METHOD AND APPARATUS FOR OPENING AND APPLYING FINISHES TO MULTI-FILAMENT TOWS

Jan. 4, 1966

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3,226,773

Filed Sept. 26, 1960

3 Sheets-Sheet 1

Fig. 1.

Fig. 2.

Fig. 3.
This application relates to treating filamentary materials, and in particular to processes of and apparatus for applying finishes to multi-filament tows.

It is frequently the practice in the manufacture of continuous synthetic filaments to coat the same with one or more of a number of different special purpose compositions, generally termed finishes. This practice is of particular importance where the filaments, subsequent to their being formed into yarns or tows, i.e., strands composed of a relatively large number of individual filaments ranging from as few as ten to as many as several millions. As is well known, continuous filament tows, for example, made of an organic derivative of cellulose, are widely employed in making cigarette filters. To this end, the originally more or less straight filaments must be specially treated to impart thereto the requisite denier, bulk, cross-sectional shape, crimp, etc. In order to facilitate this treatment, it is customary to apply the finish to the filaments prior to the initiation of the treatment. Such a finish may, by way of example, be a lubricant, an anti-static agent, or a plasticizer. It will, of course, be understood that the finish, or rather the composition, must be applied to all the filaments and, as nearly as possible, uniformly to the entire tow.

In the heretofore known processes directed to the attainment of this result, it has generally been the practice to first pass the tow through a device called a "banding jet" for the purpose of spreading the filaments and thus opening the tow, and thereafter to pass the opened tow through a second device in which are arranged means for performing the actual finish applying operation. The banding jet as employed prior to the present invention basically comprises a structure defining a passageway for the strand of filaments, the passageway being bounded on at least one side by a slotted or otherwise apertured plate through which compressed air from any suitable source is permitted to enter the said passageway for the purpose of blowing the filaments apart into the form of a more or less flat band. The slots are oriented perpendicularly to the direction of movement of the tow. Known finish applicators generally comprise such devices as transfer rollers, paddle wheels or spraying heads.

As will be readily appreciated from the foregoing, the entire treatment, therefore, includes two distinct stages. This entails the considerable disadvantage that special steps must always be taken to ensure that the opened tow remains so not only during the interval of its travel from the banding jet to the applicator but also during its travel through the applicator. Even further, it has been found that the spreading efficiency of the banding jet is nullified to a certain extent by virtue of the fact that no compressed air blow of comparable magnitude of pressure is provided in the applicator to maintain the degree of separation of the filaments attained in the banding jet. As a result, the filaments have a tendency to come together again subsequent to their leaving the banding jet and especially in the applicator region, whereby the application of the finish is rendered substantially non-uniform, in some instances to such an extent that contiguous groups of filaments located within the inner regions of the tow receive no finish at all.

It is, therefore, an important object of the present invention to provide processes of and apparatus for applying a finish to filamentary material in a manner which completely avoids the disadvantages inherent in the known filament-finishing processes and apparatus.

Principalitly, it is an object of the present invention to provide means for subjecting a closed tow of continuous filaments to a simultaneous filament-spreadng and finish-applying operation. Another object of the present invention is the provision of a novel type of banding jet for use in opening and applying finish to continuous filament tows.

A further object of the present invention is the provision of such a jet in which the tow-spreadng and the finish-application chamber are constituted by one and the same filament passageway.

A related object of the present invention, therefore, is the provision of means for and processes of applying a finish to a bundle of filaments in which a compressed air stream is employed for spreading and separating the filaments of the bundle and also as the carrier for the particles, droplets or mist of the finish composition to be applied to the filaments.

The foregoing and other objects, characteristics and advantages of the present invention will be more fully understood from the following detailed description thereof when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a front elevational view, partly broken away, of a finish applicator constructed in accordance with the principles of the present invention;

FIG. 2 is a side elevational view, partly in section, of the applicator shown in FIG. 1;

FIG. 3 is a top plan view of the banding jet part of the applicator shown in FIGS. 1 and 2;

FIG. 4 is a top plan view of an orifice plate employed as a part of the banding jet of the applicator;

FIG. 5 is a sectional view taken along the line 5--5 in FIG. 4;

FIG. 5a is an elevational view of a detail of the structure shown in FIGS. 1 to 3;

FIG. 6 is a sectional view taken along the line 6--6 in FIG. 3;

FIG. 7 is a partly sectional side elevational view of the bottom plate of the banding jet of the applicator; and

FIG. 8 is a side elevational view of the top plate of the jet.

FIG. 9 is a top plan view of a different modification of an orifice plate which may be employed as a part of the banding jet of the applicator.

In accordance with the present invention generally, the apparatus employed is composed of an improved and novel banding jet in combination with a duct or conduit system through which the required compressed air is led to the jet, while the finish to be applied to the filaments is added to the air stream. The means by which the finish is introduced into the air stream may be located laterally of or in longitudinal alignment with the air duct, the sole requirement being that the finish is entrained by the stream of air and carried thereby into the banding jet.

The jet itself preferably comprises a plenum chamber coaxial in width with the filament passageway, whereby the air is distributed over an expanse equal to the said passageway prior to being admitted into the latter. Communication between the plenum chamber and the passageway over the entire expanse of the former is established by an orifice plate which is provided with a plurality of elongated slots which in the plane of the plate form an angle of about 30⁰ to 60⁰ and preferably about 45⁰ with
the direction of movement of the filaments. Thus, while all filaments across the width of the bundle will be impinged upon by air passing through the slots, such action will neither commence nor terminate upon all of the filaments at the same time, i.e. there will be some increment between the time one filament is struck and the time an adjacent filament is struck. This time differential enables effective opening, i.e. filament separation. By contrast, if the slots are arranged at an angle of 90° to the filament movement direction all filaments will be acted upon simultaneously and opening will be less efficient. If the slots are at an angle of 0°, i.e. parallel to the filaments, obviously not all filaments will be acted upon.

The air admitted into the passageway exits through the tow outlet and also through the inlet. As it leaves through the inlet it causes the filaments to spread apart. Consequently the filaments are already in open condition when they reach the slots in the jet at which location the air has its maximum concentration of treating agent entrained as a mist or fog due to its having been sprayed into the moving air stream. The openness of the tow opposite the slots ensures a uniform deposition of treating agent and, as noted, the expanding air moving counter-current to the tow predisposes it to effective treatment.

In accordance with a preferred aspect of the present invention, there are provided two groups of parallel slots, with both groups of slots oriented angularly, i.e. obliquely, to the direction of filament movement, and with the slots in one group being oriented substantially transverse to the slots in the other group to define a "herringbone" pattern. Preferably the minimum width of the slots ranges from about 0.004 to 0.010 inch.

The process according to the present invention is particularly well suited for use in the application of finishes to synthetic filaments dry or wet spun or obtained from osmotic spinneret, the construction of which is well known and per se constitutes no part of the invention herein. Preferably, the filamentary materials may comprise organic derivatives of cellulose such as the esters or ethers thereof, e.g. cellulose acid esters such as cellulose acetate, cellulose propionate, cellulose butyrate, cellulose benzate, cellulose acetate formate, cellulose acetate propionate, cellulose acetate butyrate, and the like, ethers such as ethyl cellulose, etc. The esters may be ripened and acetone-soluble, such as conventional cellulose acetate, or may be substantially fully esterified, i.e., contain fewer than 0.29 free hydroxyl groups per anhydroglucose unit, such as cellulose triacetate.

The filaments, may, of course, be made of other materials of thermoplastic nature. Examples of these materials are the superpolymides such as nylon, superpolyesters such as polyethylene terephthalate, polyglycolic acid and copolymers thereof, polymers and copolymers of vinylidene compounds such as ethylene, propylene, vinyl chloride, vinylidene chloride, vinylidene cyanide, acrylonitrile, vinyl acetate, and the like.

The finishes, the application of which to the filaments making up a strand or tow is one of the principal objects of the present invention, may comprise a variety of substances designed, as hereinafter indicated by way of example, for lubricating, static charge-inhibiting and/or plasticizing actions. Lubricants which lend themselves to the process of the present invention are, for example, light mineral oil, olive oil, polyalkylene glycol ethers of alcohol, camphor oil, and mixtures of them containing about 8 to 18 carbon atoms, polycyclic glycol esters of acids containing about 8 to 18 carbon atoms, and other materials well known in this art. Anti-static finishes which may be employed are, for example, salts of amines such as triethanolamine or dibutylethanolamine with an acidic material such as oleic acid, stearic acid, higher alkyl partial esters of phosphoric acid, e.g. decyl, lauryl or stearyl mono-phosphate, alky or aryl sulfonic acids or partial sulfates, sodium salts of these acidic substances, magnesium chloride, quaternary ammonium salts, and like materials. As plasticizers, such substances as dibutyl phthalate, methyl phthalyl ethyl glycolate, and the like can advantageously be employed.

Referring now more particularly to the drawings, it will be seen that a finish applicator 19 according to the present invention comprises a banding jet 11 and a dust system 12 adapted to conduct the filament-spraying fluid and the finish to the jet. The manner in which the dust system 12 is connected to the jet will be more fully described hereinafter.

The banding jet 11 comprises a bottom plate 13, a center plate 14, and a top plate 15. As can be seen from FIGS. 1, 2, 6 and 7, the bottom plate 13 is a substantially rectangular cup-shaped element provided with a correspondingly shaped recess or cavity 16 open toward the top surface of the plate, the cavity thus being defined within the relatively thick marginal regions 13a of the plate 13. The latter is further provided with a central opening 17 extending from the bottom surface of the plate to the cavity or recess 16. Welded to the plate 13 at the bottom surface thereof and about the opening 17, as shown at 18, is a fitting or connecting member 19 provided with internal threads and substantially remote from the plate 13. A plurality of threaded bores 130, eight in number in the illustrated embodiment of the invention, is provided in the marginal region 13a of the plate 13.

The center plate 14 which is positioned atop the bottom plate 13 is also a rectangular element the outer border regions of which rest on the end and side marginal regions 13a of the bottom plate 13. The central region of the plate 14 thus overlies the cavity 16. Formed in the center plate 14 are two groups of slots 21 and 22 (see FIG. 4). The slots of each group (which, for the sake of clarity, are not indicated in FIG. 3) are substantially parallel to one another and are arranged at a predetermined angle to the transverse or width dimension of the plate 14, i.e., to the ultimate direction of movement of the filamentary tow over the said plate as indicated by the arrows in FIG. 4. Although the angle, as shown, is about 45° for each group, it is to be understood that the angle may vary within wide limits, e.g. advantageously about 30° to 60°. It is to be noted that the group of slots 21 as shown in FIG. 4 is oriented angularly relative to the group of slots 22. This angle is approximately 90° in the illustrated and preferred embodiment of the invention, but it will be understood that it may too vary, depending on the desired arrangement of the slots relative to the transverse dimension of the plate, from 0° to about 120°.

Referring specifically to FIG. 5, it will be seen that each slot 21, and thus each slot 22 also since all the slots are substantially identical, is essentially trapezoidal in cross-section, with the narrower end of the slot, i.e., the smaller base of the trapezoid, located at the top surface of the center plate 14. In accordance with the preferred aspect of this invention, the axis of each of the slots 21 and 22 is oriented perpendicularly to the top and bottom faces of the plate 14. Nevertheless, it is within the contemplation of the present invention that the slots may be tilted relative to the vertical, i.e., that the axes of the slots be angularly disposed relative to the top and bottom faces of the plate 14. The slots are preferably formed by standard milling techniques in a manner requiring no detailed explanation herein.

The center plate 14 is further provided with a plurality of threaded bores 23 which are so located in the marginal regions of this plate as to be in registry with the bores 130 in the bottom plate 13 when the two plates are placed one atop the other with their respective holes in registry. The plates 13 and 14 are rigidly connected to one another by means of a plurality of screws or bolts 24 extending through the aligned bores 130 and 23, care...
being taken that the axial length of each screw is not greater than the combined axial length of the corresponding pair of bores 13b and 23. It will be seen that when the bottom plate 13 and the center orifice plate 14 are so connected with one another, the cavity 16 becomes a chamber, heretofore referred to as the plenum chamber, which, in contradistinction to the plates 13 and 14, entirely imperforate in its center region (see FIG. 8). At one end edge the plate 15 is provided with a pair of longitudinally extending threaded bores 15c and 15d which receive (see FIGS. 2 and 3) respective pairs of screws or bolts 31 and 32, these serving, respectively, to affix to the bottom surface of the top plate 15 a pair of relatively thin rectangular or plates 33 and 34. The spacer plates 33 and 34 are substantially identical to one another except for a 45° chamfer 35 provided at one longitudinal edge of the plate 34. Similarly, a 45° chamfer 36 is provided at the upper end edge of the plate 15 overlying the spacer plate 34. The projecting portions of the pins 38 are rotatably received, respectively, in the bores 26c of the vertical legs 26a of the mounting plates 26. The top plate 15 when in the position shown in FIG. 2 is, therefore, spaced from the orifice plate 14 by the thickness of the plates 33 and 34. Moreover, the entire assembly 15–33–34 is pivotally mounted over the plenum chamber unit 13–14, any interference with angular movement of the former relative to the latter being prevented by the presence of the chambers 35 and 36 on the plates 15 and 34. The space 37 defined between the plates 14 and 15 constitutes the filament passageway of the banding jet 11. The advantages of such a constructional arrangement will be readily apparent. With the top plate 15 hinged to the plenum chamber unit as shown, it is possible at any time during a finish application run to interrupt the same, for example, to provide for the purpose of inspecting the orifice plate 14 for clogging or abrasion, or the extent and uniformity of spreading of the filaments in the jet, which can be done simply by raising the plate 15 after pulling the portion 29a of the latch member 29 slightly away from the front end of the bottom plate 13. Moreover, the arrangement according to the present invention permits removal of the orifice plate 14 for repair, cleaning or replacement without difficulty, since with the plate hinged back, it is merely a matter of loosening the screws 24 halfway to permit the plate 14 to be drawn out of the jet. There is, consequently, no need for disassembling the entire device. Once the orifice plate has been removed, of course, the chamber 16 may be cleaned also, again without any further disassembly of the jet or the installation.

Referring now again to FIGS. 1, 2 and 7, it will be seen that the duct system 12 comprises essentially an elongated conduit 38 which is provided at one end with an externally threaded extension or other connecting member (not shown) extending into the internally threaded fitting 19 of the jet 11. In actual practice, since the jet is usually a very light and relatively small unit, while the duct system 12 is a more or less permanent installation, it will be appreciated that this connection is effected by screwing the jet fitting or connecting member 19 onto the threaded extension of the conduit 38. According to the illustrated embodiment of the invention, the conduit 38 is provided with an opening 38' at one side. Affixed to the conduit 38 at, and communicating with the same through, the opening 38' is a tubular pipe element 39 having an end wall 40 remote from the conduit 38. Extending through and supported by the end wall 40 of the element 39 is a relatively narrow feed pipe 41. Connected to the end of the latter located inside the pipe element 39 is a coupling 42 to which in turn is connected a spray head or nozzle member 43.

The end of the conduit 38 remote from the jet 11 is connected to a suitable source (not shown) of air under pressure, while the end of the pipe 41 remote from the spray head 43 is connected to a suitable source (not shown) of finish or to a pump or the like (also not shown) adapted to force the finish through the pipe. It is to be understood, of course, that the duct arrangement need not be exactly as shown, it being possible, for example, to introduce the finish substantially axially into the conduit 38.

In operation the tow is pulled through the banding jet as by positively driven rolls (not shown). With tows of more than about 5000 filaments, where uniform treatment poses a special problem, the tendency on her filaments should be less than about 15 milligrams per fil in order to permit the filaments to separate sufficiently for the treating liquid to act upon each filament. While the tow advances through the banding jet, the finish laden stream of compressed air reaches the plenum chamber 16, expands and enters the filament passageway 37 over substantially the entire expanse thereof. In this manner, spreading of the filamentary tow into the form of a band or ribbon having the same width as the passageway is ensured, and an entirely uniform application of finish to the filaments is accomplished due to the fact that the very same air utilized for the spreading operation is also utilized for the finish applying operation. The heretofore always present time lag between the spreading and applying operations is, therefore, completely eliminated by the present invention.

While each of the slots 21, 22 has been shown as long and continuous, each could be interrupted, i.e. made up of a number of drilled holes closely aligned to produce substantially the same effect as a long slot. This modification is shown in FIG. 9 which is similar to FIG. 4 except that slots 21 and 22 of the latter figure are replaced by the corresponding series of spaced holes 21' and 22'. If desired such slots or spaced holes and a suitable plenum chamber could be provided also in plate 15, preferably offset so as not to be shown when the slots in plate 14. Also pipe 41 and nozzle 43 could discharge into conduit 38 axially rather than transversely, if desired.

The invention is further illustrated in the following example.
EXAMPLE

A 120,000 denier tow of 40,000 cellulose acetate filaments is pulled at a speed of 75 meters per second through a horizontal jet as illustrated in the drawings. The tension on the tow near the driven rolls (not shown) which pull it from the jet is about 450 grams. The passageway through which the tow moves is 0.125 inch x 4.5 inches in elevation. The slots extend at 45° angles to the direction of tow movement and in the face of plate 14 they are 1.4 inches x 0.007 inch. Air at 8 p.s.i.g. is supplied to the jet along with 2 pounds per hour of a lubricant comprising 90% of water, 6% of n-decyl phosphate and 4% of triethanolamine. The tow leaves the jet as a feely open structure uniformly carrying the lubricant as evidenced by the uniform character of the product resulting from subsequent further processing in conventional manner.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made in the invention without departing from the spirit and scope thereof.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. The process of opening an initially compact strand composed of a plurality of relatively closely adjacent individual filaments, comprising the steps of inserting said strand through a relatively wider passageway and introducing high pressure compressible inert fluid into said passageway in the form of a plurality of planar streams of said fluid arranged at an angle of approximately 30° to approximately 60° transversely to the path of the strand so that the entire width of said strand is contacted by said fluid.

2. The process of claim 1 wherein said planar streams are arranged in a herringbone pattern.

3. The process of claim 1 wherein said strand comprises at least about 5000 filaments and is pulled through said passageway under a tension of less than about 15 milligrams per fil.

4. The process of opening and applying a finish to an initially compact strand composed of a plurality of relatively closely adjacent individual filaments comprising the steps of inserting said strand through a relatively wider passageway, spraying a quantity of said finish into compressed air, and introducing said compressed air containing said finish into said passageway in the form of a plurality of planar streams of air transversely to the path of the strand so that the entire width of said strand is contacted by said air and said filaments of said strand are simultaneously spread apart and coated with said finish.

5. The process of claim 4 wherein said planar streams are arranged in a herringbone pattern.

6. The process of claim 4, wherein said strand comprises at least about 5000 filaments and is pulled through said passageway under a tension of less than about 15 milligrams per fil.

7. The process of treating and opening an initially compact strand composed of a plurality of relatively closely adjacent individual filaments comprising the steps of inserting said strand through a relatively wider passageway, introducing high pressure compressible inert fluid having a treating agent entrained therein into said passageway in the form of a plurality of planar streams of said fluid transversely to the path of the strand so that the entire width of said strand is contacted by said fluid and discharging said fluid from said passageway at least in part in countercurrent direction to the passage of said strand except that said treating agent is applied uniformly to said strand.

8. Apparatus for treating a filamentary strand composed of a plurality of relatively closely adjacent filaments, comprising banding jet means defining a relatively wide passageway for said strand and a plurality of openings each in the shape of a slot facing said passageway, duct means communicating with said passageway for directing thereto a stream of high pressure inert carrier fluid through said passageway and a plurality of planar streams of said fluid corresponding to said openings which are transverse to the path of said strand such that the entire width of said strand is contacted by said fluid, and means for spraying into said duct means a treating fluid, whereby a treating fluid is brought into said passageway by said stream of carrier fluid and said filaments of said strand are simultaneously spread apart and subjected to the action of said treating fluid.

9. Apparatus according to claim 8, said banding jet means comprising first and second spaced parallel plates, said passageway being defined between said plates, said first plate being provided with a plurality of openings arranged at an angle relative to the direction of movement of said strand through said passageway, said duct means being in communication with said openings.

10. Apparatus according to claim 9, wherein said openings in said first plate are arranged at an angle of about 30° to 60° relative to said direction of movement of said strand.

11. Apparatus according to claim 10, said openings being arranged in two groups, with the openings in each group being substantially parallel to one another and with the orientation of the openings in each group being substantially parallel to the orientation of the openings in the other group, to thereby define a herringbone pattern of said openings.

12. Apparatus according to claim 11, said banding jet means further comprising a third plate affixed to said first plate at the face of the latter remote from said passageway and said second plate, said third plate being provided with a cavity substantially coextensive with the aperted region of said first plate and communicating with said openings thereof, said duct means being connected to said third plate and communicating with said cavity.

13. Apparatus according to claim 12, said banding jet means further comprising a pair of mounting plates attached to said third plate, said second plate being pivotally connected to said mounting plates, and latch means operable to lock said second and third plates to one another and releasable from at least one of them to permit swinging of said second plate away from said first plate.

14. A banding jet, comprising first and second spaced, parallel plates defining therebetween a passageway for a strand of filaments to be spread apart, said first plate being provided with a plurality of openings each in the shape of a slot facing said passageway and arranged at an angle of approximately 30° to approximately 60° to the path of said strand, a third plate attached to said first plate at the face of the latter remote from said second plate, said third plate being provided at the face thereof adjacent said first plate with a cavity constituting a plenum chamber substantially coextensive with the aperted region of said first plate, said third plate being further provided with a bore extending from said cavity to the face of said third plate remote from said first plate for permitting establishment of communication between said plenum chamber and a source of high pressure inert fluid which is thus able to flow through said openings to form a plurality of planar streams of said fluid corresponding to said openings which are transverse to the path of said strand such that the entire width of said strand is contacted by said fluid, means pivotally connecting said second plate to one end thereof to said third plate, and latch means operable to lock said second and third plates to one another and releasable from at least one of them to permit swinging of said second plate away from said first plate.

15. A banding jet according to claim 14, said openings being arranged in two groups, with the openings in each group being substantially parallel to one another, and
with the orientation of the openings in each group being substantially transverse to the orientation of the openings in the other group, to thereby define a herringbone pattern of said openings.

16. Apparatus for treating a filamental strand composed of a plurality of relatively closely adjacent filaments, comprising banding jet means defining a relatively wide passageway for said strand and a plurality of openings each in the shape of a series of closely spaced holes aligned in a straight line facing said passageway, duct means communicating with said passageway for directing thereinto a stream of high pressure inert carrier fluid through said openings to form a plurality of planar streams of said fluid corresponding to said openings which are transverse to the path of said strand such that the entire width of said strand is contacted by said fluid, and means for spraying into said duct means a treating fluid, whereby a treating fluid is brought into said passageway by said stream of carrier fluid and said filaments of said strand are simultaneously spread apart and subjected to the action of said treating fluid.

17. A banding jet, comprising first and second spaced, parallel plates defining therebetween a passageway for a strand of filaments to be spread apart, said first plate being provided with a plurality of openings each in the shape of a series of closely spaced holes aligned in a straight line facing said passageway and arranged at an angle of approximately 30° to approximately 60° to the path of said strand, a third plate attached to said first plate at the face of the latter remote from said second plate, said third plate being provided at the face thereof adjacent said first plate with a cavity constituting a plenum chamber substantially coextensive with the apertured region of said first plate, said third plate being further provided with a bore extending from said cavity to the face of said third plate remote from said first plate for permitting establishment of communication between said plenum chamber and a source of high pressure inert fluid which is thus able to flow through said openings to form a plurality of planar streams of said fluid corresponding to said openings which are transverse to the path of said strand such that the entire width of said strand is contacted by said fluid, means pivotally connecting said second plate at one end thereof to said third plate, and latch means operable to lock said second and third plates to one another and releasable from at least one of them to permit swinging of said second plate away from said first plate.

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