APPARATUS FOR SPINNING SHEATH-CORE TYPE COMPOSITE FIBERS

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ABSTRACT
A spinning device for producing sheath-core composite fibers. The device has an end plate with two kinds of openings, one to form the sheath component and the other to form the core component, the two kinds of openings supplying the streams of two different spinning solutions isolated from each other. The device has a first distributing plate which supplies the first spinning solution to the back side of a spinnerette plate and has openings therethrough to lead streams of the second spinning solution to second and third distributing plates. The second distributing plate has openings therethrough to lead the streams of the two different spinning solutions to the subsequent third distributing plate. The third distributing plate has flowing-down grooves on the surface contacting the second distributing plate to flow streams of the second spinning solution to the back side of the spinnerette. Sheath-component flowing-in grooves are provided in the device to supply sheath-component spinning solution from the first distribution plate so as to surround the core-component-forming spinning solution streams. The spinnerette plate has spinnerette orifices with axial centers substantially coinciding with the axial centers of the flowing-down grooves in the third distributing plate through which the composite fibers are extruded.

4 Claims, 6 Drawing Figures
1 APPARATUS FOR SPINNING SHEATH-CORE TYPE COMPOSITE FIBERS

The present invention relates to a device for spinning sheath-core type composite fibers, more particularly to a device for spinning sheath-core type composite fibers, which comprises laminated plates having differently shaped stream passages for the spinning solutions and a spinnerette plate attached thereto.

Composite fibers composed of different fiber-forming components having different dyeability or thermal shrinkage joined with each other along the whole length in the axial direction of the fibers are widely used because of their properties of developing peculiar spiral three dimensional crimps, and multi-color effects or different color effects due to the difference in dyeability. Also, many devices have been proposed for spinning such composite fibers.

When the difference in thermal shrinkage between the different fiber-forming components of the composite fibers is relatively large, the development of spiral-shaped three dimensional crimps is excellent. However, in the case of the high development or crimps in the "side-by-side" type arrangement of the fiber-forming components, the different components are apt to strip off or become delaminated from each other, thus adversely affect the physical properties of the composite fibers. To prevent this, an arrangement of fiber-forming components known as "sheath-core" type arrangement has been proposed. Sheath-core type composite fibers have many advantages which are not observed in side-by-side type composite fibers. For example, when composite fibers are produced which are composed of a component excellent in sensuous fiber properties such as dyeability, touch, etc. as the sheath part, and the other component excellent in physical properties such as strength, elongation, rigidity, etc. or containing a fiber modifier such as a flame retarding agent as the core part, not only the sensuous properties of the crimped fibers such as dyeability, etc., but also the practical properties such as strength, elongation, or fire-resisting properties can be greatly improved over those of conventional side-by-side type composite fibers. However, spinning devices for extrusion-spinning sheath-core type composite fibers are generally complicated in comparison with those for extrusion-spinning side-by-side type composite fiber. This imposes a large restriction on the number of spinning orifices per unit area of the spinnerette plate. Thus, the production of sheath-core type composite fibers by the wet spinning process requiring an especially large number of spinning orifices has suffered great inconvenience in practice from such limitation on the productivity.

As a result of our research to overcome this difficulty in conventional spinning devices for producing sheath-core type composite fibers, we have found that, by using laminated distributing plates having peculiar passages for leading the streams of two different spinning solutions to the backside of the spinnerette plate to bring them into sheath-core relationship, a spinning device for producing sheath-core type composite fibers can be provided having a number of the spinnerette orifices in the spinnerette plate per unit area which is large enough for practical use in spite of its extremely simple structure in comparison with conventional devices and which provides remarkably improved joined shape of the sheath and core components.

A main object of this invention is to provide composite fiber spinning devices having structural characteristics suitable for producing sheath-core type composite fibers.

A further object of this invention is to provide novel spinning devices which have a greatly increased number of spinnerette orifices per unit area of the spinnerette plate in comparison with conventional spinning devices for producing sheath-core type composite fibers.

Another object of this invention is to provide a spinning device for producing sheath-core type composite fibers whose joined shape formed by the sheath and core components is remarkably stabilized in spite of the simplicity in structure.

Other objects of this invention will become apparent from the following description.

These objects of this invention can be attained by providing a spinning device composed of three kinds of laminated distributing plates in which peculiar stream passages for spinning solution are formed.

More particularly, this invention provides a spinning device for producing sheath-core type composite fibers characterized in that:

a. an end plate having two kinds of openings bored therethrough, the one kind for supplying the first spinning solution to form the sheath component and the other kind for supplying the second spinning solution to form the core component of the composite fibers, these two kinds of openings being to supply the streams of the two different spinning solutions in an isolated state from each other,
b. the first distributing plate having cut-off parts to cause the sheath-component forming streams supplied from the openings for supplying the first spinning solution, to flow to the backside of the spinnerette plate; and having introducing openings bored therethrough to lead the streams of the second spinning solution for forming the core component to the subsequent second and third distributing plates,
c. the second distributing plate having leading openings bored therethrough to lead the streams of the two different spinning solutions to the subsequent third distributing plates, and
d. the third distributing plates having flowing-down grooves on the surface contacting the second distributing plate, the grooves being to cause the streams of the second spinning solution for forming the core component (which have flowed thereinto through the supplying openings for the second spinning solution bored through the foregoing end plate, the introducing openings bored through the first distributing plate, and the one end leading openings bored through the second distributing plate) to flow to the backside of the spinnerette; and having supplying openings for the streams of the first spinning solution to flow therethrough, the openings communicating with the other hand leading openings bored through the second distributing plate, are laminated consecutively with the end plate at both ends, and
e. a spinnerette plate having spinnerette orifices with the axial centers substantially coinciding with the axial centers of the core-component flowing-down grooves formed in the third distributing plate is positioned in the downstream zone of the spinning so-
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This invention also provides a spinning device for producing sheath-core composite fibers characterized in that

a. an end plate having two kinds of openings bored therethrough for supplying the first spinning solution to form the sheath component and the other kind for supplying the second spinning solution to form the core component of the composite fibers, these two kinds of openings being to supply the streams of the second and different spinning solutions in an isolated state from each other,

b. the first distributing plate having cut-off parts to cause the sheath-component forming streams supplied from the openings for supplying the first spinning solution, to flow to the backside of the spinnerette plate; and having introducing openings bored therethrough to lead the streams of the second spinning solution for forming the core component to the subsequent second and third distributing plates,

c. the second distributing plate having leading openings bored therethrough to lead the streams of the two different spinning solutions to the subsequent third distributing plate, and

d. the third distributing plate having flowing-down grooves on the surface contacting the second distributing plate, the grooves being to cause the streams of the second spinning solution for forming the core component (which have flowed therethrough by the openings for the second spinning solution bored through the foregoing end plate, the introducing openings bored through the first distributing plate, and the one hand leading openings bored through the second distributing plate) to flow to the backside of the spinnerette; and having supplying openings for the streams of the first spinning solution to flow therethrough, the openings communicating the other hand leading openings bored through the second distributing plate, are laminated consecutively with the end plate at both ends,

e. sheath-component-flowing-in grooves are provided which communicate with the cut-off parts of the first distributing plate on the end surface of the second distributing plate facing the backside of the spinnerette plate and between the flowing-down grooves of the third distributing plate so that the sheath-component-forming spinning solution streams supplied to the cut-off parts of the first distributing plate can surround the core-component-forming spinning solution streams, and

f. a spinnerette plate having spinnerette orifices with the axial centers substantially coinciding with the axial centers of the core-component-flowing-in grooves formed in the third distributing plate positioned in the downstream zone of the spinning solution passages formed by the laminated body of the foregoing distributing plates.

The invention will be further explained by referring to the accompanying drawings wherein:

FIG. 1 is an exploded perspective view showing an example of the structure of the spinning device for producing sheath-core type composite fibers according to the present invention.

FIG. 2 is a partially broken sectional view to show an arrangement of the laminated body of distributing plates and the spinnerette plate.

FIG. 3 is a perspective view of a laminated body of distributing plates showing another embodiment in which sheath-component-flowing-in grooves are provided on the end surface of the distributing plate (the second and the third) in connection with the flowing-down grooves of the third distributing plate.

FIG. 4 and FIG. 5 are cross-sections to show the arrangement of the sheath component in the sheath-core type composite fibers produced by the devices of the present invention.

FIG. 6 is a cross sectional photograph of the sheath-core type composite fibers obtained by the use of a spinning device embodying this invention.

Referring to FIGS. 1 and 2, an end plate 1 has the first spinning solution-supplying opening 13 and the second spinning solution-supplying opening 14 bored therethrough to supply the streams of two different spinning solutions in an isolated state from each other. The end plate 1 is closely contacted with the first distributing plate 3 on the backside, i.e., on the side for extrusion of the spinning solutions. The first distributing plate 3 has introducing openings 17 bored therethrough to lead the streams of the spinning solution for forming the core component of the composite fibers from said distributing plate toward the second distributing plate 4 and toward the third distributing plate 5 which is closely contacted with the second distributing plate 4. The plate 3 is also formed with cut-out parts 12 to cause the streams of the other spinning solution for forming the sheath component of the composite fibers to flow to the backside of a spinnerette 6. The second distributing plate 4, being held between the first distributing plate 3 and the third distributing plate 5 so as to form a unitary structure, forms stream passages to flow down the streams of the different spinning solutions to the backside of the spinnerette 6, and also has leading openings 15 and 16 bored therethrough to lead these streams of the different spinning solutions to the subsequent third distributing plate 5 and first distributing plate 3. The third distributing plate 5 has a supplying opening 18 bored therethrough to lead the streams of the sheath component-forming spinning solution to the first distributing plate 3 and second distributing plate 4, and also has a supply opening 8a and flowing-down grooves 8 communicating with said supply opening 8a and which are arranged along an edge of plate 5 at intervals equal to the spinnerette orifices 9 mentioned hereinafter to cause the streams of the core-component-forming spinning solution to flow to the backside of the spinnerette plate 6.

In assembling the spinnerette device according to the present invention, the first, second and third distributing plate are replaced together repeatedly in the above described order depending upon the required number of the spinnerette orifices, and the thus obtained assembly of the distributing plate is bound together firmly between the end plates 1. By fastening these end plates and distributing plates with suitable clamping elements such as bolts (not shown in the drawings) into a unitary structure, a laminated assembly for introducing the spinning solution streams is formed.

Indicated with the numeral 7 is a spacer plate having openings 7a therein to form a narrow spacing T (FIG. 2) for joining the streams of the core-forming and
sheath-forming streams of the spinning solutions together into sheath-core arrangement prior to extruding them through the spinnerette orifices 9 formed in the spinnerette plate 6. The plate 7 contacts at its peripheral and central parts with the spinnerette plate 6 as well as the end surface of the laminated body on its extrusion side of the spinning solutions.

The spinnerette plate 6 has a large number of spinnerette orifices 9 therethrough the axial centers of which coincide substantially with the axial centers of the corresponding grooves 8 in the third distributing plate 5 through which the core component-forming spinning solution flows.

In the spinning devices of this invention, the streams of the spinning solution for forming the core part of the sheath-core type composite fibers flow through the grooves 8 formed in the third distributing plate 5 in a state isolated from the streams of the spinning solution for forming the sheath part, thus forming laminar flows, and reach the backside of the spinnerette plate 6 which has spinnerette orifices 9 coinciding with the axial centers of the above-mentioned grooves 8. However, the spinnerette plate 6 does not have any spinnerette orifices at the place corresponding to the downstream zone of the streams of the other spinning solution for forming the sheath component. Thus, although the cut-out parts 12 formed in the first distributing plate 3 for the flow of streams of the shear-component-forming spinning solution face the backside of the spinnerette plate 6 through the openings in the inserted plate 7, there are no spinnerette orifices in the spinnerette plate 6 in those areas corresponding to the downstream zone from the cut-out parts 12.

When streams of two different spinning solutions to form the core and sheath components of a composite fiber are supplied to the backside of the spinnerette plate 6 through the structure composed of such distributing plates and spinnerette plate, the streams of the spinning solutions are joined together at the narrow spacing T formed by the openings in the spacer plate 7 to form an arrangement in which the sheath component surrounds the core component. Accordingly, from the spinnerette orifices 9 there are extruded composite fibers having cross sections as shown in FIG. 4, formed by joining the streams of the two different spinning solutions together in sheath-core arrangement.

As another embodiment of this invention, it is possible to use a structure as shown in FIG. 3, wherein sheath component flow grooves 10 into which the sheath component flows are provided, in the laminating direction of the distributing plates, on the end surface of the second distributing plate 4 facing the backside of the spinnerette plate 6 and between the grooves 8 formed in the third distributing plate 5, and wherein the end parts of the sheath component-flow grooves 10 are communicated with the cut-out parts 12 of the first distributing plate 3. In this type of spinnerette device, the streams of the shear-component-forming spinning solution, by the aid of the shear-component-flow grooves 10, completely surround the streams of the core-component-forming spinning solution on the end surface of the spinning-solution-extruding side of the laminated body of the distributing plates. Thereafter, the streams of the spinning solutions reach the backside of the spinnerette plate 6 while maintaining the sheath-core relationship of the spinning solutions. Thus, as exemplified in FIG. 5, the sheath-core bicomponent arrangement in the extruded composite fiber can be further improved to be formed into concentric circular form.

Additionally, in order to maintain the arrangement of the core and sheath components in the cross section of the composite fiber in better shape, it is desirable that the dimension of the foregoing narrow spacing T, formed by interposing the spacer plate 7 between the end surface of the laminated body of the distributing plates and the backside of the laminated body of the distributed plates should be the same with or less than that of the shear-component-forming spacing W formed by the cut-out part 12 provided in the first distributing plate 3.

Various other modifications are possible without departing from the spirit of this invention. Thus the cross section of the spinnerette orifices through the spinnerette plate may take a non-circular cross sectional shape such as triangular cross section or a flat cross section. If desired, it is possible to provide an eccentric arrangement between the streams of the shear-component-forming spinning solution and the streams of the core-component-forming spinning solution by positioning the axial centers of the shear-component-flowing-down grooves and the axial centers of the spinnerette orifices in an eccentric relationship. Further, it is possible to vary the proportion of the sheath and core components by regulating the thicknesses of distributing plates and thus varying the amounts of the streams of the spinning solutions to be supplied.

The spinning device according to this invention makes possible to extrude composite fibers having sheath-core type arrangements of fiber-forming components under very stable spinning conditions while using an extremely simple structure, and also to increase the number of spinnerette orifices per unit area of the spinnerette plate to a great extent because of the easiness of production. Accordingly, the present invention is particularly useful for the wet spinning devices which especially require an increased number of spinnerette orifices. However, the devices of the present invention can be used, of course, also for melt spinning or dry spinning of composite fibers.

An example of the practice of this invention is described in the following, but the scope of the invention is not to be limited by this example. The percentages and parts in the example are all by weight unless otherwise indicated.

Example

An acid-dye-dyeable copolymer A consisting of 80 percent acrylonitrile, 13 percent vinyl acetate and 7 percent 2-methyl-5-vinylpyridine was prepared. A copolymer B consisting of 90 percent acrylonitrile, 9.5 percent methyl acrylate and 0.5 percent sodium methally sulfonate was prepared as a basic-dyeable copolymer. The same amounts of the copolymers A and B were dissolved respectively in 50 percent sodium rhodanate aqueous solution to produce two kinds of spinning solution. The spinning solution containing the dissolved copolymer A and the spinning solution containing the dissolved copolymer B were supplied to a spinning device of this invention as the streams for forming the core component and the streams for forming the shear component of the composite fibers respectively, and were extruded therethrough into a 10 percent sodium rhodanate aqueous solution main-
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tained at a temperature of 0° C. The spinning device used was that as shown in FIG. 1 which had a narrow spacing T of 0.1 mm. between the end surface of the spinning solution-extruding side of the laminated body of the distributing plates and the backside of the spinnerette plate.

Thereafter, the fibers thus formed were subjected to washing with water, stretching, relaxation heat treatment, and drying in the usual way. The thus-obtained fibers were immersed into a dyeing bath containing 20 percent C.I. Basic Blue 4 and 1 percent acetic acid both on the weight of fibers, the bath ratio being 1:100. The dyeing treatment was carried out in the usual way. The arrangement of the sheath and core component in the composite fibers was studied of which only the sheath component had been dyed. A cross sectional photograph of the sheath-core type composite fibers after dyeing is shown in FIG. 6. From this photograph, it will be understood that the devices of the present invention are remarkably improved in the stability of spinning to maintain excellent uniformity and concentric arrangement of sheath and core components.

What we claim is:

1. A spinning device for producing sheath-core type composite fibers, comprising:
   a. at least one first distributing plate having at least one first opening and at least one second opening therein for passing a first spinning solution for forming a sheath component and a second spinning solution to form a core component of the composite fibers through said plate, said first distributing plate further having cut-out portions therein extending from said first openings to one edge thereof;
   b. at least one second distributing plate having at least one first opening and at least one second opening therein aligned with the corresponding openings in said first distributing plate for leading the streams of first and second spinning solutions therethrough;
   c. at least one third distributing plate having at least one first opening and at least one second opening therein aligned with the corresponding openings in said first and second distributing plates and having a plurality of grooves in the surface toward said second distributing plate and communicating with said second opening and opening out of the edge thereof corresponding to said one edge of said first distributing plate; said first, second and third distributing plates being assembled in a stack;
   d. an end plate on each end of said stack and each having two openings therethrough aligned with the aligned first and second openings of said distributing plates;
   e. a spacer plate having at least one opening therein against the surface of the stack of distributing plates out of which the cut-out portions and grooves in said distributing plates open with the opening in said spacer plate aligned with said cut-out portions and said grooves; and
   f. a spinnerette plate over said spacer plate and having spinnerette orifices therethrough substantially aligned with the ends of the grooves in said third distributing plate;

whereby when the first spinning solution is supplied to said first opening in said end plates and distributing plates and the second solution is supplied to the second opening in said end plates and distributing plates, the second solution flows through said grooves, across the space formed by said opening in said spacer plate and through the orifices in the spinnerette plate and said first solution flows through said cut-out portions and the space formed by said opening in said spacer plate and out through said orifices in said spinnerette plate as a sheath around said second solution.

2. A spinning device as claimed in claim 1 in which the dimension of said cut-out portions in the direction of the length of the first distributing plate is equal to the dimension of the opening in the spacer plate in the corresponding direction.

3. A spinning device as claimed in claim 1 in which said second and third distributing plates have sheath component flow grooves through the edges thereof corresponding to the edges out of which the cut-out portions and grooves open, said sheath component grooves being between the grooves in said third distribution plates and aligned with the sheath component flow grooves in said second distributing plate.

4. A spinning device as claimed in claim 1 in which there are a plurality of stacks of distributing plates between the two end plates.

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