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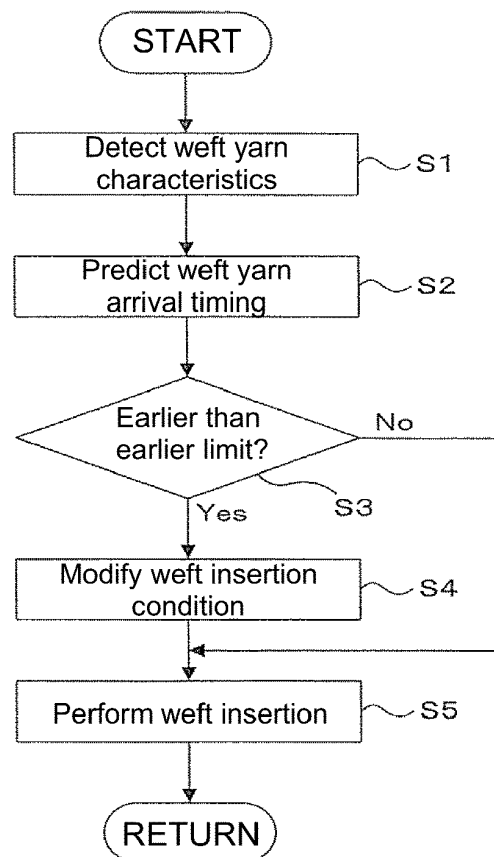
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(54) **METHOD OF CONTROLLING WEFT INSERTION OF AIR JET LOOM**

(57) A method of controlling weft insertion of an air jet loom includes the steps of: detecting a characteristic of a weft yarn (11) that is yet to be inserted; predicting a weft yarn arrival timing (TWp) at which the weft yarn (11) that is inserted in accordance with a specified weft insertion condition arrives at a specified position, on the basis of the detected characteristic of the weft yarn (11); when the predicted weft yarn arrival timing (TWp) is earlier than an earlier limit (TWf) that is predetermined relative to variations in the weft yarn arrival timing, modifying the weft insertion condition so that an actual weft yarn arrival timing is later than the earlier limit (TWf); and performing a weft insertion of the weft yarn (11) by the weft insertion nozzle (6, 7, 8) on the basis of the modified weft insertion condition.

FIG. 2



Description

BACKGROUND ART

[0001] The present disclosure relates to a method of controlling weft insertion of an air jet loom.

[0002] As a technique regarding an air jet loom in which weft yarns are inserted by utilizing compressed air, Japanese Examined Patent Application Publication No. S61-25817, for example, discloses a technique in which, when a weft yarn having a thickness smaller than normal weft yarns is inserted, smaller air injection pressure is selected to thereby prevent weft insertion failures caused by a broken weft yarns. The Publication also mentions that the duration of air injection of a main nozzle and/or sub-nozzles is shortened when the weft yarn has a thickness that is smaller than normal weft yarns.

[0003] In the technique mentioned in Japanese Examined Patent Application Publication No. S61-25817, the modifications of the air injection pressure etc. are solely based on the thickness of the weft yarn to be inserted. However, the weft yarn thickness is not the only factor associated with occurrence of a yarn break. For example, the number of twists or the turns per inch of the weft yarn may also be considered as the factor associated with the occurrence of a yarn break. Thus, the technique described in Japanese Examined Patent Application Publication No. S61-25817 may not be able to sufficiently prevent occurrence of a weft insertion failure caused by a yarn breakage.

[0004] The present disclosure has been made to solve the above problem, and is directed to providing a method of controlling weft insertion of an air jet loom that sufficiently prevents occurrence of a weft insertion failure caused by a yarn breakage.

SUMMARY

[0005] In accordance with an aspect of the present disclosure, there is provided a method of controlling weft insertion of an air jet loom. The air jet loom includes a weft insertion nozzle that injects air for weft insertion to transfer a weft yarn in a weft insertion direction. The method includes the steps of: detecting a weft yarn condition characteristic of a weft yarn that is yet to be inserted; predicting a weft yarn arrival timing at which the weft yarn that is inserted in accordance with a specified weft insertion condition arrives at a specified position in the weft insertion direction, on the basis of the characteristic of the weft yarn that is detected in the detecting step; when the weft yarn arrival timing that is predicted in the predicting step is earlier than an earlier limit that is predetermined relative to variations in the weft yarn arrival timing, modifying the weft insertion condition so that an actual weft yarn arrival timing is later than the earlier limit; and performing a weft insertion of the weft yarn by injecting air from the weft insertion nozzle on the basis of the weft insertion condition that is modified in the modifying

step.

[0006] Other aspects and advantages of the disclosure will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The disclosure, together with objects and advantages thereof, may best be understood by reference to the following description of the embodiments together with the accompanying drawings in which:

FIG. 1 is a schematic view illustrating a configuration of a weft insertion apparatus of an air jet loom according to an embodiment of the present disclosure;

FIG. 2 is a flow chart depicting a method of controlling weft insertion of the air jet loom according to the embodiment of the present disclosure;

FIG. 3 is a graph depicting variations in the weft yarn arrival timing according to a comparative example of the present disclosure where the present disclosure is not applied; and

FIG. 4 is a graph depicting variations in the weft yarn arrival timings according to the embodiment of the present disclosure where the present disclosure is applied.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0008] The following will describe in detail an embodiment of the present disclosure with reference to the accompanying drawings.

Configuration of Weft Insertion Apparatus of Air Jet Loom

[0009] FIG. 1 is a schematic view illustrating a configuration of a weft insertion apparatus, denoted as 1, of an air jet loom according to an embodiment of the present disclosure.

[0010] The weft insertion apparatus 1 includes a weft yarn cheese 2, a weft yarn characteristic detection unit 3, a weft yarn storing unit 4, a weft yarn tension correcting unit 5, a main nozzle 6, a tandem nozzle 7, sub-nozzles 8, a reed 9 for beating, and a weft yarn feeler 10. The weft insertion apparatus 1 further includes a main valve 12, a tandem valve 14, a main tank 16, a regulator 18, sub-valves 22, a sub-tank 23, a regulator 24, a control unit 31, and a function panel 32.

[0011] The weft yarn cheese 2 operates as the yarn feeding unit that feeds a weft yarn 11 to be inserted to the weft yarn storing unit 4. The weft yarn characteristics detection unit 3 is configured to detect characteristics of the weft yarn 11 supplied from the weft yarn cheese 2. The characteristics of the weft yarn 11, which are the

detection result of the weft yarn characteristics detection unit 3, are notified or sent to the control unit 31.

[0012] The weft yarn characteristics detection unit 3 is disposed between the weft yarn cheese 2 and the weft yarn storing unit 4 in a direction in which the inserted weft yarn 11 is transferred (the weft insertion direction). The weft insertion is performed at a position downstream of the weft yarn storing unit 4 in the weft insertion direction. In contrast to this, the weft yarn characteristics detection unit 3 is disposed at a position upstream of the weft yarn storing unit 4. Accordingly, the weft yarn characteristics detection unit 3 detects the characteristics of the weft yarn 11 that is yet to be inserted.

[0013] The characteristics of the weft yarn 11 detected by the weft yarn characteristics detection unit 3 include, at least, a mass of the weft yarn 11 per unit of length (hereinafter, referred to as the weft yarn mass). When a weft yarn 11 is inserted by means of a jet of air, the characteristics of the weft yarn 11 influence the flight of the weft yarn 11. Examples of the weft yarn characteristics detection unit 3 include a device disclosed in Published Japanese Translation No. 2014-500914 of PCT International Application No. PCT/CH2011/000284.

[0014] The weft yarn storing unit 4 is configured to store a weft yarn 11 that is yet to be inserted. The weft yarn storing unit 4 includes a measuring drum 15 and a holding pin 17. The weft yarn 11 that is to be supplied from the weft yarn cheese 2 to the weft yarn storing unit 4 is wound around the measuring drum 15 and stored in the weft yarn storing unit 4.

[0015] The holding pin 17 is a pin configured to hold and release the weft yarn 11 used for weft insertion. The holding pin 17 is caused to move in a direction approaching and in a direction separating from an outer peripheral surface of the measuring drum 15 with the driving of the electromagnetic solenoid 19. The control unit 31 controls the driving of the electromagnetic solenoid 19. In order to hold the weft yarn 11, the holding pin 17 is moved in the direction approaching the outer peripheral surface of the measuring drum 15 and then holds the weft yarn 11 on the outer peripheral surface of the measuring drum 15. In order to release the held weft yarn 11, the holding pin 17 is moved in the direction separating from the outer peripheral surface of the measuring drum 15. A balloon sensor 20 is disposed in the vicinity of the measuring drum 15. The balloon sensor 20 is configured to detect a balloon formed in the weft yarn 11 that is released from the holding pin 17 and let off from the measuring drum 15, and outputs or sends the detection result in a form of an electric signal to the control unit 31.

[0016] The weft yarn tension correcting unit 5 is configured to correct the tension applied to the weft yarn 11 so that an excessive tension is not applied to the weft yarn 11.

[0017] The main nozzle 6, the tandem nozzle 7, and the sub-nozzles 8 are provided as the weft insertion nozzles of the present disclosure that inject air for weft insertion so as to transfer the weft yarn 11 in the weft in-

sertion direction. The main nozzle 6 is disposed downstream of the tandem nozzle 7 in the weft insertion direction, and the sub-nozzles 8 are disposed downstream of the main nozzle 6 in the weft insertion direction. In the present embodiment, one main nozzle 6, one tandem nozzle 7, and a plurality of sub-nozzles 8 are provided.

[0018] The main nozzle 6 is connected to the main tank 16 via the main valve 12. The tandem nozzle 7 is connected to the main tank 16 via the tandem valve 14. The main tank 16 is also connected with the regulator 18. The regulator 18 is configured to adjust the pressure of compressed air compressed by an air compressor (not shown). The compressed air with the adjusted pressure adjusted by the regulator 18 is stored in the main tank 16. Part of the compressed air stored in the main tank 16 is supplied to the main nozzle 6 via the main valve 12, and part of the compressed air stored in the main tank 16 is supplied to the tandem nozzle 7 via the tandem valve 14.

[0019] The main nozzle 6 is configured to inject/stop injecting air in response to the opening/closing of the main valve 12. The tandem nozzle 7 is configured to inject/stop injecting air in response to the opening/closing of the tandem valve 14. Specifically, when the main valve 12 is open, air is injected from the main nozzle 6, and when the main valve 12 is closed, the injection of air is stopped. Similarly, when the tandem valve 14 is open, air is injected from the tandem nozzle 7, and when the tandem valve 14 is closed, the injection of air is stopped. The main valve 12 and the tandem valve 14 are respectively electrically connected to the control unit 31. The control unit 31 controls the opening/closing of the main valve 12 and the opening/closing of the tandem valve 14 individually.

[0020] The plurality of sub-nozzles 8 are disposed at specified intervals in the weft insertion direction. The weft yarn 11 that is let off with the air injected from the main nozzle 6 and the tandem nozzle 7 is transferred along a longitudinal direction of the reed 9 with the aid of air injected from the respective sub-nozzles 8. The reed 9 is configured to perform a beating operation per one picking (weft insertion) of the weft yarn 11. A cutter 21 is disposed between the main nozzle 6 and the reed 9. The cutter 21 is configured to perform a cutting operation of the weft yarn 11 per one weft insertion, i.e., per one picking, of the weft yarn 11. The control unit 31 controls the driving of the cutter 21.

[0021] In the present embodiment, the plurality of sub-nozzles 8 are divided into six equal groups, where each group consists of four sub-nozzles 8 that are adjacent to each other in the longitudinal direction of the reed 9. The number of groups of the sub-nozzles 8 may vary depending on the selected weaving width. In the present embodiment, the number of the sub-valves 22 corresponds to the number of the groups of the sub-nozzles 8, and each sub-nozzle 8 is connected to the sub-tank 23 via its corresponding sub-valve 22. The sub-tank 23 is also connected with the regulator 24. The regulator 24 is con-

figured to adjust the pressure of compressed air compressed by the aforementioned air compressor (not shown). The compressed air with the adjusted pressure adjusted by the regulator 24 is stored in the sub-tank 23. The compressed air stored in the sub-tank 23 is distributed to the respective groups of the sub-nozzles 8 via the sub-valves 22 and supplied to the respective sub-nozzles 8.

[0022] In each group of the sub-nozzles 8, each sub-nozzle 8 injects/stops injecting air in response to the opening/closing of the corresponding sub-valve 22. Specifically, in each group of the sub-nozzles 8, when the corresponding sub-valve 22 is open, air is injected from the sub-nozzles 8, and when the sub-valve 22 is closed, the injection of air is stopped.

[0023] When the weft yarn 11 is inserted, air is injected from the main nozzle 6, the tandem nozzle 7, and the sub-nozzles 8 so that the weft yarn 11 is transferred. The weft yarn feeler 10 is configured to determine whether the inserted weft yarn 11 has arrived at a specified position in the weft insertion direction or not. The specified position herein is a position near the terminal point of a weft insertion and away from the main nozzle 6, in the longitudinal direction of the reed 9 (in the weft insertion direction). The specified position is predetermined in accordance with the weaving width of a fabric to be woven.

[0024] The weft yarn feeler 10 is formed by an optical sensor or the like. The weft yarn 11 is inserted and transferred in the longitudinal direction of the reed 9 by the air injected from the weft insertion nozzles 6, 7, and 8. When the leading end of the inserted weft yarn 11 has arrived at the specified position, the weft yarn feeler 10 senses the arrival of the weft yarn 11 and outputs a detection signal. Thus, the weft yarn arrival timing at which the weft yarn 11 arrives at the specified position corresponds to the timing when the weft yarn feeler 10 outputs a detection signal.

[0025] The control unit 31 is also configured to control the operation of the weft insertion apparatus 1. The control unit 31 includes, for example, a central processing unit (CPU), a Read-Only Memory (ROM), and a Random-Access Memory (RAM). The control unit 31 uses the feed-forward control for the weft insertion of the weft yarn 11. The feed-forward control by the control unit 31 will be described in detail later.

[0026] The function panel 32 is connected to the control unit 31 as the input/output device for various data associated with weft insertion. The function panel 32 includes, for example, a display and input keys (not shown). The display device is configured to display a setting screen. Settings for the weft insertion are set on the setting screen, and, based on the settings, the control unit 31 controls the weft insertion of the weft yarn 11 using the feed-forward control. The setting is made by an operator. The operator enters the yarn type of the weft yarn 11 for weft insertion on the setting screen displayed on the display device. It is to be noted that data entered via the function panel 32 is not limited to the yarn type of the

weft yarn 11, and includes other data, for example, data for specifying setting values for weft insertion, such as the weaving width of the fabric to be woven and a target weft yarn arrival timing.

Method of Controlling Weft Insertion in Air Jet Loom

[0027] The following will describe a method of controlling weft insertion in the air jet loom according to the present embodiment of the present disclosure, with reference to the flow chart of FIG. 2. It is to be noted that the method of controlling weft insertion depicted in FIG. 2 is applied to one picking of the weft yarn 11 and accordingly repeated with the repetition of pickings.

Step 1

[0028] At first, in step S1, characteristics of the weft yarn 11 that is yet to be inserted are detected.

[0029] The weft yarn 11 to be inserted is supplied from the weft yarn cheese 2 to the weft yarn storing unit 4. The characteristics of the weft yarn 11 are detected by the weft yarn characteristics detection unit 3 at a position in a path along which the weft yarn 11 is supplied. The characteristics of the weft yarn 11 detected by the weft yarn characteristics detection unit 3 are notified or sent to the control unit 31. With this operation, the control unit 31 identifies the characteristics of the weft yarn 11 that is yet to be inserted. In the present exemplary embodiment, although the weft yarn characteristics detection unit 3 detects the weft yarn mass and sends the detection result to the control unit 31.

Step S2

[0030] Subsequently, in step S2, a weft yarn arrival timing at which the weft yarn 11 that is inserted in accordance with a specified weft insertion condition arrives at the specified position in the weft insertion direction is predicted, on the basis of the characteristics of the weft yarn 11 detected in the previous step S1. The control unit 31 performs the prediction of the weft yarn arrival timing.

[0031] In the memory of the control unit 31, specified weft insertion conditions that are determined by the material, the count, or the like are registered beforehand for each of the yarn types of the weft yarns 11. The CPU of the control unit 31 selects a weft insertion condition that corresponds to the yarn type of the weft yarn 11 to be inserted from the weft insertion conditions registered in the memory, reads out the selected weft insertion condition, and then predicts the weft yarn arrival timing using the read out weft insertion condition. The weft insertion conditions include the pressure of the main tank 16, the pressure of the sub-tank 23, the opening degree for air injection of the main nozzle 6, the opening degree for air injection of each sub-nozzle 8, the opening degree for air injection of the tandem nozzle 7, the air injection start timing of each of the main nozzle 6 and the sub-nozzles

8, and the air injection start timing of the tandem nozzle 7.

[0032] The weft yarn arrival timing predicted by the control unit 31 is herein referred to as TWp. The control unit 31 predicts the weft yarn arrival timing TWp on the basis of the characteristics of the weft yarn 11 detected by the weft yarn characteristics detection unit 3. In the present embodiment, the weft yarn characteristics detection unit 3 detects the weft yarn mass. In this case, the control unit 31 predicts the weft yarn arrival timing TWp in accordance with the weft yarn mass detected by the weft yarn characteristics detection unit 3. The details of the prediction of the weft yarn arrival timing TWp will be described below.

[0033] When the weft yarn mass detected by the weft yarn characteristics detection unit 3 is greater than a reference weft yarn mass, the control unit 31 predicts that the weft yarn arrival timing TWp will be delayed and later than the reference weft yarn arrival timing TWr. When the weft yarn mass detected by the weft yarn characteristics detection unit 3 is smaller than the reference weft yarn mass, the control unit 31 predicts that the weft yarn arrival timing TWp will be advanced and earlier than the reference weft yarn arrival timing TWr. In this case, the difference between the reference weft yarn arrival timing TWr and the predicted weft yarn arrival timing TWp predicted by the control unit 31 is determined from the difference between the reference weft yarn mass and the detected weft yarn mass. In other words, as the difference between the reference weft yarn mass and the detected weft yarn mass is greater, the difference between the reference weft yarn arrival timing TWr and the predicted weft yarn arrival timing TWp is greater.

[0034] It is to be noted that the aforementioned reference weft yarn mass is predetermined for each of the yarn types of the weft yarns 11 and prestored in the memory of the control unit 31 (such as the RAM) as data. When the weft yarn arrival timing TWp is predicted, the CPU of the control unit 31 selects a reference weft yarn mass from the memory and reads out for use.

Step S3

[0035] Subsequently, in step S3, a determination is made as to whether the predicted weft yarn arrival timing TWp predicted in step S2 is earlier than an earlier limit TWf, which is a predetermined limit value of the weft yarn arrival timing. The control unit 31 performs this determination. The earlier limit TWf is a predetermined limit value that is predetermined relative to variations in the weft yarn arrival timing.

[0036] The following will describe how the earlier limit TWf is determined relative to the variations in the weft yarn arrival timing. First of all, even though a weft insertion condition is selected from the weft insertion conditions registered in the memory of the control unit 31, in accordance with the yarn type of the weft yarn 11 specified on the function panel 32, and the selected weft insertion condition is applied to each weft insertion, the

flight or arrival of the weft yarn 11 may be advanced or delayed. Therefore, for example, when picking or inserting of the weft yarn 11 of a given yarn type is repeated for several thousand times under the same weft insertion condition, the actual weft yarn arrival timings detected by the weft yarn feeler 10 vary in a manner similar to the normal distribution having the reference weft yarn arrival timing TWr as a mean, as depicted in FIG. 3.

[0037] FIG. 3 is a graph depicting a characteristic line L of the characteristics of the movement of the leading end of the weft yarn according to a comparative example of the present embodiment, where the vertical axis represents the position of the leading end of the weft yarn in the longitudinal direction of the reed, and the horizontal axis represents the crank angle of the loom. As can be understood from FIG. 3, the weft insertion is performed while the loom is at the crank angle of from 90 to 240 degrees. It is also understood that the weft yarn arrival timing varies at or around the loom crank angle of 240 degrees. The timing at which the loom crank angle is 240 degrees corresponds to the target weft yarn arrival timing that is aimed at timing when the weft insertion is performed under a specified weft insertion condition, that is, the reference weft yarn arrival timing TWr.

[0038] In the present embodiment of the present disclosure, the earlier limit TWf is determined to be earlier than the weft yarn arrival timing TWr which corresponds to the loom crank angle of 240 degrees, among the variations in the weft yarn arrival timing depicted in FIG. 3. The earlier limit TWf is determined in accordance with the state of occurrence of weft insertion failures which may occur when the weft yarn arrives at the specified position earlier than the reference weft yarn arrival timing TWr.

[0039] The state of occurrence of weft insertion failures herein refers to the actual rate of occurrence of weft insertion failures. The state of occurrence of weft insertion failures may be obtained and confirmed for each of the yarn types of the weft yarn 11 through experiments etc. Here, a distribution area E where a weft insertion failure resulting from a yarn break is likely to occur is identified from the data obtained through experiments etc., for example, from the normal distribution of the variations in the weft yarn arrival timing. Then, a timing which corresponds to the loom crank angle, to which either the minimum loom crank angle which does not include the distribution area E or a safe angle of specified degrees (for example, about 2 degrees) is added, is set as the earlier limit TWf. In this case, the earlier limit TWf is not determined simply in accordance with the thickness of the weft yarn 11 to be inserted only, and other factors that may be associated with the occurrence of a yarn break, such as the number of twists or the turns per inch of the weft yarn 11, are also taken into consideration in the setting.

[0040] The state of occurrence of weft insertion failure, which may occur when the weft yarn arrives at the specified position earlier than the reference weft yarn arrival timing TWr, highly depends on the yarn type of the weft

yarn 11. However, the characteristics of the weft yarn 11 may also affect the state of occurrence of weft insertion failures to a small extent. Thus, the control unit 31 may modify the earlier limit TWf in accordance with the characteristics of the weft yarn 11 detected in the previous step S1. Also, the earlier limit TWf may be modified for every picking or for every predetermined number of pickings of the weft yarn 11, in accordance with the characteristics of the weft yarn 11. With the modification of the earlier limit TWf made in accordance with the characteristics of the weft yarn 11 described above, the processing of step S3 is performed by applying the modified earlier limit TWf that is suitable for the characteristics of the weft yarn 11 which is about to be inserted.

[0041] In step S3, the control unit 31 compares the earlier limit TWf that is set as described above with the predicted weft yarn arrival timing TWp that is predicted at the previous step S2, and then determines whether the weft yarn arrival timing TWp of the weft yarn 11 in the current weft insertion is earlier than the earlier limit TWf or not. Then, when it is determined as Yes in step S3, the control unit 31 proceeds the process to step S4, and if it is determined as No, the control unit 31 proceeds the process to step S5.

Step S4

[0042] Subsequently, in step S4, the weft insertion condition is modified so that the actual weft yarn arrival timing is later than the earlier limit TWf. The control unit 31 performs the modification of the weft insertion condition. There are a plurality of weft insertion conditions that may be modified by the control unit 31. However, in the feed-forward control, a high responsiveness is required so that a weft insertion with a modified weft insertion condition can be started immediately after the modification of the weft insertion condition. Contrary to this, in the case of the main tank 16 and the sub-tank 23, the responsiveness of the actuators of the pressure regulating valves to the modification of their pressure setting value is low, so that it takes time for the actual tank pressure to be stabilized to the modified pressure. Therefore, the pressures of the main tank 16 and the sub-tank 23 are not applicable as the weft insertion conditions to be modified in step S4. In the present embodiment, preferred examples of the weft insertion condition to be modified in step S4 include the opening degree for air injection of the main nozzle 6 and the air injection start timing of the tandem nozzle 7. Either the opening degree for air injection of the main nozzle 6 or the air injection start timing of the tandem nozzle 7 may be modified, or, both of the opening degree for air injection of the main nozzle 6 and the air injection start timing of the tandem nozzle 7 may be modified at the same time. The following will describe in detail the modification of the weft insertion conditions.

[0043] The modification of the opening degree for air injection of the main nozzle 6 will now be described. The opening degree for air injection of the main nozzle 6 is

determined by the duration of one picking (i.e., one weft insertion) that is, from start to end of the injection of air of the main nozzle 6. As this duration is longer, the opening degree for air injection of the main nozzle 6 is greater.

5 The opening of the main nozzle 6 is adjusted by the control of the opening/closing of the main valve 12 by the control unit 31. In this case, when the predicted weft yarn arrival timing TWp predicted in the previous step S2 is earlier than the earlier limit TWf, the control unit 31 modifies the opening degree for air injection of the main nozzle 6 to be smaller than the opening degree before the modification of the weft insertion condition.

[0044] As the opening degree for air injection of the main nozzle 6 is smaller, the transfer speed of the weft yarn 11 in the longitudinal direction of the reed 9 is lower. Thus, the control unit 31 reduces the opening degree for air injection of the main nozzle 6 by a specified ratio so that the actual weft yarn arrival timing will be later than the earlier limit TWf. The ratio of reduction of the opening degree for air injection of the main nozzle 6 may be determined on the basis of the data, such as the relationship between the opening degree for air injection of the main nozzle 6 and the weft yarn arrival timing, obtained beforehand through experiments or the like. Further, it is preferable that the opening degree for air injection of the main nozzle 6 be modified so that the actual weft yarn arrival timing coincides with the reference weft yarn arrival timing TWr.

[0045] The following will describe the modification of the air injection start timing of the tandem nozzle 7. In a picking (a weft insertion) of the weft yarn 11 using the air injected from the main nozzle 6 and the tandem nozzle 7, air is injected from the main nozzle 6 first and then from the tandem nozzle 7 to accelerate the speed of the weft yarn 11. In this case, the air injection start timing of the tandem nozzle 7 is set on the basis of the air injection start timing of the main nozzle 6. Assuming that the air injection start timing of the main nozzle 6 corresponds to the timing at which the loom crank angle is θ m, then the air injection start timing of the tandem nozzle 7 corresponds to the timing at which the loom crank angle is θ m + α .

[0046] The air injection start timing of the tandem nozzle 7 is adjusted by controlling the switching timing at which the tandem valve 14 that is then closed is opened by the control unit 31. In this case, when the predicted weft yarn arrival timing TWp predicted in the previous step S2 is earlier than the earlier limit TWf, the control unit 31 modifies or delays the air injection start timing of the tandem nozzle 7 so as to be later than the air injection start timing before the modification of the weft insertion condition.

[0047] As the air injection start timing of the tandem nozzle 7 becomes later, the transfer speed of the weft yarn 11 in the longitudinal direction of the reed 9 becomes lower. In this case, the control unit 31 modifies or delays the air injection start timing of the tandem nozzle 7 by a specified amount of time so that the actual weft yarn ar-

rival timing will be later than the earlier limit TWf. The ratio of the delay of the air injection start timing of the tandem nozzle 7 may be determined on the basis of the data, such as the relationship between the air injection start timing of the tandem nozzle 7 and the weft yarn arrival timing, obtained beforehand through experiments or the like. Further, it is preferable that the air injection start timing of the tandem nozzle 7 be modified so that the actual weft yarn arrival timing coincides with the reference weft yarn arrival timing TWr.

Step S5

[0048] Subsequently, in step S5, the control unit 31 controls the opening/closing of the main valve 12, the tandem valve 14, and the sub-valve 22 individually so that the weft insertion of the weft yarn 11 is performed with the air injected from the main nozzle 6, the tandem nozzle 7, and the sub-nozzles 8. In this case, when it is determined as Yes in the previous step S3, the control unit 31 controls the opening/closing of the main valve 12, the tandem valve 14, and the sub-valve 22 individually in accordance with the modified weft insertion condition modified in step S4, and then the weft insertion of the weft yarn 11 is performed. Alternatively, when it is determined as No in the previous step S3, the control unit 31 controls the opening/closing of the main valve 12, the tandem valve 14, and the sub-valve 22 individually in accordance with the weft insertion condition before the modification made in step S4, and then the weft insertion of the weft yarn 11 is performed.

Effects of the Embodiment

[0049] As illustrated in FIG. 4, by adopting the method of controlling the weft insertion of the air jet loom according to the present embodiment of the present disclosure, the distribution of the actual weft yarn arrival timings of the weft yarn 11 does not form a normal distribution and does not include the distribution area E where weft insertion failure due to a yarn break is likely to occur, unlike the normal distribution illustrated in FIG. 3. Thus, the timing at which the weft yarn feeler 10 senses the arrival of the weft yarn 11, that is, the actual weft yarn arrival timing will not be earlier than the earlier limit TWf. Therefore, the occurrence of weft insertion failure due to a yarn break that may occur when the weft yarn 11 is inserted in the air jet loom is sufficiently prevented.

Modifications

[0050] It is to be noted that the technical scope of the present disclosure should not be construed as limited to the embodiment described above and may include various modifications and improvements thereof, as long as such modifications and improvements derive specific effects obtained by the components or elements of the present disclosure or a combination thereof.

[0051] For example, in the above embodiment, although the weft yarn mass is exemplified as a characteristic of the weft yarn 11 to be detected by the weft yarn characteristics detection unit 3, the characteristics of the present disclosure is not limited thereto. For example, the thickness or fluffiness of the weft yarn, which may influence the flight of a weft yarn, if any, may be detected by the weft yarn characteristics detection unit 3 and then be used by the control unit 31 for the feed-back control of the weft insertion.

Claims

1. A method of controlling weft insertion of an air jet loom, the air jet loom comprising a weft insertion nozzle (6, 7, 8) that injects air for weft insertion to transfer a weft yarn (11) in a weft insertion direction, the method being **characterized by** comprising the steps of:

detecting a characteristic of a weft yarn (11) that is yet to be inserted;

predicting a weft yarn arrival timing (TWp) at which the weft yarn (11) that is inserted in accordance with a specified weft insertion condition arrives at a specified position in the weft insertion direction, on the basis of the characteristic of the weft yarn (11) that is detected in the detecting step;

when the weft yarn arrival timing (TWp) that is predicted in the predicting step is earlier than an earlier limit (TWf) that is predetermined relative to variations in the weft yarn arrival timing, modifying the weft insertion condition so that an actual weft yarn arrival timing is later than the earlier limit (TWf); and

performing a weft insertion of the weft yarn (11) by injecting air from the weft insertion nozzle (6, 7, 8) on the basis of the weft insertion condition that is modified in the modifying step.

2. The method of controlling weft insertion of the air jet loom according to claim 1, **characterized in that** the earlier limit (TWf) is modified on the basis of the characteristic of the weft yarn (11) that is detected in the detecting step.

3. The method of controlling weft insertion of the air jet loom according to claim 1 or 2, **characterized in that** the weft insertion nozzle (6, 7, 8) includes a main nozzle (6), and when the weft yarn arrival timing (TWp) that is predicted in the predicting step is earlier than the earlier limit (TWf), an opening degree for air injection of the main nozzle (6) is modified as the weft insertion condition in the modifying step.

4. The method of controlling weft insertion of the air jet loom according to any one of claims 1 to 3, **characterized in that** the weft insertion nozzle (6, 7, 8) includes a tandem nozzle (7), and
when the weft yarn arrival timing (TWp) that is predicted in the predicting step is earlier than the earlier limit (TWf), an air injection start timing of the tandem nozzle (7) is modified as the weft insertion condition in the modifying step.

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FIG. 1

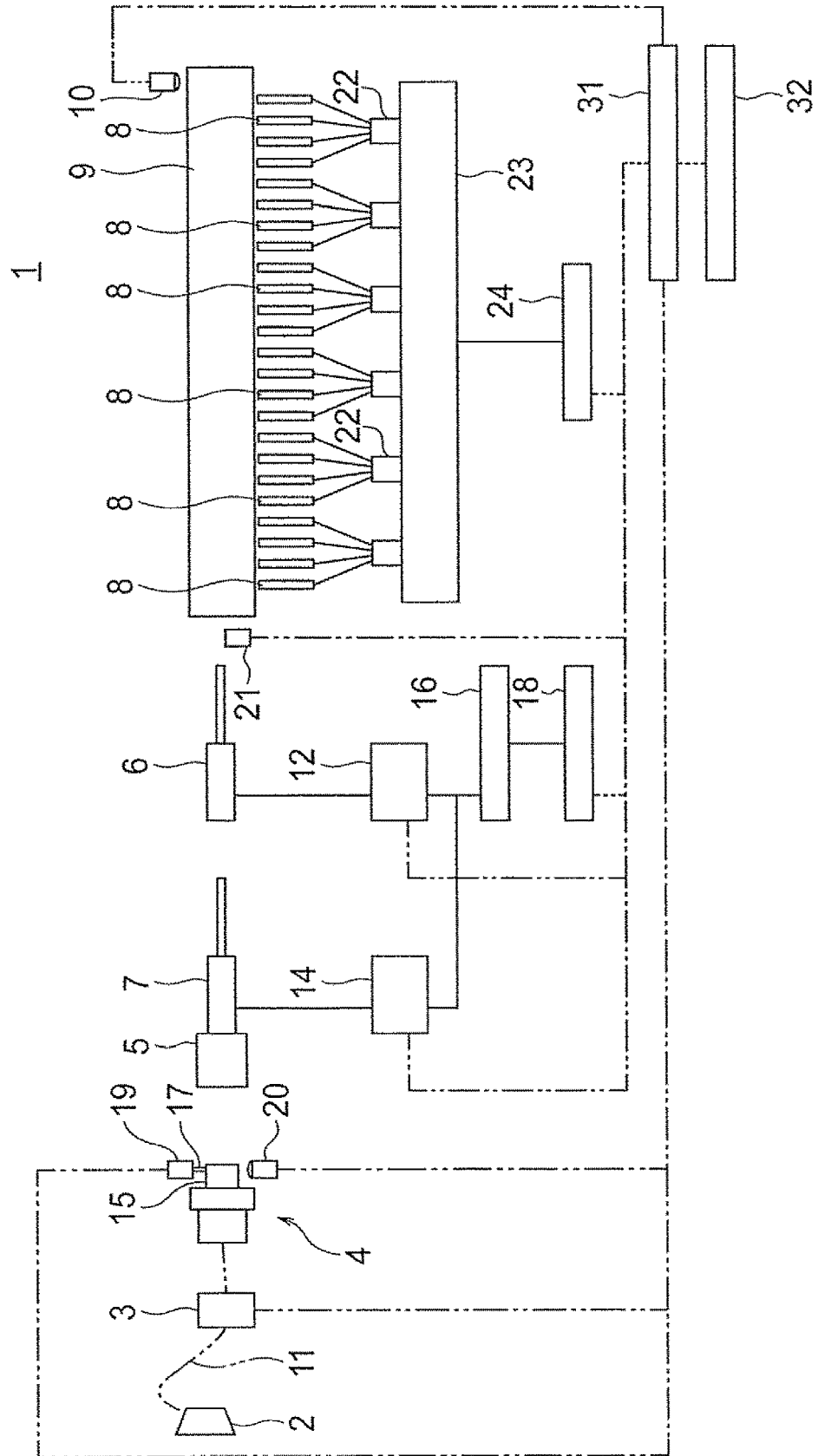


FIG. 2

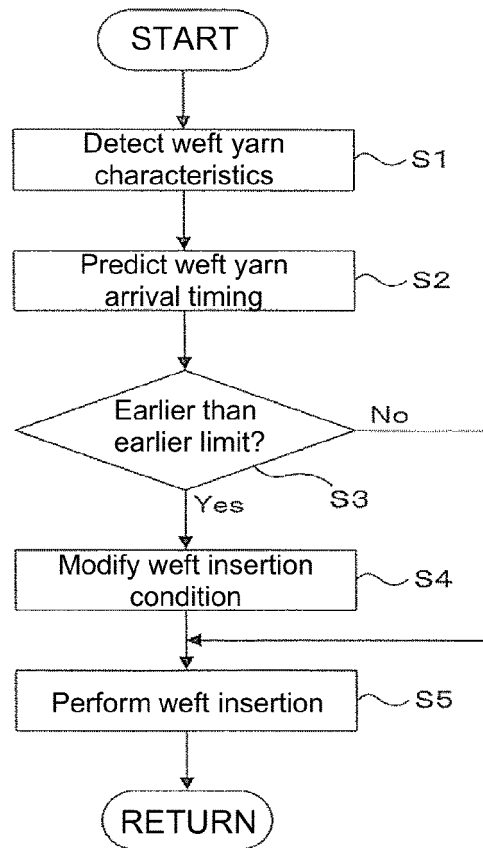


FIG. 3

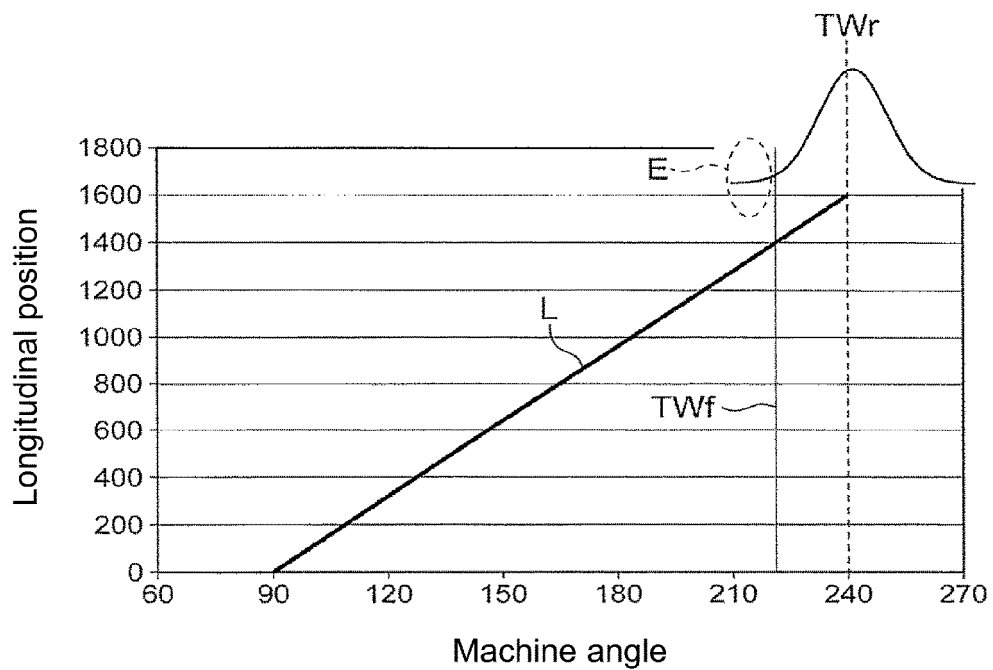
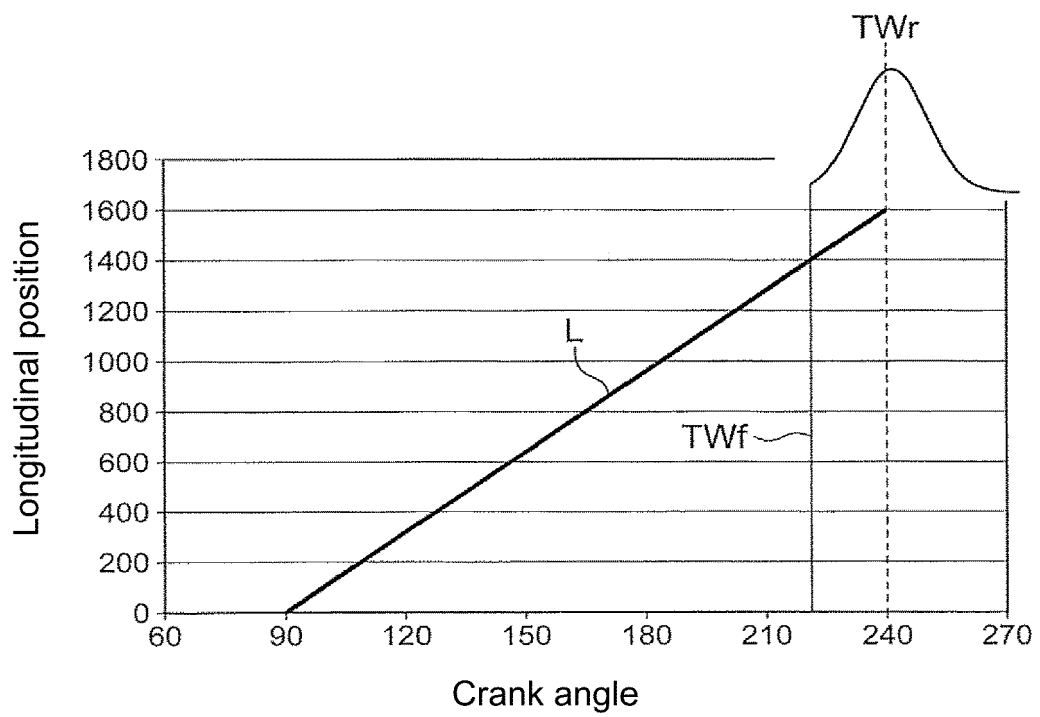


FIG. 4





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Place of search Munich		Date of completion of the search 11 September 2019	Examiner Louter, Petrus
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