Sept. 14, 1965 AKIRA KATO 3,205,645

SPINNING POT OF CENTRIFUGAL SPINNING MACHINE

Filed June 21, 1963

FIG. 1

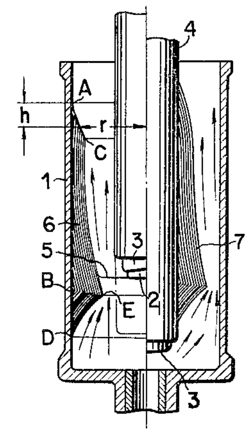


FIG. 2

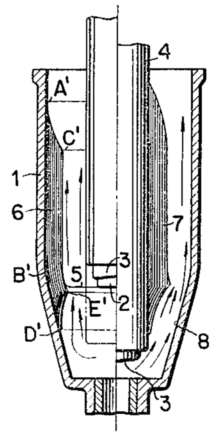


FIG. 3

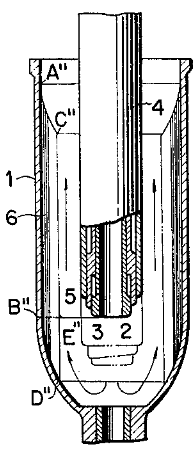


FIG. 4

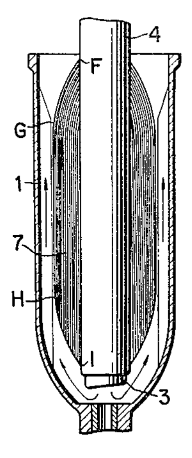
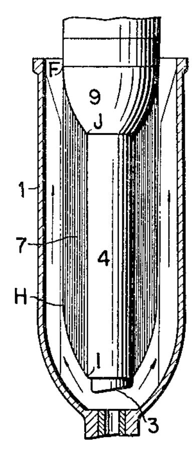


FIG. 5



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SPINNING POT OF CENTRIFUGAL SPINNING MACHINE

Akira Kato, Asa-gun, Hiroshima Prefecture, Japan, assignor to Mitsubishi Shipbuilding & Engineering Company, Limited, Tokyo, Japan

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3 Claims. (Cl. 57—76)

This invention relates generally to centrifugal spinning machines such as spinning frames, twisting machines or the like and more particularly to a spinning pot for such a machine operative when rotating at a high speed to twist and wind a bundle of fibers such as roving or yarn on the internal peripheral surface thereof by utilizing the centrifugal force due to its rotational movement.

In a spinning machine for twisting and winding bundles of fibers for example yarns by the action of centrifugal force each yarn is twisted and wound on the internal peripheral surface of a spinning pot of cylindrical shape rotating at a high speed by drawing the same out from the free end of a yarn guiding tube which is vertically reciprocable within the spinning pot, along the longitudinal axis thereof.

When a predetermined length of the yarn has been wound into layers on the internal peripheral surface of the spinning pot, the winding operation can be ceased and a rewinding tube inserted coaxially into the interior of the spinning pot. Then the roll of yarn formed on the inside of the spinning pot is rewound on the outer surface of the rewinding tube to form the finished cop which, in turn, may be removed from within the pot.

In order to prevent entanglement of the yarn during the rewinding operation, the angle formed between the path of ascending yarn and the subsequent path of descending yarn or the angle formed between a pair of succeeding traverse sections in the traverse motion which may be called a "traverse angle" should be relatively small or acute. Also the angle (spinning angle) between the internal peripheral surface of the pot and the surface formed by the upper ends of the yarn layers is preferably small.

If the yarn is wound on the internal peripheral surface of the spinning pot in such a manner that, the traverse angle is small, the yarn may be displaced in such a direction that the inside diameter of the roll is increased, and when any small vibration displaces a portion or portions of the yarn in that direction the centrifugal force is higher on the displaced portion or portions of the yarn than the other portions thereof and promotes further displacement of the displaced portion or portions of the yarn until a small chord or chords of the yarn are formed on said displaced portion or portions. When the roll of yarn layers thus formed on the internal surface of the pot is rewound on a rewinding tube entanglement of the yarn frequently occurs.

In order to prevent such entanglement of the yarn the yarn can be wound within the pot on tilted surfaces on which the yarn can not at all be displaced in a direction such that the inside diameter of the yarn roll is increased. Alternatively, the yarn must be wound on a completely circularly cylindrical surface. To do so the yarn fed at a uniform velocity into the cylindrical pot should have a traverse motion having a uniform speed and a predetermined fixed amplitude to thereby be wound to a uniform thickness on the cylindrical surface, and the upper ends of the wound yarn layers should be shifted gradually downward to form a surface tilted relatively to the cylindrical surface at an angle suitable for the type and size of the finished yarn with each yarn layer to be superposed

being always maintained on a circularly cylindrical surface.

The conventional type of spinning pots heretofore proposed include a right cylindrical pot comprising a hollow cylindrical member having its upper end open and its lower end closed and a conical-cylindrical pot comprising a hollow cylindrical member open at its upper end and a hollow, truncated conical member connected on its enlarged end to the cylindrical member at its lower end with the tilted angle of the conical surface approximating the required spinning angle. In such spinning pots, air flows from the free end of the yarn guiding tube toward the internal peripheral surface of the pot for the purpose of causing a bundle of fibers such as a yarn to cling to said internal peripheral surface and then passes to the upper open end of the pot along said internal surface. Under these circumstances, if the yarn is given a traverse motion having a uniform speed and a predetermined fixed amplitude and is wound in layers on the internal peripheral surface of the pot in such a manner that the upper ends of the successive yarn layers are gradually displaced downward so as to render the angle of the surface formed by said upper ends of the layers equal to a magnitude determined in accordance with the size and type of the finished yarn, then a vibrational movement and the flow of air as above described have frequently caused undesirable shift of the spun yarn on the lower end portions of the wound yarn layers. In addition, upon rewinding the roll of yarn thus formed on a rewinding tube undesirable entanglement and shift of the yarn have often taken place to a considerable extent.

The object of the invention is to provide an improved spinning pot for a centrifugal spinning machine having a profile ensuring that a yarn can be wound in layers on the internal peripheral surface of the spinning pot without any shift of the wound yarn occurring and hence that the roll of yarn formed on the internal peripheral surface of the pot can be rewound on a rewinding tube inserted within the pot without entanglement, shift and break of the yarn.

The invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is an elevational view, partly in longitudinal section of a spinning pot of a prior art type with the lefthand half illustrating fragmentarily the step of taking up a yarn while the righthand half illustrates fragmentarily the finished cop of yarn formed on a rewinding tube;

FIG. 2 is a view similar to FIG. 1 but illustrates another spinning pot of a prior art type;

FIG. 3 shows, partly in longitudinal section and partly in elevation, a spinning pot constructed in accordance with the teachings of the invention and its associated components; and

FIGS. 4 and 5 are fragmental sectional views illustrating the manner in which cops of different shapes may be formed on rewinding tubes by using the spinning pot illustrated in FIG. 3.

Referring now to FIG. 1 of the drawings, the pot designated by the reference numeral **1** comprises a hollow, right cylindrical member open at the upper end, having a bottom plane and adapted to be rotated at a high speed. Coaxially disposed in the hollow portion of the pot **1** is a yarn guiding tube **2** for vertically reciprocal movement. The yarn guiding tube **2** is surrounded by a supporting tube **3** which, in turn, is surrounded by a rewinding tube **4**. A bundle of fibers such as a yarn **5** to be twisted and wound is fed into the hollow portion of the pot **1** rotating at a high speed through the free end of the yarn guiding tube **2** being reciprocally moved along the longitudinal axis of the pot **1** whereby the yarn is twisted and wound in layers on the internal peripheral surface of the pot **1**. At the beginning of the twisting and winding operation the yarn is wound on that portion of the internal wall surface of the pot **1** positioned between an upper horizontal line represented by the point A on the internal wall surface of the pot and a lower horizontal line represented by the point B on the internal wall surface of the pot **1**. The yarn guiding tube **2** is designed and arranged such that the range over which the same is reciprocally moved in the vertical direction is gradually lowered as the operation proceeds. Accordingly, the upper end of the yarn wound on the internal wall surface of the pot **1** is displaced along the line AC while the lower end thereof is displaced along the line BD. Eventually, the yarn is wound in lengths from the point C through the point E to the point D and forms a roll of yarn layers **6**.

Let it now be assumed that dv/dt represents the speed at which the yarn is fed into the pot or the yarn volume sucked into the same per unit time dh/dt the length through which the uppermost point of the vertically reciprocal stroke for the yarn is lowered per unit time, l the length of that reciprocal stroke and r the distance between the longitudinal axis of the pot and any point on a curved surface of rotation on which the yarn is wound, or the radius of that surface. Let it also be assumed that

$$\frac{dv}{dt}=k_1 \tag{1}$$

where k_1 is a constant,

$$\frac{dh}{dt}=k_1 \tag{2}$$

where k_2 is a constant.

Let it further be assumed that yarn layers cling on the internal wall surface of the pot with a constant volume per unit length of the yarn. In other words, the yarn is assumed to have its apparent density constant over the entire length. Then the incremental volume of the yarn layer dv is expressed by the equation

$$dv=2\pi r dr.l \tag{3}$$

From the above Equation 1 we have the following equation

$$\frac{k_1}{k_2}\cdot dh=2\pi r dr.l$$

Solving the differential equation there is obtained the equation

$$h=K_1 r^2+K_0 \tag{4}$$

where K_1 and K_0 are constants. The Equation 4 represents the curve AC (see FIG. 1) which is the generatrix for the curved surface formed by the adjacent upper ends of the wound yarn layers on the internal wall surface of the pot. It is apparent that the constants K_1 and K_0 depend upon the yarn feeding speed, the speed of the traverse motion, the radius at which the yarn is initially wound within the pot, etc.

On the other hand, if it is assumed that the envelope surface ED for the lower end of the traverse motion of the yarn will be affected by parameters such as the resistance of air and the like similar to those affecting the envelope surface for the upper end thereof then the curve ED has to be a mirror image of the curve AC. In this case, the lower end of the initial yarn layer begins at the point B and the lower ends of the succeeding yarn layers form, a tilted surface gradually increasing in area until the same forms the surface ED.

During the operation of spinning the yarn within the pot **1**, therefore, any vibrational movement tends to cause shift of the yarn on the lower envelope surface due to the lower ends of the yarn layers resulting in the formation of many small chords of yarn. At the same time, this tendency for the yarn to form the small chords is enhanced by the upward flow of air spouted by the yarn guiding tube **2** and passing along the internal wall surface of the pot **1** as illustrated by the arrows in FIG. 1. Thus when the roll of yarn layers **6** formed on the internal wall surface of the pot **1** is rewound on the rewinding tube **4** to form a cop of yarn **7**, the yarn being rewound is entangled at many points thereof.

In FIG. 2 wherein like reference numerals designate components similar to those illustrated in FIG. 1 the arrangement is similar to that shown in FIG. 1 except that the lower portion of the hollow cylindrical member is in the form of a truncated conical surface **8** with the tilted angle approximating the required spinning angle.

The yarn is initially wound on that portion of the internal wall surface of the pot **1** between the point A′ and the point B′ and finally wound on a surface designated by the line C′E′D′ to form a roll of yarn layers **6**. Under these circumstances it is assumed that the parameters such as yarn supply and the like are quite identical with the case of the spinning pot shown in FIG. 1. Then a tilted surface such as the envelope surface ED shown in FIG. 1 does not appear but as the internal wall surface B′D′ of the conical portion **8** is superposed on the parabolic surface designated by the curve A′C′ the point E′ protrudes. The protuberance at this point E′ is enhanced by the flow of air spouted by the yarn guiding tube **2** and passing upwardly along the internal wall surface of the cylindrical member. In addition, the point E′ will greatly protrude for the reason that, as the radius at which the yarn is wound decreases the yarn layer is reduced in apparent density. Consequently, a tilted surface similar to the envelope surface ED shown in FIG. 1 is locally formed in the arrangement illustrated in FIG. 2. Therefore it will be appreciated that the cop of yarn **7** formed on the rewinding tube **4** involves entanglement of the yarn at many points thereof.

The foregoing discussion based upon Equation 4 has been made on the assumption that the yarn layers have a constant apparent density throughout the roll. It will be appreciated that, because of both the tension of the yarn being wound and the centrifugal force applied to a particular yarn layer, the yarn being wound has a higher apparent density at a larger spinning radius that at a smaller radius. As an example, a yarn spun in a spinning pot rotating at an angular velocity of from 1500 to 2500 radians per second and having a spinning radius of from 2 to 7.5 centimeters has an apparent density ranging from 0.2 to 0.6 gram per cubic centimeter. Within this range of density the spun yarn can be considered to have an average density substantially directly proportional to the taking up radius. Now, if it is assumed that the apparent density of a layer layer is designated by δ g./cm.^{3} and the spinning radius designated by r cm. then

$$\delta=k_3 r+k_4$$

where k_3 and k_4 are constants. Since the constant K_1 in the Equation 4 can be expressed by the equation

$$K_1=k_5\delta$$

where k_5 is a constant, the Equation 4 is transformed into

$$h=k_5(k_3 r+k_4)r^2+K_0$$

$$h=K_2 r^3+K_3 r^2+K_0 \tag{5}$$

where K_2 and K_3 are also constants.

From the above Equation 5 it will be apparent that, by taking into account the effect of centrifugal force, the displacement h of the upper end of a yarn layer is represented by a cubic expression of the spinning radius. If r_1 designates the initial spinning radius, r_2 the final spinning radius and h_0 designates the total length of the envelope surface measured on a plane passing through the longitudinal axis then the relationship between the thickness of the wound yarn layers and the total length of the envelope surface is required to actually satisfy the following inequalities

$$0.15<(r_1-r_2)/h_0<0.5$$

The results of experiments indicate that, if

$$(r_1-r_2)/h_0<0.15$$

a tilted surface formed on the basis of the Equation 4 or 5 approximates a conical surface resulting in great diminution in the effect provided by the invention. On the contrary, if $(r_1-r_2)/h_0>0.5$ a cop of yarn formed on a rewinding tube includes many disturbed yarn layers.

Therefore, so long as the internal wall surface of the pot comprises either a right cylindrical surface or such a right cylindrical surface with a truncated conical surface on the lower portion, the yarn layers wound on that wall surface will include formed on the lower end portion a protuberance which, in turn, makes it difficult to satisfactorily rewind the yarn on a rewinding tube. Consequently, entanglement of the yarn is likely to occur on that portion of the rewound yarn on the rewinding tube corresponding to the lower end portion of the yarn layers wound on the inside of the pot.

The invention contemplates the prevention of the aforesaid protuberance by forming the lower end portion of the internal wall surface of the pot into a special curved surface. To this end, that portion of the internal wall surface of the spinning pot positioned below the point which the lower ends of the yarn layers wound on the surface reach at the beginning of a yarn winding operation is chosen to coincide in configuration with the surface formed by the upper ends of the yarn layers. In other words, that portion of the lower internal wall surface on which the lower end portions of the yarn layers are adapted to be wound, comprises a surface of rotation whose generatrix follows a curve represented by the aforesaid equation 4 or 5 or a curve somewhat modified from the same. This measure permits the innermost layer of yarn being wound to be always maintained as a circularly cylindrical surface whereby, during its vertically reciprocal movement the yarn being wound has continuously applied thereto a uniform centrifugal force with the result that the yarn is wound in a close roll while preventing substantially the occurrence of the protuberance as previously described.

Referring now to FIG. 3 of the drawings wherein like reference numerals designate components similar to those in FIGS. 1 and 2, the spinning pot designated by the reference numeral 1 comprises a right cylindrical member open at the upper end and including a cup-shaped bottom. More specifically, spinning pot 1 has its internal wall in the form of a right cylindrical surface except that its lower portion between points B″ which are the lower limit of taking up stroke at the beginning of the operation and points D″ which are the lower limit of the same at the end of the operation is formed into a curved surface substantially equal in configuration to the curved surface A″ C″ formed by the upper ends of the yarn layers wound on the inside of the pot. In other words, the portion B″D″ of the internal wall surface is substantially equal in configuration to a surface of rotation whose generatrix is expressed by the aforesaid Equation 4 or 5.

In operation, the yarn guiding tube 2 inserted within the pot 1 along the longitudinal axis is vertically reciprocated at a uniform speed by means of a lift device (not shown) which movement has a predetermined fixed amplitude equal to the length A″B″. When a bundle of fibers such as a yarn 5 leaving the lower end of the moving tube 2 reaches the internal wall surface of the pot 1 the yarn is first wound on that surface through lengths between the point A″ and the point B″ and eventually it is wound on a surface C″E″D″ to thereby form a roll of yarn layers 6. As clearly shown in FIG. 3 the roll of yarn layers 6 has its exposed surface C″E″D″ rectilinear and includes no protuberance. Also it will be seen that an annular spacing is formed between the rewinding tube 4 and the roll of yarn layers 6 formed on the inside wall of the pot 1 so as to have a uniform width throughout the entire length. This annular spacing of uniform width ensures that the flow of air passing through said spacing is prevented from locally accelerating and hence from aiding in the formation of a protuberance on the lower end portion of the roll of yarn layers 6 as in the conventional type of spinning pots.

FIG. 4 shows a cop 7 formed on a rewinding tube 4 by rewinding on the same the roll of yarn layers 6 as shown in FIG. 3. As shown by curve FGHI in FIG. 4 the cop has an outer surface whose generatrix consists of three curves FG, GH and HI merging into each other. It has been found that the cop does not involve entanglement of yarn nor disturbance of yarn layers.

As well known, the tension under which a yarn is being rewound depends upon the inside diameter of the yarn roll 6 wound on the internal wall surface of the pot 1, the outside diameter of the rewinding tube 4 on which a cop is to be rewound or of the cop being formed on the tube and the speed of rotation of the pot. With the arrangement illustrated in FIG. 3, the roll of yarn layers 6 wound on the internal wall surface of the pot 1 is not abruptly changed in inside diameter thereby resulting in small variation in the tension of the yarn being rewound, which tension is normally doubled by variation in such inside diameter. This ensures that yarn breaking is minimized. It will be apparent that when a portion of the yarn is rewound on the rewinding tube 4 so as to form the portion FG of the cop 7 that portion FG is changed in radius with the result that the yarn being rewound is difficult to be free from variation in tension. In order to prevent yarn breaking due to such variation in tension the speed of rotation of the pot may be reduced during the rewinding operation as a practical means.

The rewinding tube shown in FIG. 5 is similar to that illustrated in FIG. 4 expect that its upper portion 9 is in the form of a truncated cone with the reduced end rigidly secured to the main body of the tube. The purpose of this conical portion is to form a cop whose upper surface portion FG is vertically aligned with the middle surface portion GH. When the rewinding tube 4 shown in FIG. 5 is used, the rewinding tension is maintained more uniformly and yarn shifting occurs scarcely.

As an example of the invention assumed that a 48_s (metric count) yarn is taken up by a pot having an inside diameter of 8 cm. and rotating at 20,000 r.p.m. Under these circumstances, the required minimum centrifugal force is provided when the roll of yarn layers has a mininum inside diameter of 6 cm. Since experiences indicate that the angle B″A″C″ shown in FIG. 3 is to be equal to 12 degrees, the difference between the levels of the points B″ and D″ or the height E″D″ in centimeters is calculated as follows:

$$E''D''=B''E''\cot 12^\circ=\frac{8-6}{2}\cot 12^\circ=4.7$$

Assuming the B″E″ represents the axis of abscissa $h=0$ and a straight line perpendicular to B″E″ and passing through the point B″ represents the axis of ordinate $r=0$, the figures of the coordinates of the points B″ and D″ are substituted in the Equation 4. Then

$$0=4^2K_1+K_0$$
$$4.7=3^2K_1+K_0$$

From these equations $K_1=-0.671$ and $K_0=-10.7$ are obtained. Thus the equation (4′) $h=-0.671r^2+10.7$ expresses the curve B″D″ or the generatrix for the lower portion of the internal wall surface of the pot.

In this case the ratio of the total thickness of the yarn layers to the projection of the tilted surface of the yarn layers on the internal wall surface of the pot is calculated at

$$\frac{r_1-r_2}{h_0}=0.213$$

because $r_1=4$ cm., $r_2=3$ cm. and $h_0=4.7$ cm. Therefore, this ratio satisfies the aforesaid inequalities

$$0.15<(r_1-r_2)h_0<0.5$$

By using the Equation 5 a curved surface suitable for the lower portion of the internal wall surface of the pot can be similarly calculated.

What I claim is:

1. In a centrifugal spinning machine, a container of circular cross section rotating about its axis at a constant high speed, a yarn guide tube extending axially into said container for feeding a bundle of fibres into said container at a constant rate, said fibres being twisted as yarn and deposited in successive layers on the inner surface of said container by centrifugal force, said guide tube being reciprocated longitudinally relative to said container at a predetermined uniform speed through a stroke of constant length to distribute said spun fibres along the length of the container, the upper and lower limits of movement of said guide tube being progressively lowered relative to said container at a uniform rate as layers of said spun fibre are deposited in the container, whereby the upper ends of successive layers generate a substantially parabolic curve as viewed in an axial section through the container, the inner peripheral surface of the container in the range between initial upper and lower limits of the travel of said guide tube being cylindrical and the lower portion of the inner peripheral surface of the container in the range between the initial and final lower limits of the travel of said guide tube being substantially parabolic and corresponding in curvature to said parabolic curve generated by the upper ends of successive layers.

2. Apparatus as claimed in claim 1, wherein that portion of said internal peripheral surface of the container corresponding to that part of the stroke of said guide tube between the lower limit thereof at the beginning of the operation and at least the lower limit thereof at the end of said operation comprises a surface of rotation whose generatrix is expressed by the equation

$$h=K_1r^2+K_0$$

where h is a vertical distance between the lower limit of the stroke at the beginning of the operation and the lower limit of the stroke at any time during the operation, r is the inside radius of a roll of yarn layers being formed on the internal peripheral surface of the container, and K_0 and K_1 are constants, the inside radius of the container r_1 and the inside radius of the finished roll of yarn layers r_2 being correlated with a vertical distance h_0 between the lower limit of the stroke at the beginning of the operation and the lower limit of the stroke at the end of the operation such that

$$0.15<\frac{r_1-r_2}{h}<0.5$$

3. A taking up pot as claimed in claim 1, wherein that portion of said internal peripheral surface of the container corersponding to that part of the stroke of said guide tube between the lower limit thereof at the beginning of the operation and at least the lower limit thereof at the end of said operation comprises a surface of rotation whose generatrix is expressed by the equation

$$h=K_2r^3+K_3r^2+K_0$$

where h is a vertical distance between the lower limit of the stroke at the beginning of the operation and the lower limit of the stroke at any time during the operation, r is the inside radius of a roll of yarn layers being formed on the internal peripheral surface of the container, and K_0, K_2 and K_3 are constants, the inside radius of the container r_1 and the inside radius of the finished roll of yarn layers r_2 being correlated with a vertical distance h_0 between the lower limit of the stroke at the beginning of the operation and the lower limit of the stroke at the end of the operation such that

$$0.15<\frac{r_1-r_2}{h}<0.5$$

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MERVIN STEIN, *Primary Examiner.*