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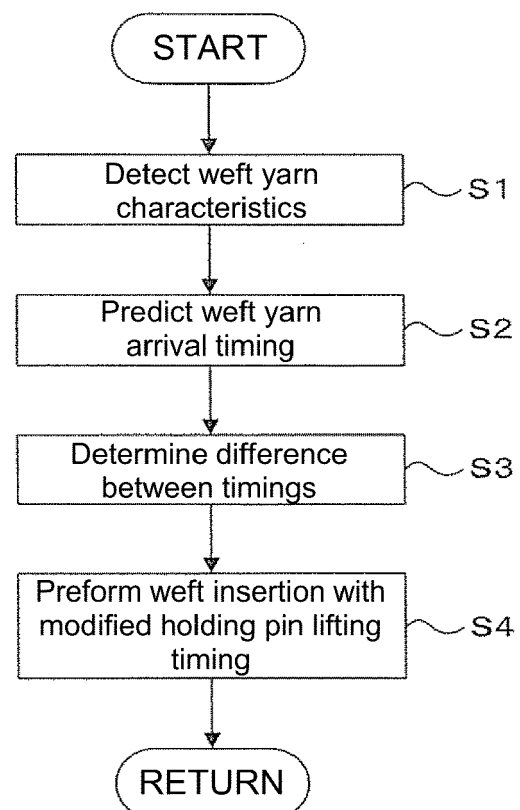
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(54) **METHOD OF CONTROLLING WEFT INSERTION OF AIR JET LOOM**

(57) A method of controlling weft insertion of an air jet loom that includes a holding pin (17) configured to hold and release a weft yarn (11), and a weft insertion nozzle (6, 7, 8) that injects air is provided. The method includes the steps of: detecting a characteristic of the weft yarn (11) that is yet to be inserted; predicting a weft yarn arrival timing at which the weft yarn (11) inserted in accordance with a specified weft insertion condition arrives at a specified position in a weft insertion direction, on the basis of the detected characteristic of the weft yarn (11); determining a difference between the predicted weft yarn arrival timing (TWp) and a target weft yarn arrival timing (TWr); modifying a lifting timing of the holding pin (17) in accordance with the determined difference; and lifting the holding pin (17) at the modified lifting timing to insert the weft yarn (11).

FIG. 4



Description

BACKGROUND ART

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

[0002] A technique regarding an air jet loom in which weft yarns are inserted by utilizing compressed air is disclosed, for example, in Published Japanese Translation No. 2014-500914 of PCT International Application No. PCT/CH2011/000284. According to the Publication, a weft insertion is controlled using a feed-forward control on the basis of the characteristics of the weft yarn that is yet to be inserted. The characteristics of the weft yarn that is yet to be inserted is detected by means of a sensor and the air pressure or the duration of opening of a nozzle is calculated based on the detected characteristics of the weft yarn to thereby control the weft insertion.

[0003] In an air jet loom, a weft yarn is transferred to a specified position using air injected from weft yarn nozzles. In this case, the weft yarn arrival timing at which the weft yarn transferred by the air arrives at a specified position may be too early or too late and such early arrival or late arrival the weft yarn may result in a weft insertion failure. Thus, in the feed-forward control, when the predicted weft yarn arrival timing that is predicted prior to the actual weft insertion is deviated from the target weft yarn arrival timing, such deviation needs to be corrected by modifying the weft insertion condition. According to the technique described in Published Japanese Translation No. 2014-500914 of PCT International Application No. PCT/CH2011/000284, as the parameter of the feed-forward control, the air pressure of a nozzle or the duration of opening of the nozzle is calculated.

[0004] However, the varying manner of the weft yarn arrival timing after the duration of opening of the nozzle is modified varies depending on the type of the weft yarn (material and yarn count). Furthermore, even the weft yarn arrival timing of a fixed type of weft yarn also varies depending on the air pressure of the nozzle used for the weft insertion. As the reason for such varying weft yarn arrival timing, the influences of the duration of opening of the nozzle and the air pressure of the nozzle on the transfer speed of the weft yarn are considered. For example, how the transfer speed of the weft yarn varies after the duration of opening of the nozzle is modified depends on the type of the weft yarn and the air pressure of the nozzle. Thus, when a weft insertion is performed by the feed-forward control utilizing the duration of opening of the nozzle or the air pressure of the nozzle as a control parameter, in the same manner as the technique described in Published Japanese Translation No. 2014-500914 of PCT International Application No. PCT/CH2011/000284, the calculation values to be used for the control vary depending on the type of the weft yarn or the air pressure of the nozzle. Thus, in the technique described in Published Japanese Translation No. 2014-500914 of PCT International Application No.

PCT/CH2011/000284, complicated calculation is required for the feed-forward control.

[0005] 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 simplifies the calculations for weft insertion that uses the feed-forward control.

SUMMARY

[0006] In accordance with an aspect of the present disclosure, there is provided a method of controlling weft insertion of an air jet loom that includes a holding pin configured to hold and release a weft yarn that is used for weft insertion; and a weft insertion nozzle that injects air for weft insertion, wherein the weft yarn is inserted by lifting the holding pin to release the weft yarn and transferring the released weft yarn in a weft insertion direction with the air injected from the weft insertion nozzle. The method includes the steps of: detecting a characteristic of the 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; determining a difference between the predicted weft yarn arrival timing that is predicted in the predicting step and a target weft yarn arrival timing; modifying a lifting timing of the holding pin at which the holding pin is lifted in accordance with the difference between the predicted weft yarn arrival timing and the target weft yarn arrival timing that is determined in the determining step; and lifting the holding pin at the modified lifting timing that is modified in the modifying step to insert the weft yarn.

[0007] 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

[0008] 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 diagram for describing a first operating state of a holding pin;

FIG. 3 is a diagram for describing a second operating state of the holding pin; and

FIG. 4 is a flow chart depicting a method of controlling

weft insertion of the air jet loom according to the embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0009] 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

[0010] 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.

[0011] The weft insertion apparatus 1 includes a weft yarn cheese 2, a weft yarn characteristics 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.

[0012] 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.

[0013] 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.

[0014] 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 injection of air, the characteristics of the weft yarn 11 influences 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.

[0015] The weft yarn storing unit 4 is configured to store a weft yarn 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.

[0016] The holding pin 17 is a pin configured to hold and release the weft yarn 11 for weft insertion. The holding pin 17 is caused to operate in accordance with the driving of the electromagnetic solenoid 19. The control unit 31 controls the driving of the electromagnetic solenoid 19. The operating state of the holding pin 17 is switchable by the control of the driving of the electromagnetic solenoid 19 by the control unit 31. The operating state of the holding pin 17 includes a first operating state and a second operating state that will be described later in detail.

[0017] The first operating state of the holding pin 17 herein refers to the state in which the holding pin 17 is caused to extend in a direction approaching an outer peripheral surface of the measuring drum 15 by driving the electromagnetic solenoid 19, so that the holding pin 17 holds the weft yarn 11 (hereinafter, referred to as the holding state), as depicted in FIG. 2. Under the holding state, the weft yarn 11 is held on the outer peripheral surface of the measuring drum 15 so that the weft yarn 11 wound around the measuring drum 15 is not let off toward the tandem nozzle 7.

[0018] The second operating state of the holding pin 17 herein refers to the state in which the extended holding pin 17 is lifted or retracted in a direction separating from the outer peripheral surface of the measuring drum 15 by driving the electromagnetic solenoid 19, so that the holding state of the holding pin 17 holding the weft yarn 11 is released (hereinafter, referred to as the release state), as depicted in FIG. 3. Under the release state, the weft yarn 11 that is wound around the measuring drum 15 prior to the lifting of the holding pin 17 is released and let off toward the tandem nozzle 7 upon the lifting of the holding pin 17.

[0019] 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.

[0020] 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.

[0021] 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 insertion 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.

[0022] The main nozzle 6 is connected to the main tank 16 via the main valve 12. The tandem nozzle 7 is con-

nected 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.

[0023] 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.

[0024] In a picking (weft insertion) of the weft yarn 11 using the air injected from the main nozzle 6 and the tandem nozzle 7, the main valve 12 and the tandem valve 14 are opened at their respective specified timings to inject compressed air from the main nozzle 6 and the tandem nozzle 7. After compressed air for one picking of the weft yarn is injected from each of the main nozzle 6 and the tandem nozzle 7, breeze air is kept flowing from the main nozzle 6 and the tandem nozzle 7 until the next picking (weft insertion). With the breeze air, the posture of the weft yarn 11 is maintained horizontally in a segment of the weft path between the tandem nozzle 7 and a point immediately before the reed 9. When the holding pin 17 holding the weft yarn 11 that is wound around the measuring drum 15 is lifted by driving the electromagnetic solenoid 19, the weft yarn 11 is released and transferred to the downstream side by the air injected from the main nozzle 6 and the tandem nozzle 7. Thus, the lifting timing of the holding pin 17 at which the holding pin 17 is lifted and the weft insertion start timing occur substantially at the same time.

[0025] 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.

[0026] 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 configured 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.

[0027] 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.

[0028] 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.

[0029] 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.

[0030] 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.

[0031] 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 (material, yarn count) 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 the weaving width of the woven fabric.

Method of Controlling Weft Insertion in Air Jet Loom

[0032] 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. 4. It is to be noted that the method of controlling weft insertion depicted in FIG. 4 is applied to one picking of the weft yarn 11 and accordingly repeated with the repetition of pickings.

Step 1

[0033] At first, in step S1, characteristics of the weft yarn 11 that is yet to be inserted are detected.

[0034] 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

[0035] 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.

[0036] In the memory of the control unit 31, specified weft insertion conditions for each of the yarn types of the weft yarns 11 are registered beforehand. The CPU of the control unit 31 selects a weft insertion condition that cor-

responds 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 duration of air injection of the main nozzle 6, the duration of air injection of the tandem nozzle 7, the air injection start timing of the main nozzle 6, and the air injection start timing of the tandem nozzle 7. Among the above weft insertion conditions, the pressure of the main tank 16 and the pressure of the sub-tank 23 correspond to the aforementioned air pressure, and the duration of air injection of the main nozzle 6 and the duration of air injection of the tandem nozzle 7 correspond to the aforementioned duration of opening of the nozzle.

[0037] 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.

[0038] 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 is later than the target 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 target weft yarn arrival timing TWr. In this case, the difference between the target 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.

[0039] 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

[0040] Subsequently, in step S3, a difference or deviation between the predicted weft yarn arrival timing TWp that is predicted in the previous step S2 (hereinafter, simply referred to as the predicted arrival timing TWp) and the target weft yarn arrival timing TWr (hereinafter, simply referred to as the target arrival timing TWr) is determined. The control unit 31 performs the processing of Step S3. The target arrival timing TWr is set to a timing at which the loom is at a specified crank angle in the range from 0 to 360 degrees. The control unit 31 confirms whether the predicted arrival timing TWp is advanced or delayed relative to the target arrival timing TWr, and determines the difference or deviation from the target arrival timing TWr. The control unit 31 recognizes the target arrival timing TWr and the predicted arrival timing TWp as their corresponding loom crank angles. When the predicted arrival timing TWp corresponds to the loom crank angle of θ_a and the target arrival timing TWr corresponds to the loom crank angle of θ_b , then the control unit 31 recognizes the difference or deviation between the predicted arrival timing TWp and the target arrival timing TWr as the difference $\Delta\theta$ between the two loom crank angles θ_a and θ_b . That is, the difference $\Delta\theta$ between the timings TWp and TWr is calculated using the equation $\Delta\theta = \theta_a - \theta_b$.

[0041] For example, when $\theta_a = 235^\circ$ and $\theta_b = 240^\circ$, the difference $\Delta\theta$ between the predicted arrival timing TWp and the target arrival timing TWr is calculated using the above equation. In this case, the control unit 31 recognizes the difference $\Delta\theta$ is -5° . When $\theta_a = 243^\circ$ and $\theta_b = 240^\circ$, the difference $\Delta\theta$ between the predicted arrival timing TWp and the target arrival timing TWr is calculated using the above equation. In this case, the control unit 31 recognizes the difference or deviation $\Delta\theta$ is $+3^\circ$. When $\Delta\theta$ is a negative value, the predicted arrival timing TWp is earlier than the target arrival timing TWr, whereas when $\Delta\theta$ is a positive value, the predicted arrival timing TWp is later than the target arrival timing TWr. In the present embodiment, the predicted arrival timing TWp and the target arrival timing TWr are recognized as their corresponding loom crank angles. However, the predicted arrival timing TWp and the target arrival timing TWr may be recognized by the time elapsed since a given loom crank angle is reached.

Step S4

[0042] Subsequently, in step S4, a lifting timing of the holding pin 17 is modified in accordance with the difference or deviation in the weft yarn arrival timings calculated in the previous step S3. The holding pin 17 is retracted and lifted at the modified lifting timing and a weft insertion of the weft yarn 11 is performed. In the processing of step S4, the control unit 31 performs the modification of the lifting timing of the holding pin 17, and the lifting of the holding pin 17 is controlled by the driving of the

electromagnetic solenoid 19 by the control unit 31. Weft insertion of the weft yarn 11 is performed using the air injected from the weft insertion nozzles 6, 7, and 8, and the injection of air from the weft insertion nozzles 6, 7, and 8 is controlled by controlling the opening/closing of the valves 12, 14, and 22, respectively by the control unit 31. It is to be noted that the weft yarn 11 that is yet to be inserted is maintained in the holding state by the holding pin 17 until the holding pin 17 is lifted in step S4.

[0043] The weft insertion conditions to be applied to the prediction of the weft yarn arrival timing TWp include the pressure of the main tank 16, the pressure of the sub-tank 23, the duration of air injection of the main nozzle 6, the duration of air injection of the tandem nozzle 7, the air injection start timing of the main nozzle 6, and the air injection start timing of the tandem nozzle 7, or the like. However, each and every of these weft insertion conditions has an influence on the transfer speed of the weft yarn 11. Thus, for example, when the duration of air injection of the main nozzle 6 is modified in accordance with the difference or deviation between the predicted arrival timing TWp and the target arrival timing TWr, how the transfer speed varies in response to the modification of the duration of air injection, and how the weft yarn arrival timing varies in response to the varied transfer speed need be determined for each of the yarn types of the weft yarn 11, and the determination requires complicated calculations.

[0044] In contrast to this, in the present embodiment, only the lifting timing of the holding pin 17, which has no influence on the transfer speed of the weft yarn 11, is modified instead of the above conditions that influences the transfer speed of the weft yarn 11. Specifically, the control unit 31 modifies and moves the lifting timing of the holding pin 17 to the reverse side by the same amount as the amount of the difference or deviation between the predicted arrival timing TWp and the target arrival timing TWr. Moving the lifting timing of the holding pin 17 to the reverse side herein refers to moving the lifting timing of the holding pin 17 in a direction opposite to the direction of deviation of the predicted arrival timing TWp from the target arrival timing TWr. For example, when the predicted arrival timing TWp is deviated to the advanced side relative to the target arrival timing TWr, the lifting timing of the holding pin 17 is moved to the delayed side that is opposite to the direction of the deviation, and when the predicted arrival timing TWp is deviated to the delayed side relative to the target arrival timing TWr, the lifting timing of the holding pin 17 is moved to the advanced side that is opposite to the direction of the deviation.

[0045] Here, it is assumed that the lifting timing of the holding pin 17 that is yet to be modified is the reference lifting timing, then the control unit 31 modifies the lifting timing of the holding pin 17 to be applied to the actual weft insertion in the following manner. For example, when $\theta_a = 235^\circ$ and $\theta_b = 240^\circ$, the control unit 31 modifies and moves the lifting timing of the holding pin 17 to the delayed side by the same amount as the amount of deviation.

tion, $\Delta\theta = -5^\circ$, that is, the amount of deviation corresponding to the loom crank angle of 5° . When $\theta_a = 243^\circ$ and $\theta_b = 240^\circ$, the control unit 31 modifies and moves the lifting timing of the holding pin 17 to the advanced side by the same amount as the amount of deviation, $\Delta\theta = +3^\circ$, that is, the amount of deviation corresponding to the loom crank angle of 3° . With this operation, the difference or deviation between the predicted arrival timing TWp and the target arrival timing TWr is cancelled by the modification of the lifting timing of the holding pin 17.

[0046] After the lifting timing of the holding pin 17 is modified as described above, the control unit 31 drives the electromagnetic solenoid 19 in accordance with the modified lifting timing of the holding pin 17 to retract the holding pin 17. Thus, the holding state of the weft yarn 11 is released at the same time of the lifting of the holding pin 17. The weft yarn 11 that is wound around the measuring drum 15 is let off toward the tandem nozzle 7 at the same time of the lifting of the holding pin 17. The weft yarn 11 that is let off from the measuring drum 15 is transferred and inserted in the longitudinal direction of the reed 9 by the air injected from the weft insertion nozzles 6, 7, and 8.

Effects of the Embodiment

[0047] In the present embodiment of the present disclosure, when a weft insertion is performed on the basis of the characteristics of the weft yarn 11 and using the feed-forward control, the lifting timing of the holding pin 17 is modified in accordance with the difference or deviation between the predicted arrival timing TWp and the target arrival timing TWr, and the holding pin 17 is retracted in accordance with the modified lifting timing. In this case, the lifting timing of the holding pin 17 does not influence the transfer speed of the weft yarn 11. The lifting timing of the holding pin 17 is a factor that determines the weft insertion start timing. Therefore, by modifying the lifting timing of the holding pin 17, the deviation of the weft yarn arrival timing may be corrected without modifying the transfer speed of the weft yarn 11. With this operation, even when a weft yarn 11 of a different type is inserted, the lifting timing of the holding pin 17 may be modified using the same equation. Thus, the calculation for the weft insertion with the feed-forward control may be simplified. Furthermore, the amount of data required for the feed-forward control may be reduced.

Modifications

[0048] 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.

[0049] For example, in the above embodiment, al-

though 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.

[0050] In the above embodiment, the control unit 31 modifies the lifting timing of the holding pin 17 by the same amount as the amount of the difference or deviation between the predicted arrival timing TWp and the target arrival timing TWr. However, the configuration of the present disclosure is not limited thereto. For example, the control unit 31 may multiply the amount of the deviation between the predicted arrival timing TWp and the target arrival timing TWr by a predetermined coefficient and modify the lifting timing of the holding pin 17 by the amount corresponding to the value obtained by the multiplication.

[0051] A method of controlling weft insertion of an air jet loom that includes a holding pin (17) configured to hold and release a weft yarn (11), and a weft insertion nozzle (6, 7, 8) that injects air is provided. The method includes the steps of: detecting a characteristic of the weft yarn (11) that is yet to be inserted; predicting a weft yarn arrival timing at which the weft yarn (11) inserted in accordance with a specified weft insertion condition arrives at a specified position in a weft insertion direction, on the basis of the detected characteristic of the weft yarn (11); determining a difference between the predicted weft yarn arrival timing (TWp) and a target weft yarn arrival timing (TWr); modifying a lifting timing of the holding pin (17) in accordance with the determined difference; and lifting the holding pin (17) at the modified lifting timing to insert the weft yarn (11).

Claims

1. A method of controlling weft insertion of an air jet loom, the air jet loom including:

a holding pin (17) configured to hold and release a weft yarn (11) that is used for weft insertion; and
a weft insertion nozzle (6, 7, 8) that injects air for the weft insertion, wherein the weft yarn (11) is inserted by lifting the holding pin (17) to release the weft yarn (11) and transferring the released weft yarn (11) in a weft insertion direction with the air injected from the weft insertion nozzle (6, 7, 8),
the method being **characterized by** comprising the steps of:

detecting a characteristic of the 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 5
the weft insertion direction, on the basis of
the characteristic of the weft yarn (11) that
is detected in the detecting step;
determining a difference between the pre- 10
dicted weft yarn arrival timing (TWp) that is
predicted in the predicting step and a target
weft yarn arrival timing (TWr);
modifying a lifting timing of the holding pin
(17) at which the holding pin (17) is lifted in 15
accordance with the difference between the
predicted weft yarn arrival timing (TWp) and
the target weft yarn arrival timing (TWr) that
is determined in the determining step; and
lifting the holding pin (17) at the modified 20
lifting timing that is modified in the modifying
step to insert the weft yarn (11).

2. The method of controlling weft insertion of the air jet
loom according to claim 1, **characterized in that** 25
in the modifying step, the lifting timing of the holding
pin (17) is moved in a direction opposite to a direction
of deviation of the predicted weft yarn arrival timing
(TWp) from the target weft yarn arrival timing (TWr),
and by an amount that is the same as an amount of 30
the difference between the predicted weft yarn arrival
timing (TWp) and the target weft yarn arrival timing
(TWr).

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FIG. 1

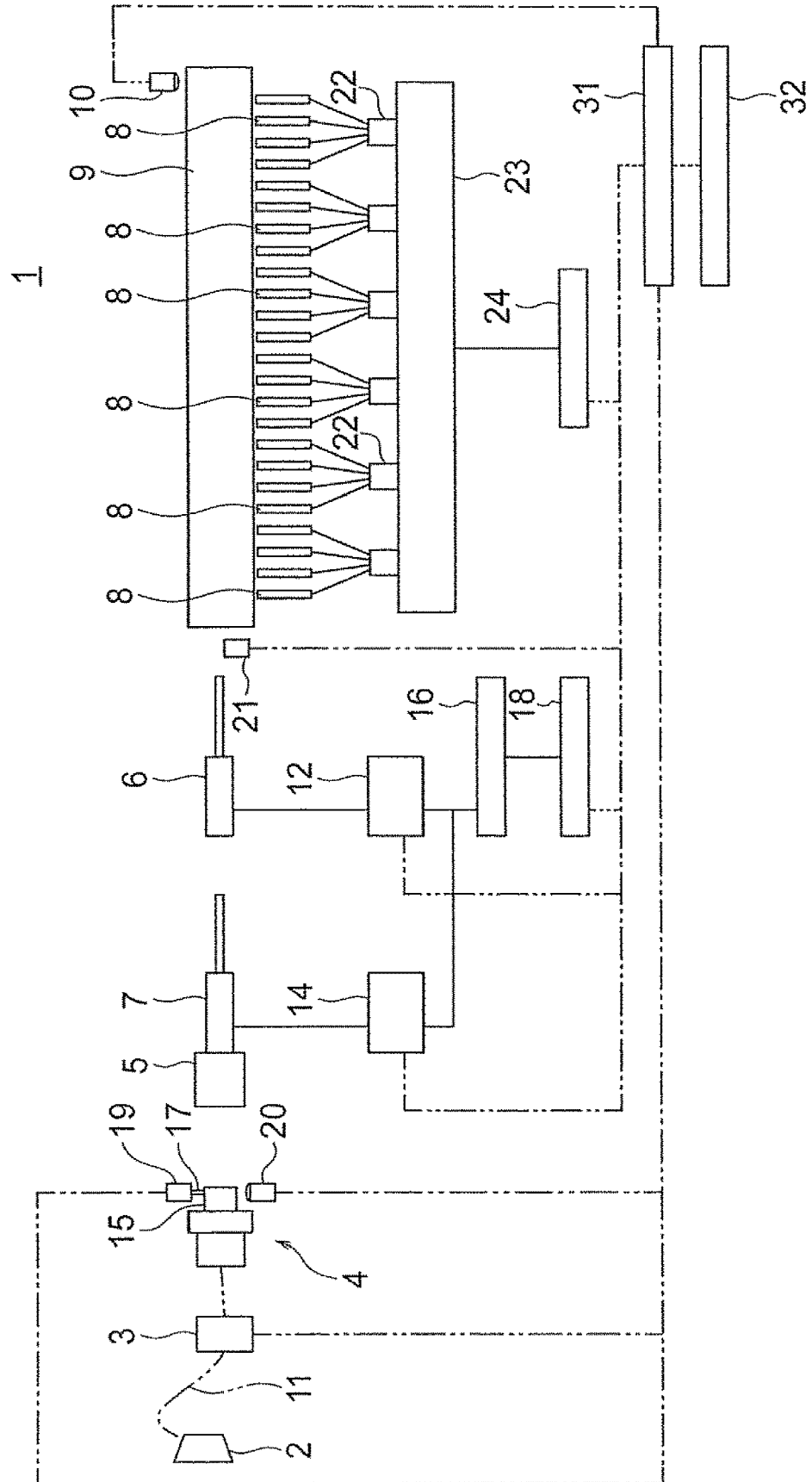


FIG. 2

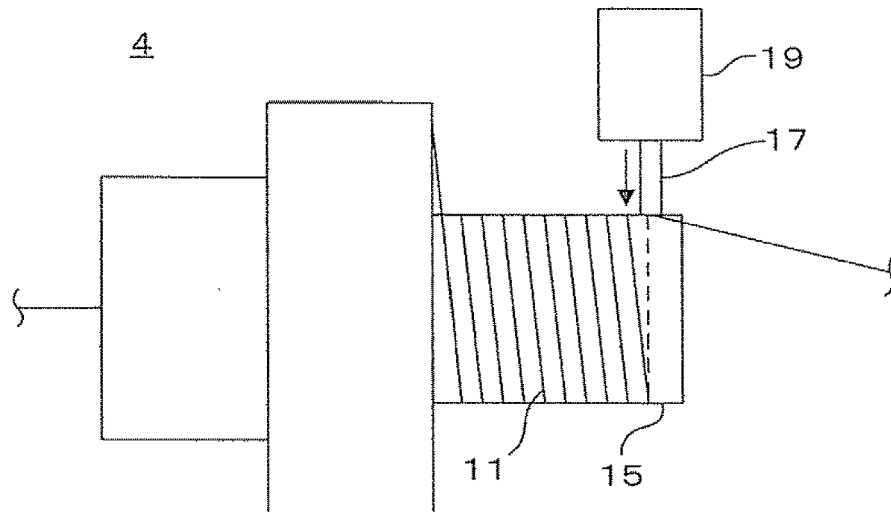


FIG. 3

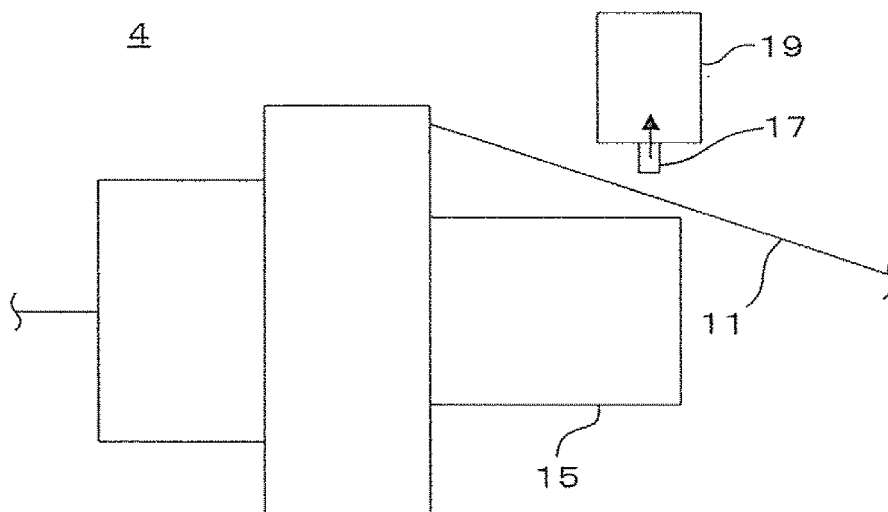
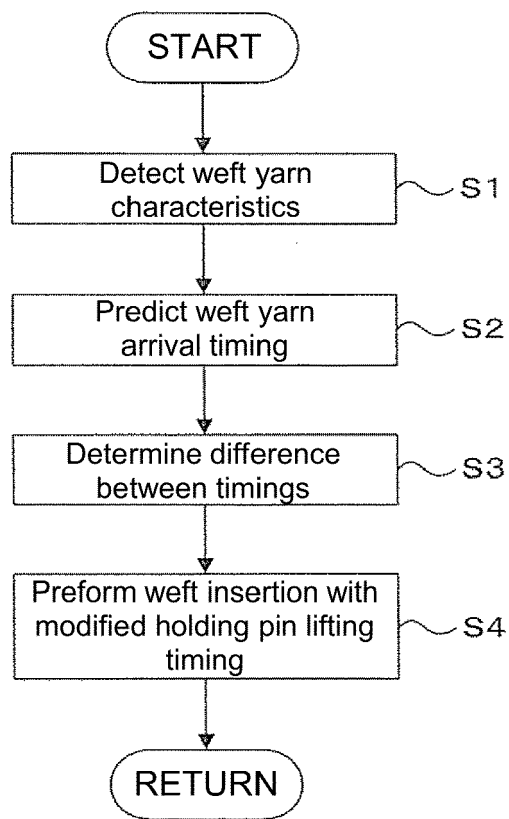


FIG. 4





EUROPEAN SEARCH REPORT

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			TECHNICAL FIELDS SEARCHED (IPC)
			D03D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 August 2019	Examiner Louter, Petrus
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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