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- **GAO, Weidong**
Wuxi
Jiangsu 214122 (CN)
- **YANG, Ruihua**
Wuxi
Jiangsu 214122 (CN)
- **GUO, Mingrui**
Wuxi
Jiangsu 214122 (CN)

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(71) Applicant: **Jiangnan University**
Wuxi, Jiangsu 214122 (CN)

(74) Representative: **Berkkam, Ayfer**
Berkkam Patent Consulting
Büklüm Sokak, No. 5/16-3
06680 Kavaklıdere Ankara (TR)

(72) Inventors:
• **XUE, Yuan**
Wuxi
Jiangsu 214122 (CN)

(54) **ROTOR SPINNING METHOD AND APPARATUS USING TWO-COTTON-SLIVER ASYNCHRONOUS INPUT AND THREE-STAGE CARDING**

(57) Disclosed is a device for a rotor spinning method using multi-level carding. The device includes a spinning system and a computer control system. The spinning system includes a feeding and carding mechanism, a collecting and twisting mechanism, and a winding mechanism. The feeding and carding mechanism includes a combined feeding roller (2-1, 2-2) with two rotational freedom degrees and a multi-level carding roller (2-6, 2-7, 2-8), the speed ratio of two rollers of the combined feeding roller (2-1, 2-2) with two rotational freedom degrees is adjustable, and therefore the linear density and blending ratio of rotor spun yarn can be regulated and controlled freely. A rotor spinning method using two-cotton-sliver asynchronous inputting and three-level carding is also disclosed.

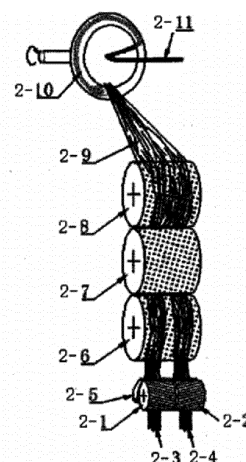


FIG. 2

Description**TECHNICAL FIELD**

[0001] The present invention relates the field of rotor spinning in the textile industry.

BACKGROUND

[0002] The basic principle of the rotor spinning yarn is that the sliver is fed through the trumpet and is held by a feeding plate and a feeding roller. The feeding roller rotates to feed the sliver to the carding area. The sliver is opened and stripped, carded separately and mixed by the carding roller, which rotates at a high speed in the carding area, so that the sliver becomes single fibers which are separated and arranged in parallel to each other. The single fibers enter into a fiber transport channel. Under the action of air flow, the fiber flows into the rotor through the fiber transport channel. With the centrifugal force of the rapidly rotating rotor, the fibers in the collection groove are further piled up and mixed, and then the fibers are jointed with the mother-yarn and twisted by a navel to form a yarn.

[0003] In the Patent "Rotor spinning melange yarn forming method and device and product (Application No. CN201410190891.1)" and "Device of spinning rotor spun melange yarn (CN201420229715.X)", the speed of the feeding roller is controlled to keep feeding in an invariable amount, or two or more drawn slivers are fed in segments in different amounts, resulting in a blending ratio that has a monochromatic or a multi-color fiber mixture, so as to achieve an effect that the blending ratio can be adjusted while the density of the spun yarn is invariable. However, these two inventions have two problems. First, in those inventions, only the concept of realizing the blending and segment-color spinning process with invariable linear density through the proposed coupling and drafting method, and no indication is given to show how to change the mixing ratio or color blending ratio under the condition that the coupling and drafting achieves an invariable linear density. In the meantime, no specific embodiments and examples are disclosed. Second, a conventional single carding roller is still used in those patent applications. When three slivers are fed at the same time, the original carding and drafting system cannot adequately strip, card, mix, break down and draft a plurality of slivers, which will cause inadequate break down of fiber plexus, resulting in blocking the carding roller and rotor, and will be prone to yarn broken and slub, nep and other defects. At the same time, although the total amount of each sliver by coupling and feeding is invariable, there is still a difference in the feeding amount of each sliver, and the short carding area causes little chance of horizontal fiber mixing, resulting in unsatisfactory color blending effect.

[0004] At present, the patent "Method and equipment for rotor spun slub yarn" (patent number CN00137211.4) can achieve invariable blending ratio but the linear density changes during the rotor spinning process. The principle of the patent is that the asynchronous motor and the stepper motor drive feeding roller through the differential, screw and worm wheel. The stepper motor, under the control of the intelligent controller, performs the following operations: reducing from high speed to low speed; continuing to run for a period of time; accelerating to high speed; continuing to run for a period of time, and the rotor spins a segment of slub yarn. The patent can produce a yarn with variable densities but cannot change blending ratios of the yarn.

[0005] The production of the yarn with the linear density and blending ratio both changed, requires not only that the feeding amount of the two or more of the fed roving can be controlled separately on line, but also that the total amount of the fed roving can be controlled when the feeding amount of the roving is changed. There is no prior art that discloses the production of such yarn. The main problem of the existing rotor spinning technology which can produce the yarn having an invariable linear density and blending ratio is that it is impossible to blend two or more fibers in any proportion during the rotor spinning process.

SUMMARY OF THE INVENTION

[0006] In order to solve the above problem, the present invention improves the structure of the conventional rotor spinning machine. A device for implementing a rotor spinning method with three-level carding and multi-component feeding, includes a spinning system and a computer control system. The spinning system comprises a feeding and carding mechanism, a collecting and twisting mechanism, and a winding mechanism. The device is characterized in that the feeding and carding mechanism comprises a three-level carding roller and a combined feeding roller with two rotation freedom degrees. The speed ratio of the two combined feeding rollers with two rotational freedom degrees that can be adjusted. The collecting and twisting mechanism include a fiber transport channel, a rotor, and a yarn guider. The winding mechanism includes a couple of guide rollers and winding mechanism. The computer control system includes a PLC programmable controller, a servo driver, and a servo motor. The combined feeding roller with two rotation freedom degrees and the three-level carding roller are driven by the servo motor. The combined feeding rollers with rotational freedom degrees comprises a shaft, a bearing, a hollow shaft, a first gear, a second gear, a washer, a first movable roller, and a second movable roller. The first and the second gears and the first and the second movable rollers

rotate around the same axis. The first and the second gears respectively drive the first and the second movable rollers. The three-level carding roller comprises the first carding roller, the second carding roller, and the third roller that are arranged in parallel. The rotation speed of the three-level carding roller is progressively increased from the first level to the third level. The rotation speed of the first carding roller is 1500-3000 rpm, the rotation speed of the second carding roller is 3000-6000 rpm, and the rotation speed of the third carding roller is 6000-12000 rpm. The density of carding needles of the three-level carding roller progressively increases from the first carding roller to the third carding roller.

[0007] Another objective of the present invention is to provide a rotor spinning method using the above device. The method includes feeding, carding, collecting and twisting, guide and winding. The method is characterized in that the combined feeding roller with two rotational freedom degrees are used in the fiber feeding to feed the fiber into the carding area asynchronously, and three-level carding roller is used in the carding process.

[0008] With the combined rollers and the three-level carding roller configured in the present invention, two slivers (or two different raw material slivers, or two kinds of colored slivers, hereinafter referred to as two components) can be asynchronously fed into the rotor spinning and carding area through the combined feeding roller. After opening, carding, orienting, separating and mixing by the three-level carding roller, the two slivers are gradually combed into bundle fibers and further combed into single fibers. Under the action of centrifugal force and air flow, a continuous flow comprised by single fiber flow released and transferred from the carding roller enters into the rotor rotating at a high speed. In the rotor, the fiber flow, under the centrifugal force, is collected together into a sliver again, and then twisted by the navel, and then guided by the guide roller to form the rotor spinning yarn. In the process of spinning, the servo driving system is controlled by a computer program to feed two slivers asynchronously to the carding area by the feeding roller having two freedom degrees. By controlling the feeding amount and feeding ratio of the two feeding rollers, it is possible to dynamically configure the final yarn density of the rotor spinning and the blending ratio of the two components to produce slub yarn, segment-color yarn, segment-color slub yarn, and mélange yarn.

[0009] The speed of the first carding roller is relatively low, so that it is ensured that when the plurality of the slivers with great difference are fed, the total number of carding fibers of each sliver carded by the carding roller are within a reasonable range, thereby reducing damage to the fiber. The speed of the second carding roller is higher than that of the first carding roller. After being carded by the second carding roller, the longitudinal orientation of the fiber is optimized, horizontal transfer mixing of the fiber is further optimized. The third carding roller is a high-speed carding roller. The fiber, after being carded by the third carding roller, obtains not only a better carding and transfer, but also the transport speed is improved, thereby meeting the requirement of centrifugal force for entering the fiber transport channel. Therefore, the fiber can smoothly and orderly go into the rotor to form yarns. Through the multi-level stripping, opening, cleaning, carding, separating, and transferring, the large-scale drafting function where the slivers are combed into web, which is then combed into bundles of fibers, which are then separated as single fibers is successfully completed, which enhances the function of the carding area of the rotor spinning, providing flexibility, high efficiency, and high yield.

(2) Based on the mechanical innovation design, the present invention constructs the corresponding mathematical model of spinning and the algorithm of the program. Through the mechatronic servo control system, the random control of the linear density and blending ratio of the rotor spinning yarn are achieved. In specific embodiments, the four kinds of spinning yarns are shown as following:

- ① a yarn with invariable linear density and variable blending ratio, such as gradient-color or segment-color yarn with an invariable linear density segment;
- ② a yarn with invariable blending ratio and variable linear density, such as slub yarn, big-belly yarn, dot yarn;
- ③ a yarn with variable linear density and variable blending ratio, such as segment-color slub yarn, segment-color big-belly yarn, segment-color dot yarn;
- ④ a yarn with invariable linear density and invariable blending ratio but mixed with any proportion of blended yarn or color-mixed yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG.1 is a flowchart of the rotor spinning.

FIG.2 is a diagram of the carding and drafting process of the rotor spinning method with three-level carding roller.

FIG.3 is a diagram showing the transmission of the feeding roller, wherein 3b is the right-side view of 3a.

FIG.4 is a structural view of the combined feeding roller.

FIG.5 is a diagram of a spinning control system with two components asynchronous fed and carded.

FIG.6 is a diagram of a control model of a rotor spinning yarn system with two components asynchronous input.

1-1, 1-2, 1-3: carding roller; 1-4, 1-5: trash ejection port; 1-6: feeding roller; 1-7: sliver; 1-8: compression spring; 1-9: feeding plate; 1-10: fiber transport channel; 1-11: navel; 1-12: rotor; 1-13: degassing hole; 1-14, 1-15: guide roller, 1-16: yarn;
 2-1, 2-2: feeding roller; 2-3, 2-4: sliver; 2-5: feeding plate; 2-6, 2-7, 2-8: carding roller; 2-9: fiber flow; 2-10: rotor; 2-11: yarn;
 3a-1, 3a-4: rollers; 3a-2, 3a-7: gears; 3a-3, 3a-5: idler gear; 3a-6: roller shaft; 3a-8, 3a-9, 3a-10: carding roller, 3a-11: spun yarn, 3b-1: gear; 3b-2: roller; 3b-3, 3b-4: gears;
 4-1: bearing; 4-2: hollow shaft; 4-3: gears; 4-5, 4-6: rollers; 4-7: gear; 4-8: shaft; two movable roller (4-5, 4-6) are driven by the gears (4-3, 4-7) respectively.

DETAILED DESCRIPTION OF THE INVENTION

[0011] Spinning process design:

V_{01} : linear velocity of the feeding roller 1; V_{02} : linear velocity of the feeding roller 2; V_1 : the linear velocity of the carding roller 1; V_2 : the linear velocity of the carding roller 2; V_3 : the linear velocity of the carding roller 3; V_4 : the linear speed of the rotor; V_5 : the linear velocity of the guide roller.

ρ_1 : linear density of sliver A (g / m)

ρ_2 : linear density of sliver B (g / m)

p : yarn density (g / m);

ρ_{11} : linear density of the sliver A passing through the carding roller 1 (g / m)

ρ_{12} : linear density of the sliver A passing through the carding roller 2 (g / m)

ρ_{13} : linear density of the sliver A passing through the carding roller 3 (g / m)

ρ_{14} : linear density of the sliver A in the rotor (g / m)

ρ_{21} : linear density of the sliver B passing through the carding roller 1 (g / m)

ρ_{22} : linear density of the sliver B passing through the carding roller 2 (g / m)

ρ_{23} : linear density of the sliver B passing through the carding roller 3 (g / m)

ρ_{24} : linear density of the sliver B in the rotor (g / m)

E_1 : draft ratio of the carding roller 1 to the feeding roller;

E_2 : draft ratio of the carding roller 2 to the carding roller 1;

E_3 : draft ratio of the carding roller 3 to the carding roller 2;

E_4 : draft ratio of the rotor to the carding roller 3;

E_5 : draft ratio of the guide roller to the rotor;

E : total draft ratio of rotor spinning, which is equal to the draft ratio of guide roller to feeding roller.

[0012] Subscripts 1, 2 represent component A, component B, respectively.

(1) Three-level roller carding process design:

[0013] As to feeding a plurality of the slivers, when the feeding speeds of feeding rollers are greatly different, the fiber holding time of each component is also greatly different. In the rotor spinning with single carding roller, due to the need of balancing the stripping /carding fibers, as well as the requirement of the fiber speed when transferring to the fiber transport channel, the rotation speed of the single carding roller is high. Therefore, when there is a significant difference in feeding amount, the number of times that a fiber of the two slivers is carded will be significantly different, and the more the fiber experiences carding, larger will be the damage to this fiber.

[0014] In order to solve the problem of the rotation speed of the carding roller against the damage to fiber and the even mixture of fibers, the present invention adopts the form of three-level carding roller, that is, the first carding roller, the second carding roller and the third carding roller. The rotation speed of the first carding roller ($\omega = 1500-3000\text{rpm}$) is relatively low, the needle density is relatively low, the working angle of the needle is relatively small. It is mainly configured for stripping, opening, cleaning and carding and focusing on making the total carding number of fibers of each sliver within a reasonable range, thereby reducing damage to the fiber. The speed of the second carding roller ($\omega = 3000-6000\text{rpm}$) is mainly configured for stripping, carding and transferring fibers, wherein the needle density is larger than the needle density of the first carding roller, and the working angle of the needle is relatively larger than that of the first carding roller. After being carded by the second carding roller, the longitudinal orientation of the fiber is optimized, and horizontal transfer mixing of the fiber is further optimized. The third carding roller is a high-speed carding roller ($\omega = 6000-12000\text{rpm}$), which is mainly configured for stripping, carding and separating, and transferring fibers, wherein the needle density is also larger than the needle density of the second carding roller, and the working angle of the needle is largest. Fibers passing through the third carding roller gets better carding and transfer. Furthermore, due to the high

speed of the third carding roller, under the action of centrifugal force and air flow, a highly separated and continuous fiber flow passes through the fiber transport channel and enters orderly into the rotor to form yarns.

[0015] Through the stripping, opening, cleaning, carding, and transfer of the three-level carding roller, the large-scale drafting function, where the slivers are combed into web, which is then combed into fiber bundles which are separated into single fibers, is successful completed, which enhances the function of the carding area of the rotor spinning, meets the special requirements for the carding of multiple slivers asynchronously feeding into the rotor spun unit. The effects of flexibility, high efficiency, and high yield are realized.

(2) Draft ratio of the rotor spun yarn:

[0016]

$$E_1 = \frac{(\rho_1 + \rho_2) V_1}{\rho_1 V_{01} + \rho_2 V_{02}} = \frac{\rho_1 + \rho_2}{\rho_{11} + \rho_{21}}$$

$$E_2 = \frac{V_2}{V_1} = \frac{\rho_{11} + \rho_{21}}{\rho_{12} + \rho_{22}}$$

$$E_3 = \frac{V_3}{V_2} = \frac{\rho_{12} + \rho_{22}}{\rho_{13} + \rho_{23}}$$

$$E_4 = \frac{V_4}{V_3} = \frac{\rho_{13} + \rho_{23}}{\rho_{14} + \rho_{24}}$$

$$E_5 = \frac{V_5}{V_4} = \frac{\rho_{14} + \rho_{24}}{\rho}$$

$$E = E_1 * E_2 * E_3 * E_4 * E_5 = \frac{(\rho_1 + \rho_2) V_5}{\rho_1 V_{01} + \rho_2 V_{02}} = \frac{\rho_1 + \rho_2}{\rho}$$

$$E = \frac{(\rho_1 + \rho_2) V_5}{\rho_1 V_{01} + \rho_2 V_{02}} = \frac{\rho_1 + \rho_2}{\rho}$$

(3) Linear density of spun yarn:

[0017]

$$\rho = \frac{\rho_1 V_{01} + \rho_2 V_{02}}{V_5}$$

(4) Blending ratio

[0018] The blending ratio of components A and B in the rotor spinning yarn are K_1 and K_2 respectively:

$$K_1 = \frac{\rho_1 V_{01}}{\rho_1 V_{01} + \rho_2 V_{02}}$$

$$K_2 = \frac{\rho_2 V_{02}}{\rho_1 V_{01} + \rho_2 V_{02}}$$

(4)) Dynamic linear density of rotor spun yarn

[0019] Assuming that the speed V_5 of the guide roller is invariable, the variables of feeding speed V_{01} and V_{02} , of the components A and B are as follows:

$$V_{01}' = V_{01} + \Delta V_{01}$$

$$V_{02}' = V_{02} + \Delta V_{02}$$

[0020] So that the new changed linear density of rotor spun yarn is

$$\rho' = \frac{\rho_1 (V_{01} + \Delta V_{01}) + \rho_2 (V_{02} + \Delta V_{02})}{V_5}$$

$$= \frac{\rho_1 V_{01} + \rho_2 V_{02}}{V_5} + \frac{\rho_1 \Delta V_{01} + \rho_2 \Delta V_{02}}{V_5}$$

$$\Delta \rho = \frac{\rho_1 \Delta V_{01} + \rho_2 \Delta V_{02}}{V_5}$$

(5)) Dynamic blending ratio of rotor spun yarn is:

[0021] Assuming that: $\rho_1 = \rho_2 = \rho_0$

$$V_{01} + V_{02} = V_0$$

[0022] Reference blending ratios are shown as below:

$$K_1 = \frac{V_{01}}{V_0}$$

$$K_2 = \frac{V_{02}}{V_0}$$

[0023] When $V_{01}+V_{02} \rightarrow V_{01}+\Delta V_{01}+V_{02}+\Delta V_{02}$, the blending ratio becomes as below:

$$K_1' = \frac{V_{01} + \Delta V_{01}}{V_0 + \Delta V_0}$$

$$K_2' = \frac{V_{02} + \Delta V_{02}}{V_0 + \Delta V_0}$$

[0024] Assuming that

$$k_1 = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1$$

$$k_2 = 1, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1, 0$$

[0025] Mixed configuration is gradient to realize different color scheme.

[0026] By changing V_{01} and V_{02} , the blending ratio (color mixing ratio) of different fibers (different colors) in the yarn can be changed under the condition that V_0 is kept invariable, so that k_1 and k_2 are changed between 0 - 100%. In various color mixing modes of two primary colors, the minimum increment of the color mixing ratio is 0.1, wherein the color scheme is as follows:

Table 1 color scheme

		color A color mixing ratio k_1	color B color mixing ratio k_2	Color code
Monochromatic	Color A	1	0	1
	Color B	0	1	2
Double-color mixing	AB	0.1	0.9	3
		0.2	0.8	4
		0.3	0.7	5

(continued)

		color A color mixing ratio k_1	color B color mixing ratio k_2	Color code
		0.4	0.6	6
		0.5	0.5	7
		0.6	0.4	8
		0.7	0.3	9
		0.8	0.2	10
		0.9	0.1	11
Note: for $k_1+k_2 = 100\%$, there can be numerous combinations.				

[0027] In the present invention, 0.1 is selected as a gradient to perform color matching. According to the above statistics, based on the two primary colors (two kinds of color sliver) by coupling drawing, color change, color matching, alternating gradient twisting mixed, 11 color schemes can eventually be formed, and 11 kinds of color distribution can be formed in the yarn to form a segment-color yarn.

(6) Random dynamic control method of spun yarn density and blending ratio

[0028] Dynamic change rate of density of rotor spun yarn is shown as below:

$$\epsilon_p = \frac{\Delta \rho}{\rho} = \frac{\frac{\rho_1 \Delta V_{01} + \rho_2 \Delta V_{02}}{V_s}}{\frac{\rho_1 V_{01} + \rho_2 V_{02}}{V_s}} = \frac{\rho_1 \Delta V_{01} + \rho_2 \Delta V_{02}}{\rho_1 V_{01} + \rho_2 V_{02}}$$

and

$$\rho_1 = \rho_2 = \rho_0$$

$$V_{01} + V_{02} = V_0$$

then

$$\epsilon_p = \frac{\Delta V_{01} + \Delta V_{02}}{V_0} = \frac{\Delta V_0}{V_0}$$

[0029] From the absolute increment of the linear density and relative increment of the linear density, it can be found that the change of yarn linear density, which totally depends on the $V_{01} + \Delta V_{01}$, $V_{02} + \Delta V_{02}$, can have 5 different patterns. Therefore, there can be 5 kinds of yarn in different forms.

① A yarn with variable linear density, wherein one component has variable linear density and one components has invariable linear densities.

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [V_{01} + (V_{02} + \Delta V_{02})]$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [V_{02} + (V_{01} + \Delta V_{01})]$$

② A yarn with variable linear density, wherein both of two components have variable linear densities.

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})]$$

③ A yarn with variable linear density, wherein one component is continuous and one component is discontinuous.

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})] \quad (0 \leq t \leq T_1)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{02} + \Delta V_{02})] \quad (T_1 \leq t \leq T_2)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})] \quad (T_2 \leq t \leq T_3)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{02} + \Delta V_{02})] \quad (T_3 \leq t \leq T_4)$$

④ A yarn with variable linear density, wherein both of two components are discontinuous.

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})] \quad (0 \leq t \leq T_1)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01})] \quad (T_1 \leq t \leq T_2)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})] \quad (T_2 \leq t \leq T_3)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{02} + \Delta V_{02})] \quad (T_3 \leq t \leq T_4)$$

⑤ A yarn with variable linear density, wherein two components are continuous and have variable linear densities.

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})]$$

⑥ The method of dynamic feed speed control of spun yarn
Because

$$\Delta V_0 = \Delta V_{01} + \Delta V_{02}$$

ΔV may come from ΔV_{01} , or come from ΔV_{02} , which can be determined by the blending ratio. Then:

$$\Delta V_{01} = K'_1(V_0 + \Delta V) - V_{01}$$

$$\Delta V_{02} = K'_2(V_0 + \Delta V) - V_{02}$$

$$\frac{K'_1}{K'_2} = \frac{V_{01} + \Delta V_{01}}{V_{02} + \Delta V_{02}}$$

Claims

1. A rotor spinning method for two-silver asynchronous inputting and three-level carding, **characterized in that:**

- 1) feeding fiber by a combined feeding roller with two rotational freedom degrees into carding area where a three-level carding roller is used for carding;
- 2) moving the combined feeding rollers 1 and 2 at linear speeds V_{01} and V_{02} , respectively; moving a rotor at a linear speed V_4 and moving a guide roller at a linear speed V_5 ; setting linear densities of the two slivers drafted by two feeding rollers to be ρ_1 and ρ_2 , respectively, and setting a rotor spun yarn density to be ρ , such that a draft ratio of a rotor spinning yarn is as below:

$$E = \frac{(\rho_1 + \rho_2) V_5}{\rho_1 V_{01} + \rho_2 V_{02}} = \frac{\rho_1 + \rho_2}{\rho} \quad (1)$$

a linear density of the rotor spun yarn is formed,

$$\rho = \frac{\rho_1 V_{01} + \rho_2 V_{02}}{V_5} \quad (2)$$

wherein speeds of three carding rollers are as follows: a speed of a first carding roller is 1500-3000 rpm, a speed of a second carding roller is 3000-6000 rpm, a speed of a third carding roller is 6000-12000 rpm,
3) blending ratios of two slivers in the rotor spinning yarn are K1 and K2 respectively:

$$K_1 = \frac{\rho_1 V_{01}}{\rho_1 V_{01} + \rho_2 V_{02}} \quad (3)$$

$$K_2 = \frac{\rho_2 V_{02}}{\rho_1 V_{01} + \rho_2 V_{02}} \quad (4)$$

4) assuming that the speed V_5 of the guide roller is invariable, the variables of feeding speeds V_{01} and V_{02} of the feeding rollers of the two slivers are respectively as follows: $V_{01}' = V_{01} + \Delta V_{01}$, $V_{02}' = V_{02} + \Delta V_{02}$, then the dynamic linear density of the rotor spun yarn is obtained according to formula (2)

$$\Delta \rho = \frac{\rho_1 \Delta V_{01} + \rho_2 \Delta V_{02}}{V_5} \quad (5)$$

5) assuming that $\rho_1 = \rho_2 = \rho_0$, $V_{01} + V_{02} = V_0$, obtaining a reference blending ratio according to the formulas (3),

(4) as $K_1 = \frac{V_{01}}{V_0}$, $K_2 = \frac{V_{02}}{V_0}$, wherein, when $V_{01} + V_{02} \rightarrow V_{01} + \Delta V_{01} + V_{02} + \Delta V_{02}$, the blending ratio becomes as below:

$$K_1' = \frac{V_{01} + \Delta V_{01}}{V_0 + \Delta V_0} \quad (6)$$

$$K_2' = \frac{V_{02} + \Delta V_{02}}{V_0 + \Delta V_0} \quad (7)$$

realizing dynamically adjustable spinning of different color blending ratios or color mixing ratios in the yarn with different fibers or colors by controlling of V_{01} and V_{02} .

2. The method according to claim 1, **characterized in that:** assuming $\rho_1 = \rho_2 = \rho_0$, $V_{01} + V_{02} = V_0$, obtaining a dynamic change rate of the rotor spun yarn density according to formulas (2) and (5):

$$\epsilon_\rho = \frac{\Delta V_{01} + \Delta V_{02}}{V_0} = \frac{\Delta V_0}{V_0} \quad (8)$$

achieving a random dynamic regulation of the density and the blending ratio of the rotor spun yarn by controlling the speed of the two rollers.

3. The method according to claim 2, **characterized in that:**

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [v_{01} + (v_{02} + \Delta v_{02})]$$

or

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [v_{02} + (v_{01} + \Delta v_{01})]$$

changing speed of one of the rollers to achieve a yarn with variable linear density, wherein one component has variable linear density and one component has invariable linear density.

4. The method according to claim 2, **characterized in that:**

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{01} + \Delta v_{01}) + (v_{02} + \Delta v_{02})]$$

changing speed of two of the rollers to achieve a yarn with variable linear density, wherein two components have variable linear densities.

5. The method according to claim 2, **characterized in that:**

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{01} + \Delta v_{01}) + (v_{02} + \Delta v_{02})] \quad (0 \leq t \leq T_1)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{02} + \Delta v_{02})] \quad (T_1 \leq t \leq T_2)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{01} + \Delta v_{01}) + (v_{02} + \Delta v_{02})] \quad (T_2 \leq t \leq T_3)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{02} + \Delta v_{02})] \quad (T_3 \leq t \leq T_4)$$

wherein speed change of two rollers and speed change of one of these two rollers alternate to realize a yarn with variable linear density wherein one component is continuous and one component is discontinuities, wherein t, T1, T2, T3 and T4 represent time.

6. The method according to claim 2, **characterized in that:**

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{01} + \Delta v_{01}) + (v_{02} + \Delta v_{02})] \quad (0 \leq t \leq T_1)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(v_{01} + \Delta v_{01})] \quad (T_1 \leq t \leq T_2)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})] \quad (T_2 \leq t \leq T_3)$$

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{02} + \Delta V_{02})] \quad (T_3 \leq t \leq T_4)$$

wherein speed change of two rollers and speed change of one of these two rollers alternate while changing speed of one of the two rollers to realize a yarn with variable linear density wherein two components are discontinuities, wherein t , T_1 , T_2 , T_3 and T_4 represent time.

7. The method according to claim 2, **characterized in that**:

$$\rho' = \rho + \Delta \rho = \frac{\rho}{V_0} * [(V_{01} + \Delta V_{01}) + (V_{02} + \Delta V_{02})]$$

changing speed of two rollers to realize a variable linear density yarn with two continuous components with variable linear densities.

8. The method according to claim 2, **characterized in that**: in control method of dynamic feeding speed of the yarn, $\Delta V_0 = \Delta V_{01} + \Delta V_{02}$, change of the speed is derived from ΔV_{01} or ΔV_{02} and determined by the blending ratio, and then $\Delta V_{01} = K'_1(V_0 + \Delta V) - V_{01}$, $\Delta V_{02} = K'_2(V_0 + \Delta V) - V_{02}$.

9. A device for realizing the method according to any one of the preceding claims, **characterized in that**, the device comprises a spinning system and a computer control system, the spinning system comprises a feeding and carding mechanism, a collecting and twisting mechanism, and a winding mechanism, **characterized in that**, the feeding and carding mechanism comprises a combined feeding roller having two rotation freedom degrees, a three-level carding roller; wherein a speed ratio of two rollers of the combined feeding roller with two rotational freedom degrees can be adjusted, the collecting and twisting mechanism includes a fiber transport channel, a rotor, and a guide device; the winding mechanism includes a guide and winding mechanism; the computer control system includes a PLC programmable controller, a servo driver, a servo motor; wherein the combined feeding roller with two rotational freedom degrees and the three-level carding roller are driven by the servo motor.

10. The device according to claim 9, **characterized in that** the combined feeding roller with two rotational freedom degrees comprises a shaft, a bearing, a hollow shaft, a first gear, a second gear, a washer, a first movable roller, a second movable roller, wherein the first and the second gears and the first and the second movable rollers are rotated around the same axis, the first and the second gears drive the first and the second movable rollers, respectively.

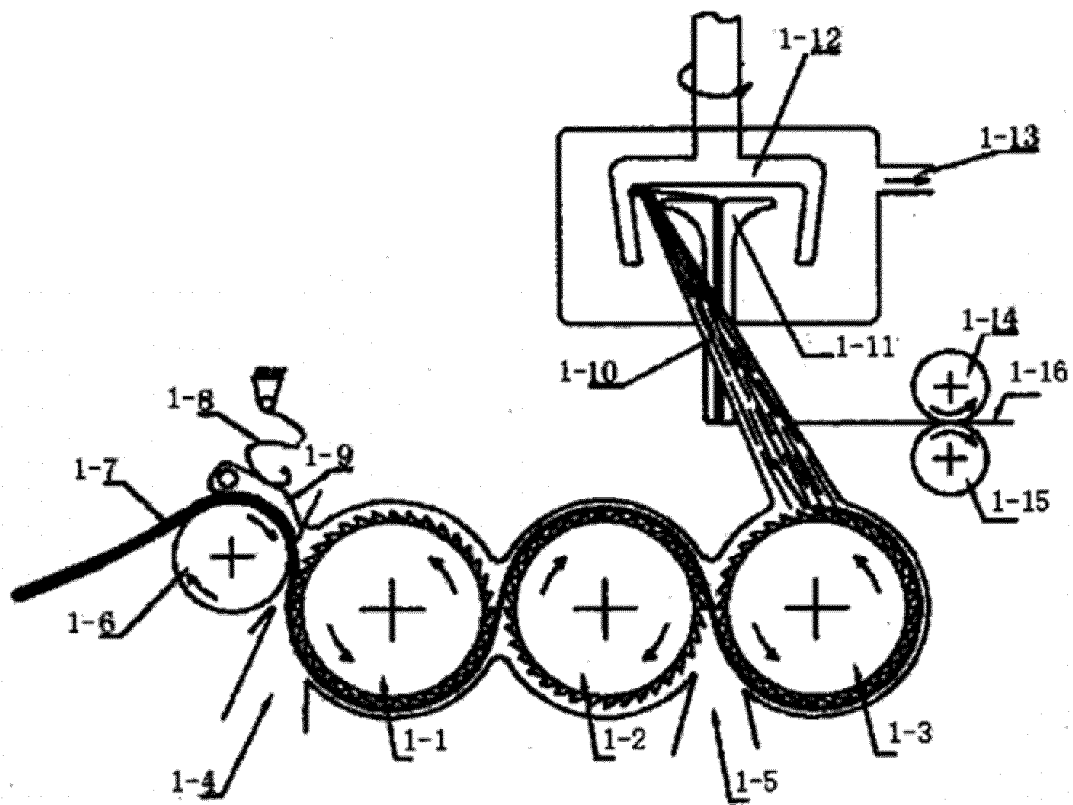


FIG. 1

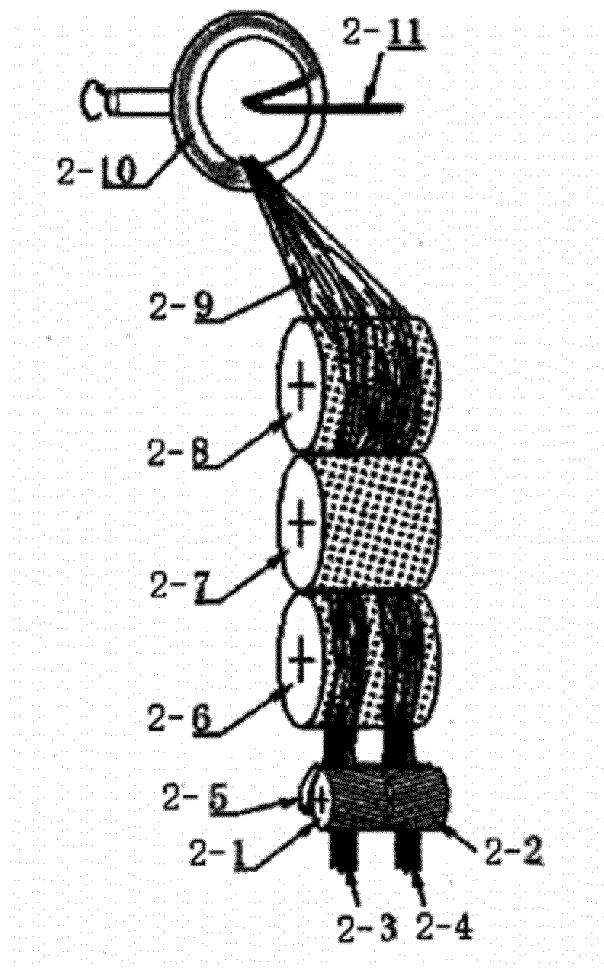
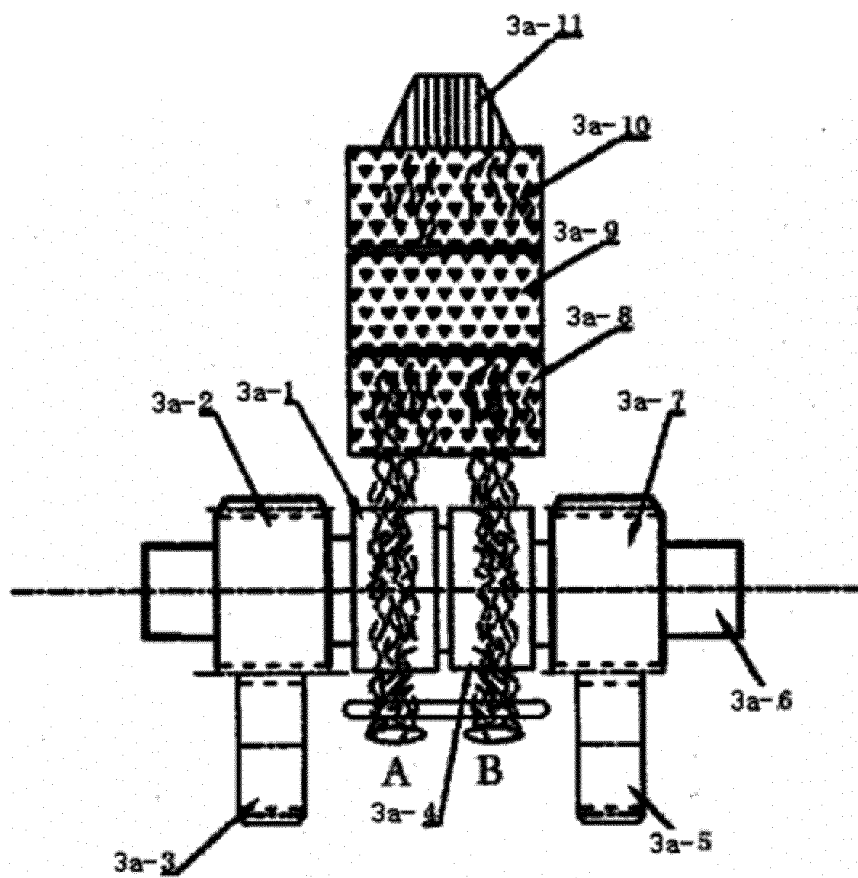
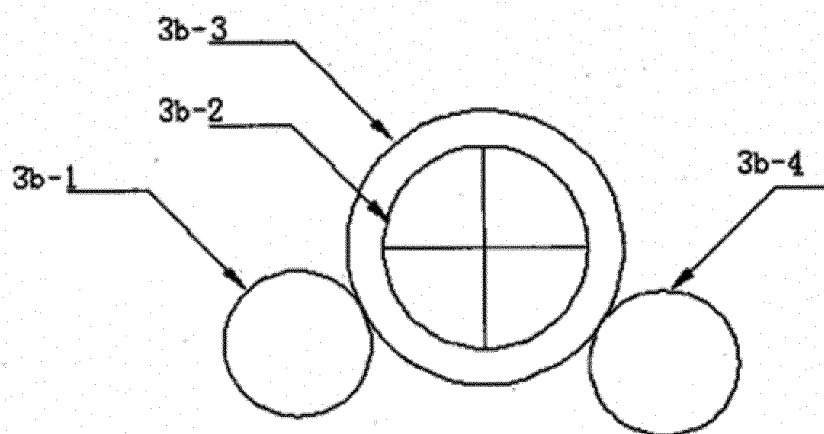


FIG. 2



3a



3b

FIG. 3

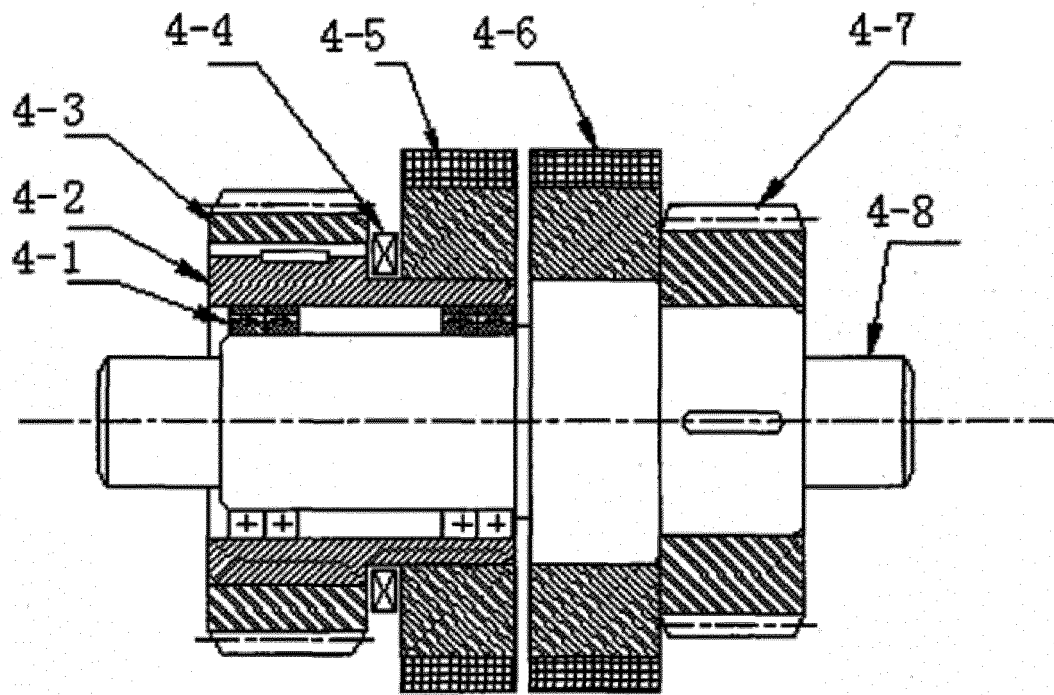


FIG. 4

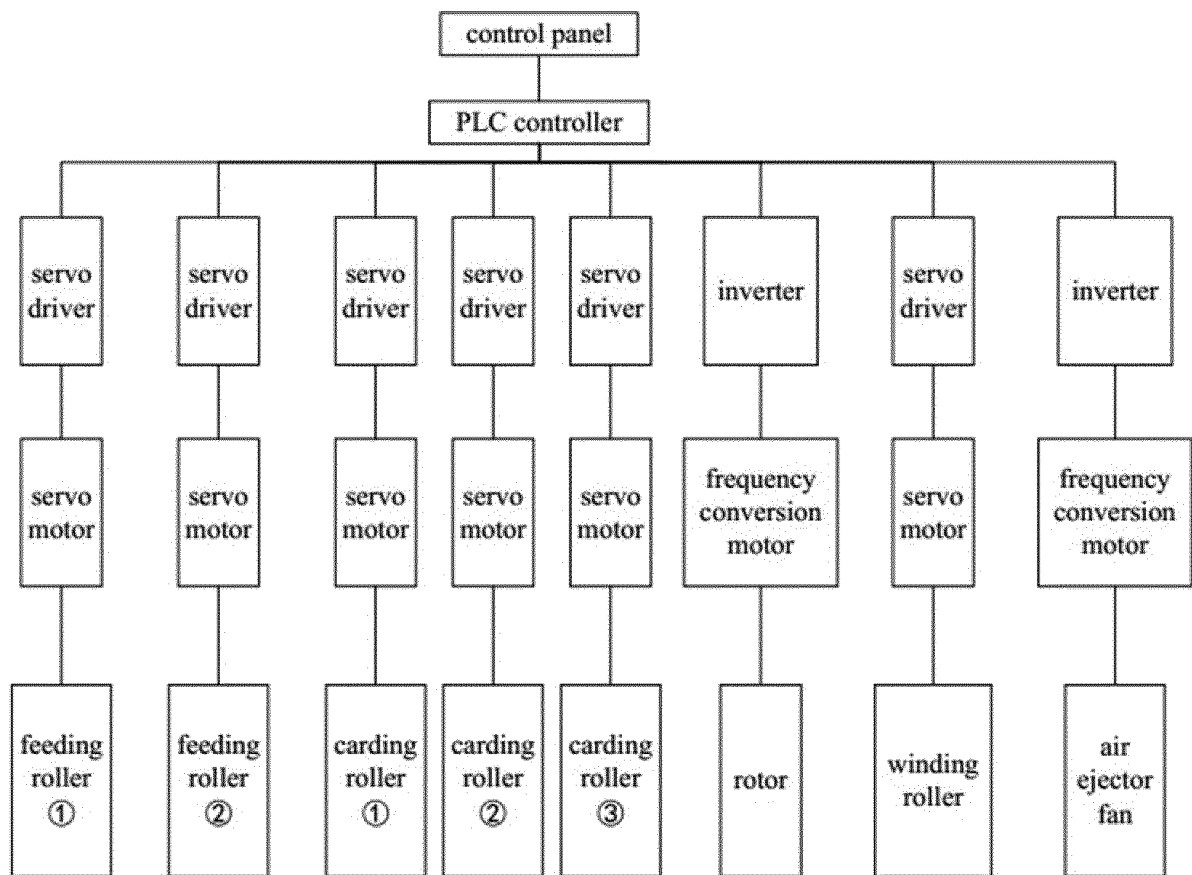


FIG. 5

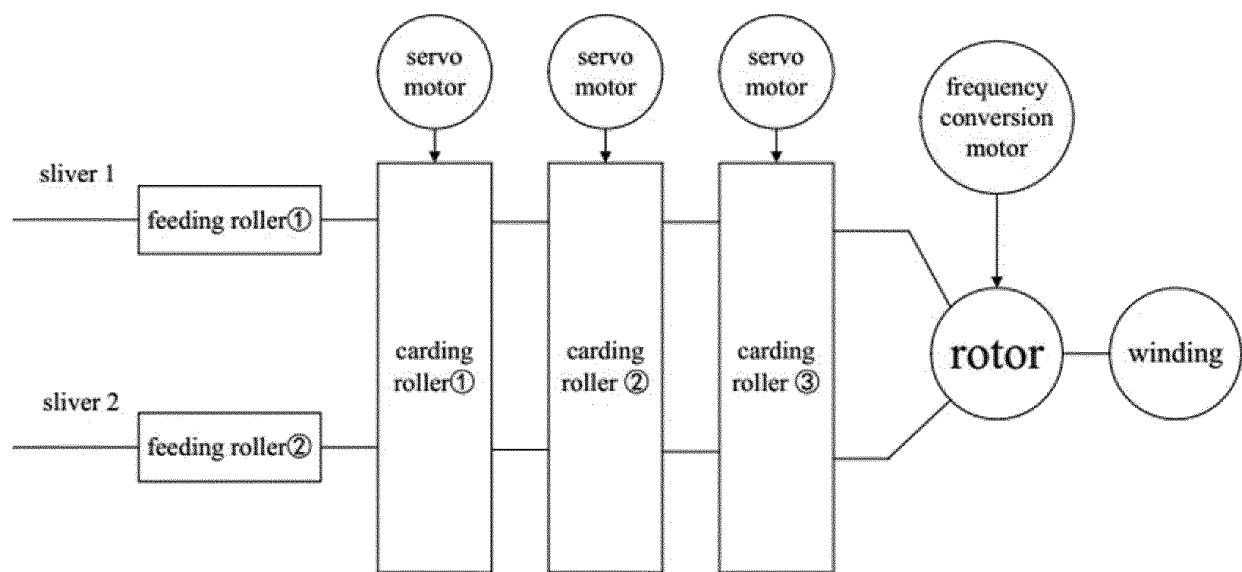


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/000738

A. CLASSIFICATION OF SUBJECT MATTER

D01H 4/08 (2006.01) i; D02G 3/04 (2006.01) i; D02G 3/34(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D01H, D02G, D01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, DWPI: rotor spinning, rotor, import, carding, feed, roller, blending, combing, multilevel, threelevel, velocity, speed

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	CN 205133850 U (JIANGNAN UNIVERSITY), 06 April 2016 (06.04.2016), description, particular embodiment, and figures 1-6	1-10
A	CN 103938322 A (JIAXING UNIVERSITY), 23 July 2014 (23.07.2014), description, particular embodiment, and figures 1-3	1-10
A	CN 103911697 A (DONGHUA UNIVERSITY et al.), 09 July 2014 (09.07.2014), the whole document	1-10
A	CN 1298969 A (DONGHUA UNIVERSITY), 13 June 2001 (13.06.2001), the whole document	1-10
A	JP 4819567 B1 (TORAY IND INC.), 14 June 1973 (14.06.1973), the whole document	1-10
A	CN 203795057 U (JIAXING UNIVERSITY), 27 August 2014 (27.08.2014), the whole document	1-10

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

 Date of the actual completion of the international search
 21 April 2016 (21.04.2016)

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 Name and mailing address of the ISA/CN:
 State Intellectual Property Office of the P. R. China
 No. 6, Xitucheng Road, Jimenqiao
 Haidian District, Beijing 100088, China
 Facsimile No.: (86-10) 62019451

 Authorized officer
 LI, Qing
 Telephone No.: (86-10) 62085410

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/000738

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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 205133850 U	06 April 2016	None	
CN 103938322 A	23 July 2014	None	
CN 103911697 A	09 July 2014	None	
CN 1298969 A	13 June 2001	CN 1091813 C	02 October 2002
JP 4819567 B1	14 June 1973	None	
CN 203795057 U	27 August 2014	None	

Form PCT/ISA/210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 201410190891 [0003]
- CN 201420229715X [0003]
- CN 00137211 [0004]