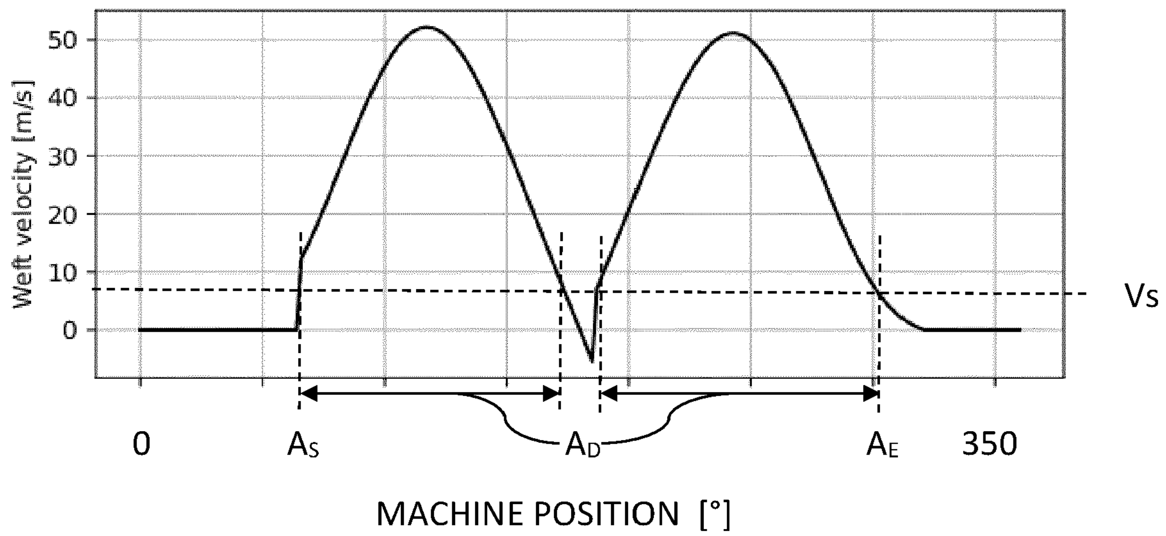

Weft velocity [m/s]
50
40
30
20
10
0
Vs
0
AS
AD
AE
350
MACHINE POSITION [°]

Fig. 3

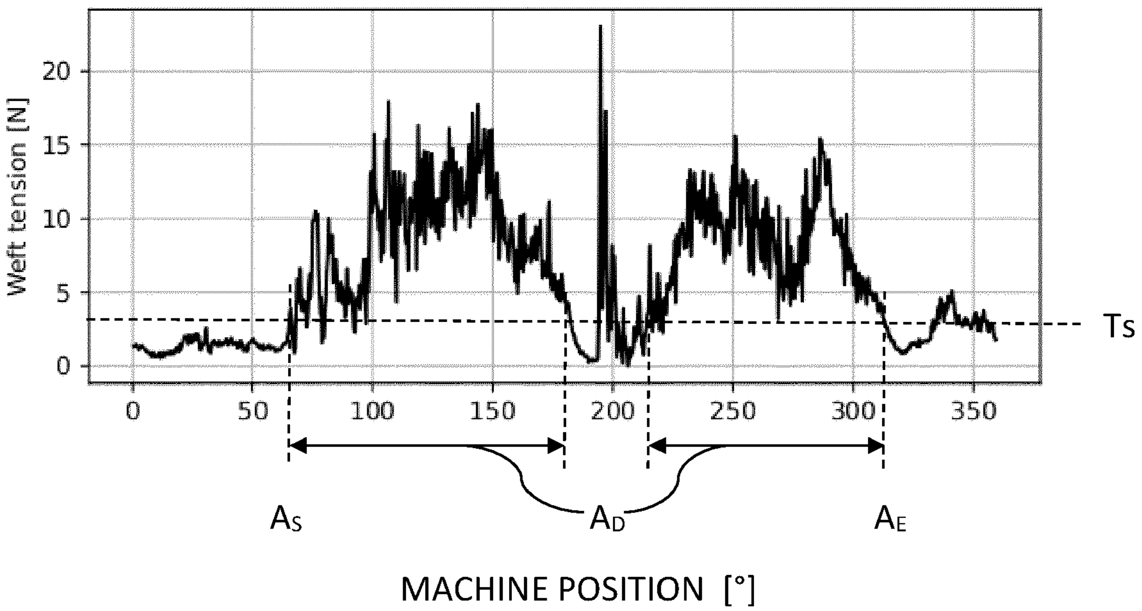

Weft tension [N]
20
15
10
5
0
Ts
0
50
100
150
200
250
300
350
AS
AD
AE
MACHINE POSITION [°]

Fig. 4

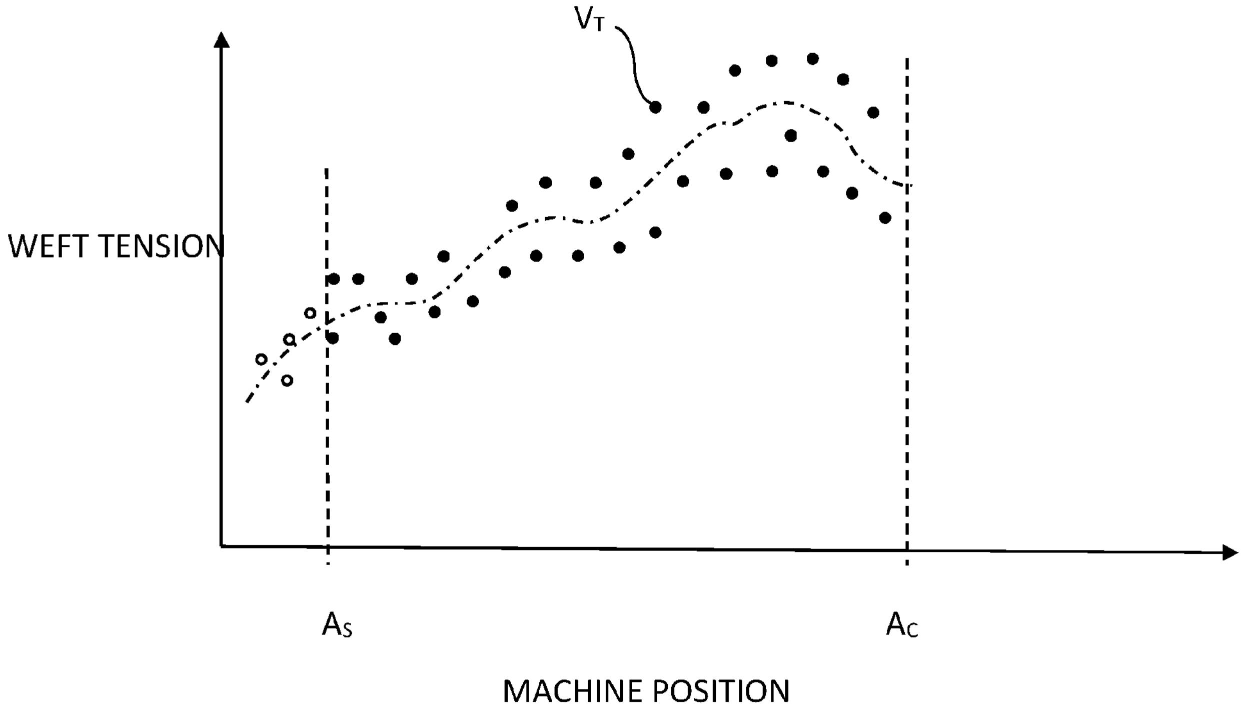
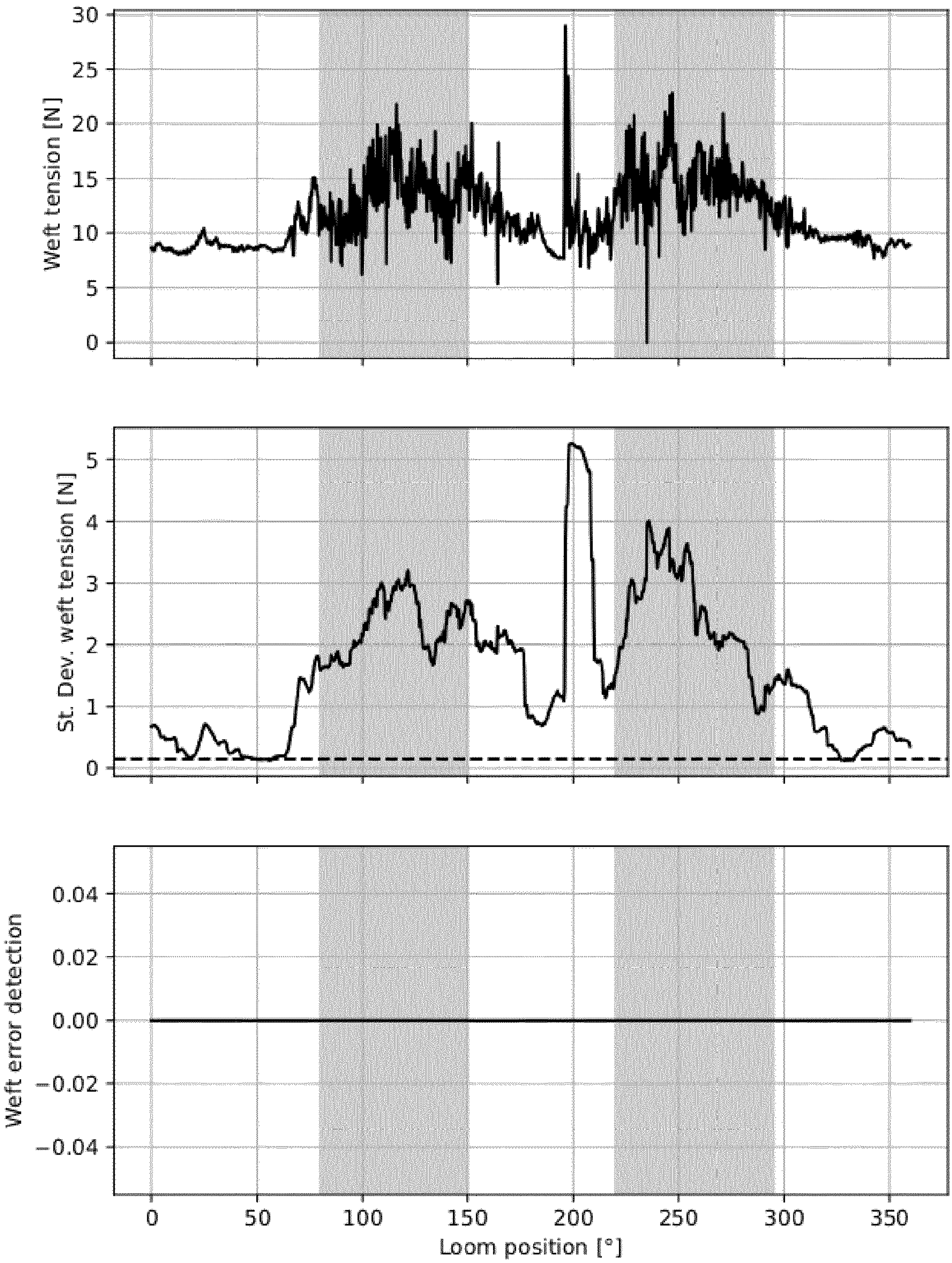


Fig. 5



Weft tension [N]
30
25
20
15
10
5
0
St. Dev. weft tension [N]
5
4
3
2
1
0
Weft error detection
0.04
0.02
0.00
−0.02
−0.04
0
50
100
150
200
250
300
350
Loom position [°]

Fig. 6

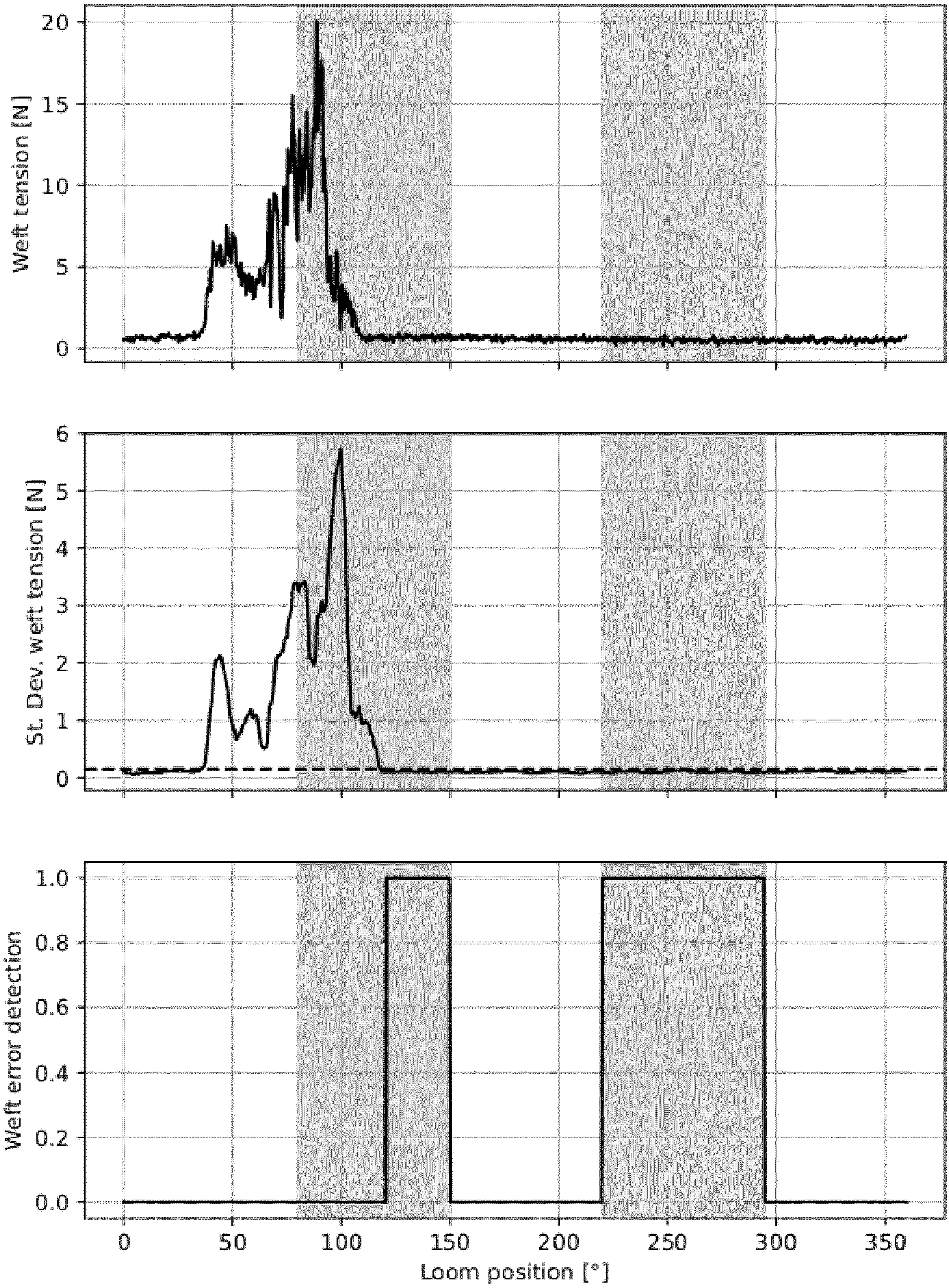

Weft tension [N]
20
15
10
5
0
St. Dev. weft tension [N]
6
5
4
3
2
1
0
Weft error detection
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
350
Loom position [°]

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 7200

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	-/--		TECHNICAL FIELDS SEARCHED (IPC)
			D03D D03J

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	3 November 2023	Heinzelmann, Eric

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Application Number
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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	3 November 2023	Heinzelmann, Eric

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