ROVING IMPREGNATOR FOR MAKING LOW-VOID FILAMENT WOUND ARTICLES

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ABSTRACT OF THE DISCLOSURE

An impregnator for use in making low-void filament wound articles by eliminating voids from the filaments prior to winding, the impregnator comprising a resin chamber through which the filaments pass and which is divided into successive compartments, the dividing means including guide elements defining tortuous path for the filaments and having cooperating sealing elements that contact the guide elements and are also including progressively reduced height whereby fresh resin introduced at the filament exit compartment spills over the divider to fill each compartment successively toward the filament input compartment.

The present invention relates to a filament impregnator for use in apparatus for making low-void filament wound articles, that is, articles having a wall consisting of winding filaments that are fixed in position by a binding material. The filaments are generally of glass or other material characterized by high tensile strength and low weight, or, stated differently, a very high strength-to-weight ratio. The binding material may be a thermosetting resin such as an epoxy polymer, which impregnates the windings and, when cured, becomes permanently set and thus binds the winding filaments into a self-supporting article. These articles are designed primarily for use in applications requiring light weight as well as the capacity for withstanding high pressure or other stresses, for example, a rocket case or the boom of a "cherry picker," or the capacity for withstanding high electrical stresses as required for use in circuit breaker tubes.

More particularly, the present invention relates to an impregnator for use in a so-called wet-winding process wherein a group or bundle of filaments, which is called a roving, is impregnated with the binding material before winding, and the low-void characteristics of the winding structure are produced by working the roving during impregnation to eliminate the voids from it. Thus, there is eliminated from the wound structure any voids that would otherwise result from winding with roving having air trapped between between or on the filaments. The voids are removed from the roving by running the same over a series of guides while immersed in the resinous binding material, and by complementary wiping members acting upon the rotors as it passes over the guide elements to wipe the encapsulated and entrained air from the surface and to collapse the roving and thereby force or squeeze out the entrapped air.

The objects of the present invention are to provide a roving impregnator of the above referred to type for making low-void filament wound articles, which impregnator is simple and is easy to use and to maintain, and will more effectively eliminate voids from the roving.

The above and other objects have been achieved in accordance with this invention by an impregnator of the above type wherein the guide elements defining the immersed roving path are mounted in path members that constitute baffles or dividers that separate the resin chamber into a plurality of successive compartments and which themselves can be readily removed from their operative positions for cleaning the dividers or the impregnator. The successive compartments of the resin chamber are effectively sealed by the guide members whereby the air removed from the roving at each divider is confined to the chamber in which it is removed and is not carried by the roving or by the circulation of the binding material to the successive chambers.

With the above and other objects in view, the present invention is hereininafter described with reference to the accompanying drawings, in which:

FIG. 1 is a top plan view of an impregnator embodying the present invention.
FIG. 2 is a longitudinal sectional view taken substantially on the line 2--2 of FIG. 1.
FIG. 3 is a transverse sectional view taken substantially on the line 3--3 of FIG. 1.
FIG. 4 is an elevational view of the exit end of the impregnator of FIG. 1.
FIG. 5 is a top plan view similar to FIG. 1 of another impregnator embodying the present invention.
FIG. 6 is a sectional view taken substantially on the line 6--6 of FIG. 5.
FIG. 7 is a sectional view taken substantially on the line 7--7 of FIG. 5.

With reference to the drawings, there is illustrated an impregnator comprising a resin chamber 1 having a double-walled bottom 2, sides 3 and 4, and an end wall 5 at the filament input end. The filament output or exit end of the chamber is closed by an end wall 6. A series of baffles 7 are provided between the wall members of the double-walled bottom, sides and end to define a flow path for a heating fluid through the enclosed space from an input 8 to the output 9.

Disposed within the resin chamber 1 is a series of four guide members 11 arranged transversely thereof in spaced relation and acting to divide the chamber into a plurality of resin compartments including a filament input compartment 12, a filament output or exit compartment 13 and three intermediate compartments 14. Resin is introduced into the filament exit compartment 13 by a resin input 15. From the compartment 13, the resin spills over the top of the guide members 11 to fill successively each of the intermediate compartments 14 and to supply resin to the input compartment 12. The height of the guide members 11 determines the operating level of the resin in each of the compartments, which level is indicated at 13a, 14a, 14b, 14c and 12a in FIG. 2, in the successive compartments from the filament output compartment 13 toward the input compartment 12.

The guide members 11 each comprise a base 16, the ends of which are slidably received in an opposed pair of vertical U-shaped channel members 17 secured to the inner wall members of the side walls 3 and 4. Each of the bases 16 carries a plurality of guide elements 18, three in the embodiment illustrated in FIGS. 1-4, which may be in the form of pins upstanding from the base 16 and arranged in spaced relation along the base 16 and toward the one end thereof so that when the guide members 11 are mounted in the chamber 1 in an alternating reversed fashion, the corresponding pins 18 on the successive members 11 are staggered longitudinally of the chamber to define a zig-zag yarn path.

To prevent resin from moving from one compartment to the next except by spilling over the tops of the guide members 11, the members 11 are each provided with upstanding end pieces 19 that may also, for convenience, be in the form of pins, and which are designed to provide a substantially smooth upward extension of the end wall of the base 16 engaging the adjacent face of the channel member 17. The one end piece 19 that is spaced at a great-
er distance from the adjacent guide element 18 is connected to that adjacent guide element 18 by a sheet-like partition 20. Between the other end piece 19 and the adjacent guide element 18, as well as between each pair of guide elements 18, there is disposed a sealing element 21 that comprises an upstanding support 22 (FIG. 2) that may also be in the form of a pin or upstanding from the base 16. The support 22 has a reduced diameter portion intermediate the ends thereof that is surrounded by a flexible and inflatable sleeve 23 sealed at its ends to the periphery of the support by the bore in the base 16 that receives the lower end of the support 22 and by a cap 24 that encircles the upper end of the support 22.

The sleeve 23 is adapted to be inflated into resin sealing engagement with the respective guide elements 18 or end piece 19 by air or other fluid introduced through a transverse bore in the support 22 that communicates with an axial bore 25 which in turn communicates with a bore 26 in the base 16. The bore 26 is connected to a source of fluid under pressure by a conduit 27 and a bore axially of the one end piece 19. The sleeve 23 not only provides a deformable seal that permits the roving R to pass while preventing the passage of resin, but also tends to compress the roving R against the filament guiding surface of the guide elements 18 and thus tends to squeeze entrapped air from it and to collapse the voids.

The guide members 11 are substantially identical except that they are arranged alternately end-for-end in order to provide a staggered arrangement of the guide elements 18 endwise of the chamber 1 and are progressively shorter in height from the filament exit end to the filament input end. The staggered arrangement is designed to provide a tortuous or zig-zag path for the individual roving R through the resin chamber 1 so that they are more sharply bent over the guide elements 18 and the entrapped air is more effectively worked out of the rovings. The progressively shorter height, which may be confined to the guide elements 18 and the partitions 20, so that the sealing elements 21 of the different guide members 11 may all be identical, is designed to ensure that the resin will flow only toward the filament input end of the chamber 1 and will thus isolate the air-contaminated resin at the input end. Thus, as the filaments pass successively to the intermediate compartments 14 and finally to the exit compartment 15, they pass into resin that is progressively more airfree.

The elevation of the roving R in the resin chamber 1 of the illustrated embodiment of the invention is controlled by a guide rod 29 extending transversely of the resin chamber 1 in the compartment 12, and by a pair of transverse guide rods 30 and 31 in the filament output compartment 13. Immediately in front of the rods 30 and 31 in the compartment 13 there is provided a separator guide 32 that consists of a base 33 slidable mounted at its ends in the channel members 34 that, like the channel members 17, are secured vertically to the side walls 3 and 4 of the housing 1. The base 33 has a staggered arrangement of a plurality of upstanding guide pins 35 through which the rovings R are threaded, thus providing control of the width of the impregnated roving band.

In the end wall 6 of the chamber 1 there is provided an exit seal, generally indicated at 36, for permitting escape of the roving R from the chamber 1 in a manner to minimize entrapment of air on the surface of the roving or drawing air into the resin. The exit seal 36 comprises a body 37 that is secured to the end wall 6 of the resin chamber 1 as by bolts 39 having the shanks 38 thereof threaded into the body 37. The body 37 is disposed over 40 in the end wall 6 and acts to close the same. Formed centrally of the body 37 is an upstanding peripheral wall of which constitutes a guiding surface that receives the roving R from the guide rod 31. The body 37 has a tubular mounting section 42 on which the hub 43 of an inner flap member 44 is mounted. Cooperating with the inner flap member 44 to define a deformable seal through which the roving R can pass without leaking resin, is an outer flap member 45 that is mounted between a supporting disk 46 and a compression member 47 that are in turn carried by a bolt 48 mounted on a bracket 49 secured to the body 37. For threading purposes, the body 37 has an upwardly open slot 50 that intersects the opening 41.

In operation of the impregnator in accordance with this invention, resin is fed into the chamber 1 through the inlet 15 and is maintained at the optimum temperature by means of the heating jacket afforded by the double walls and to which heating fluid is directed by the inlet 8 and from which it is exhausted by the outlet 9. Heating coils may also be included within the resin area of the impregnator. Roving R is directed under the guide rod 29, about the guide elements 18 of the successive guide members 11, to the guide rods 30 and 31 and finally to the exit seal 36. As the roving advances, the major portion of the air that is trapped within the filaments thereof or entrained on the surface, is removed as the roving passes into the resin in the inlet compartment 12 and as it passes under the guide rod 29 and between the guide element 18 and its cooperating sealing element 21 into the first intermediate compartment 14. The roving R then passes between the guide elements 18 and their cooperating sealing elements 21 of the successive guide members 11. At each guide element 18 the roving is collapsed and the air is worked and squeezed from it. The roving thus becomes progressively more air free as it moves toward the exit seal 36 from which it eventually emerges in a substantially air-free condition.

One of the primary advantages of the present invention is that the individual guide members 11 can be quickly removed simply by lifting them vertically from the channel members 17 for cleaning the member 11 or the chamber 1, or for repair or replacement of the guide member. The sleeves 23, which are preferably rubber, can be readily replaced when they become unserviceable because of deterioration or abrasion and the entire assembly can be readily and thoroughly cleaned. To a certain extent, the tension imposed upon the roving, which has a significant influence upon the winding characteristics, can also be controlled by control of the pressure imposed on the sleeves 23.

Because of the counterflow of the resin from the output end of the chamber 1 to the input end, the resin in the successive resin compartments is progressively more air-free so that the amount of air that is carried by the roving into the following compartment is successively reduced. The positive collapse of the roving by the sealing elements 21 against the filament guiding surfaces of the guide elements 18 also helps to eliminate air and voids from the roving.

In FIGS. 5, 6 and 7, there is illustrated an embodiment of the invention that differs from the embodiment of FIGS. 1–4 primarily in that the filament guiding elements are horizontal instead of vertical, and are adapted to be pivoted to an open or a threading position. The impregnator of FIGS. 5, 6 and 7 comprises a resin chamber 1 that is designated 1a and which, like the resin chamber 1, has a double walled bottom 2a, sides 3a and 4a, and an end wall 5a at the filament input end. The filament exit end of the chamber 1a is closed by an end wall 6a.

In the chamber 1a there is divided by a series of four transverse guide members 11a into a plurality of resin compartments including a filament input compartment 12a, a filament exit compartment 13a and three intermediate compartments 14a. Resin is introduced into the exit compartment 13a through an inlet 15a and from there, spills over the top of the guide members 11a to the successive intermediate compartments 14a and finally to the exit compartment 12a.

The embodiment of the invention illustrated in FIGS. 5–7 is designed primarily to facilitate threading of the filaments through the impregnator and towards this end,
the guide elements 18a are disposed horizontally instead of vertically. More particularly, each of the guide members 11a comprises a base 16a, the ends of which are slidably received in an opposed pair of vertical U-shaped channel members 17a secured to the side walls 3a and 4a. The guide members 11a also include covering bars 51 over-hanging each of the bases 16a. The guide elements 18a are carried alternately by the bases 16a and the bars 51 with the alternating ones of the bases 16a and bars 51 being of different height as illustrated in FIG. 6 in order to define a tortuous or zig-zag path for the filaments. For assembly purposes, the base 16a or bar 51 may be split to receive the guide element 18a.

Each of the bars 51 is pivotally mounted at one end by means of a pivot pin 52 to an upstanding arm 53 of the base 16a. The bars 51 are held in spaced relation at their pivoted ends by spacing sleeves 54 that surround the pivot pin 52. At their free ends, the bars 51 are spaced by a handle 55 having a cross piece 56, a depending arm 57 extending between the cross piece 56 and each of the bars 51, and a handle piece 58. The handle 55 thus provides for lifting the bars 51 simultaneously about their pivots to provide for threading the impregnator.

The guide elements 11a are of progressively reduced height from the filament exit compartment 13a toward the filament input compartment in order to confine the air-contaminated resin at the filament input end of the impregnator.

The sealing elements 21a on the different guide members 11a are carried alternately by the bars 51 and the bases 16a. The sealing elements 21a are in the form of tubes and are seated in grooves in the edges of the bars 51 and bases 16a. Each of the tubes 21a is connected at its free end to a fitting 59 (FIG. 7) mounted in the bar 51 or in the base 16a at the end of the groove which fitting is adapted to hold the tube releasably and to close the end thereof. Each tube 21a extends from the fitting 59, along the respective groove, around the pivoted end of the bar 51 and upwardly between the end of the bar 51 and the inner wall member of the side wall 4a, and is connected at is end to a manifold 60 for supplying air under pressure to the sealing elements and thereby urge the same into sealing engagement with the respective guide element 18a.

The filaments are received from the source and guided to the first guide member 11a by a guide bar 61 disposed in the filament input compartment 12a that is carried by brackets 62 detachably secured to the side walls 3a and 4a. From the last guide member 18a the filaments are directed to an exit seal 36a by a separator guide 32a that comprises a base 33a slidably mounted at its ends in channel members 34a and having a staggered arrangement of a plurality of upstanding guide pins 35a.

The impregnator of FIGS. 5-7 is provided with a drain 63 in the bottom of the filament input compartment 12a for draining air-filled resin from the system.

One advantage of the impregnator of FIGS. 5, 6 and 7 relative to that of FIGS. 1-4, in addition to the easier threading mentioned above, is that a greater proportion of the length of the guide elements 18a is active in guiding filaments so that the impregnator is thus, in one sense, more efficient. A further advantage of the impregnator of FIGS. 5-7 is that the tube 21a, which is usually made of rubber to provide the necessary flexibility and resilience required for sealing but which deteriorates quite rapidly in heated resin, can be readily replaced.

What we claim and desire to protect by Letters Patent is:

1. An impregnator for use in a winding machine for making low-void filament wound articles, said impregnator comprising a resin chamber adapted to be filled with

resin to an operating resin level, filament exit means providing for passage of resin-wet filaments from the chamber, a plurality of filament guide members adapted to be mounted in operative positions wherein they constitute individual abutments spaced along the resin chamber and extending transversely thereof to divide the resin chamber into successive resin compartments including a filament input compartment and a filament exit compartment, means for removably mounting said filament guide members in the operative positions, each of said guide means comprising a base, a filament guide element carried by the base and having a filament engaging surface below the resin level, and a deformable sealing means adapted to cooperate resiliently with the guide element to compress the filament passing between the guide element and the sealing means against the filament engaging surface of the respective guide elements and to provide a seal to prevent resin from passing with the filament from one of said compartments to the adjacent compartment through the opening at said guide element in the guide member, said guide members comprising means for preventing the flow of resin past the same in the direction longitudinally of the resin chamber from the filament input compartment to the filament exit compartment.

2. An impregnator in accordance with claim 1 in which said filament exit means is disposed below the resin level and includes means for preventing the escape of resin with the filaments.

3. An impregnator in accordance with claim 2 in which said filament exit means comprises a pair of flexible discs between which the filaments pass.

4. An impregnator in accordance with claim 1 in which said sealing means comprises an inflatable tube adapted to be expanded against said guide element.

5. An impregnator in accordance with claim 1 in which said guide members are removable vertically from said resin chamber.

6. An impregnator in accordance with claim 5 in which said guide members are slidably mounted for vertical movement into and out of their operative positions.

7. An impregnator in accordance with claim 5 in which said guide members are mounted for pivotal movement into and out of their operative positions.

8. An impregnator in accordance with claim 1 in which the resin chamber is provided with a resin inlet directed into the resin compartment adjacent to the filament exit means and the resin supply for each compartment is provided by resin passing over each of said guide members successively from the filament exit compartment to the filament input compartment.

9. An impregnator in accordance with claim 8 in which the guide members are of successively reduced height from the filament exit compartment to the filament input compartment.

10. An impregnator in accordance with claim 1 in which the guide elements of the successive guide members define a tortuous path for the filaments through the resin compartment.

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