DRY SPINNING APPARATUS AND PROCESS

Filed Feb. 2, 1972 2 Sheets-Sheet 1

FIG. I

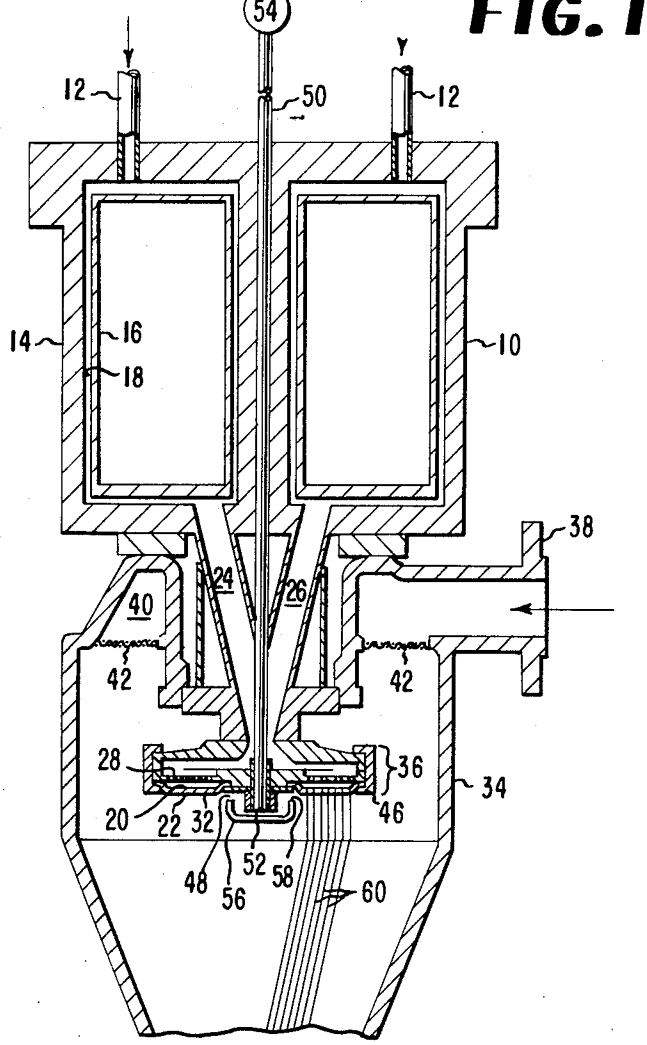


FIG. 2

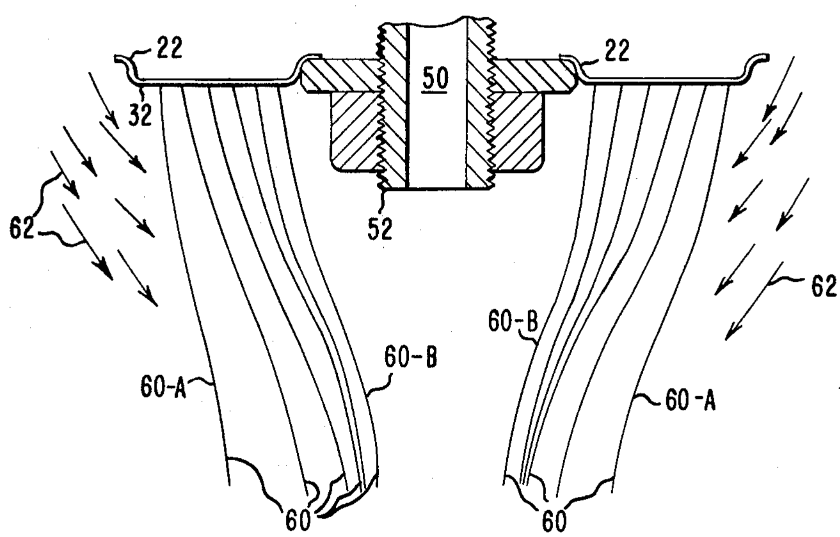


FIG.4

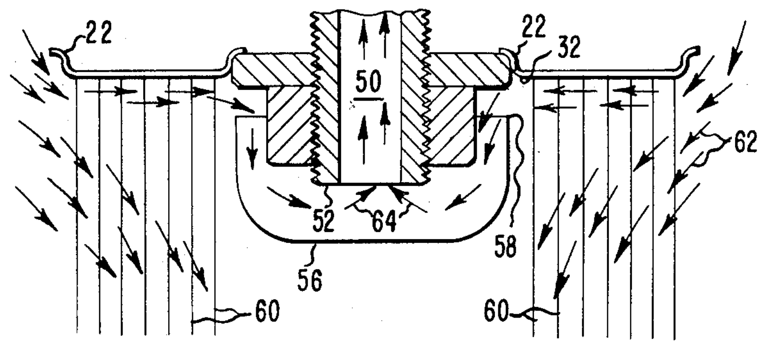


FIG.3

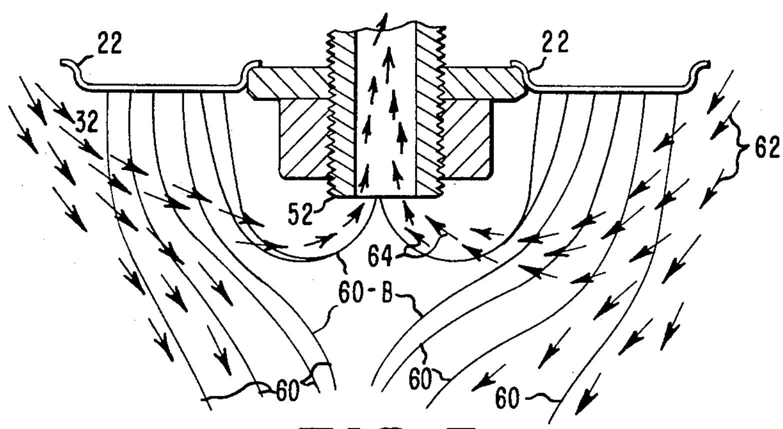
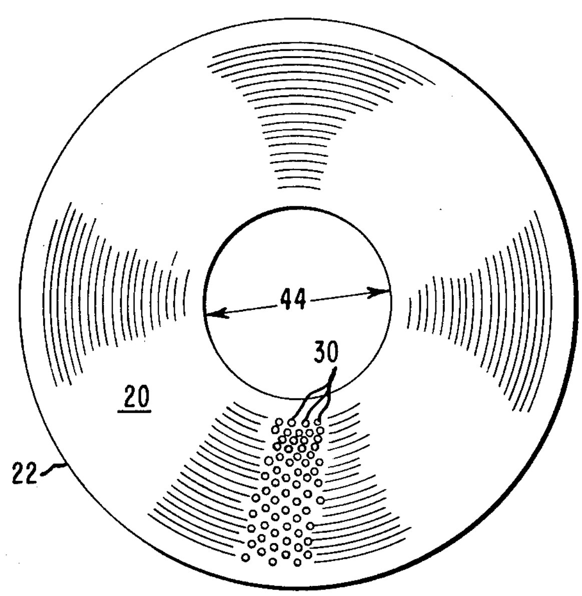


FIG.5



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DRY SPINNING APPARATUS AND PROCESS

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ABSTRACT OF THE DISCLOSURE

In conventional dry-spinning apparatus and procedure a hot inert gas is introduced to evaporate spinning solvent. In the present invention, a portion of the hot gas is constrained to flow through the filaments as they emerge from the annular spinneret by a gas deflector device located concentrically inside the ring of emerging filaments and by a conduit provided in the center of the spinning head. A vacuum applied to the conduit draws hot gas perpendicularly across the emerging filaments near the exit-face of the spinneret and the deflector device aids in directing the hot gas (now entrained with spinning solvent) to the conduit and in preventing filaments from clogging the conduit. Productivity of the spinning apparatus can be doubled.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to an improved apparatus and process for dry-spinning polymer solutions to form filaments. More particularly, the invention is directed to a dry-spinning apparatus which includes an aspiration device to greatly increase the productivity of the spinning apparatus.

Description of the prior art

Dry-spinning is a well-established method for producing filaments from soluble polymers, and apparatus for dry-spinning is well known. In the usual dry-spinning techniques, a hot polymer solution is extruded through spinneret orifices arranged in a series of concentric circles, and then the solvent is rapidly evaporated. If the solvent is not rapidly evaporated, the filaments remain moist and tacky and will fuse with one another, especially if the orifices of the spinneret are closely spaced. Usually, a sheath of hot inert gas is directed downward around the emerging filaments to evaporate and carry away the solvent. Usually, also, the hot inert gas, called the aspiration gas, is introduced at the top of the spinning cell and thus first contacts the outermost ring of emerging filaments. Ordinarily, the gas and the evaporated solvent are exhausted near the bottom of the spinning cell. Thus, as the aspiration gas flows into the multiple rings of filaments, gradients are encountered which cause non-uniformity in filament treatment. These gradients include both a temperature gradient resulting from heat loss as the hot gas evaporates solvent around the outermost circle of filaments, and a velocity gradient due to the numerous filament circles the gas must pass through.

Thus, productivity of the spinning procedure is limited. The use of additional concentric rings of spinneret orifices to increase productivity only results in the filaments produced in the inner rings becoming slack and tacky due to the gradients discussed above. Increasing the flow-rate of the aspiration gas results in better heat-transfer but such an increase also results in the introduction of turbulence among the filaments.

By the means of the present invention, some of the aspiration gas is caused to pass through the freshly emerged filaments to effectively evaporate solvent from all the emerging filaments including ones emerging from the inner rings of orifices. The result is that the productivity of each spinneret can be essentially doubled.

SUMMARY OF THE INVENTION

In the present invention, a portion of the aspiration gas, introduced in the conventional manner, is constrained to flow perpendicularly through the freshly emerged filaments by a receiver, or gas deflector, device located adjacent the exit-face of the spinneret and having its outer periphery within the periphery of the smallest ring of orifies of the spinneret. By applying a vacuum to a conduit located adjacent the deflector device, aspiration gas is drawn to the device and exits through the conduit.

Thus, the apparatus of the present invention can be described as follows:

In a dry-spinning appaartus which comprises in combination:

a container for containing a heated polymer solution,
an annular spinneret assembly having multiple passageways extending from entrance-face to exit-face arranged in spaced concentric rings,
means for feeding said solution from the container to the entrance-face of the spinneret,
a cylindrical casing surrounding said spinneret, said casing being closed at its end adjacent to and above the spinneret by abutment with the spinneret assembly, and being open at its other end, said casing having gas inlet means positioned adjacent to and above said spinneret assembly and arranged to direct hot gas downwardly onto filaments emerging from the exit-face passageways of the spinneret;

The improvement which comprises:

a longitudinal conduit located within the innermost ring of said annular spinneret assembly and having a common axis with that of said annular spinneret, said conduit having one terminus which communicates with external means for exhausting gas, and having a second terminus communicating with the casing interior at said exit-face, and
a deflector device mounted in the casing interior adjacent the second terminus of the conduit and spaced sufficiently from said terminus to provide a passage for the flow of said hot gas therebetween, said deflector having a circular periphery that is less in diameter than the diameter of the smallest spaced concentric ring formed by the passageways of the spinneret.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical cross-section of a dry-spinning apparatus incorporating the improvement of this invention.

FIG. 2 is an enlarged cross-section of a spinneret showing operation without aspiration.

FIG. 3, analogously to FIG. 2, shows the effect of removing the aspiration gas through the novel conduit used in this invention alone.

FIG. 4, analogously to FIGS. 2 and 3, shows the effect of removing the aspiration gas through the novel conduit used in this invention after the spinneret has been equipped with the novel cup-like gas deflector device used in the invention.

FIG. 5 is a plane view of the entrance-face of a cup spinneret showing some of the orifices in a plurality of concentric rings.

DESCRIPTION OF THE INVENTION

A typical spinning apparatus can be described as follows. With reference to FIG. 1, polymer solution from a supply (not shown) is injected into heater **10** via openings 12. Either or both of the external walls 14 or internal walls 16 of heater 10 are heated in order to elevate the temperature of the polymer solution as it passes through narrow passages 18 in good thermal contact with walls 14 and 16. Heated polymer solution is distributed to the entrance-face 20 of an annular cup-spinneret 22 via conduits 24 and 26 and preferably with the use of perforated metering plate 28. Annular cup-spinneret 22 has a plurality of concentric circles of orifices 30 extending completely through spinneret 22 from entrance-face 20 to exit-face 32 thereof. These orifices are too small to indicate in FIG. 1. FIG. 5, however, shows an enlarged view of the entrance-face 20 of cup-spinneret 22 in which a plurality of circles of orifices 30 is shown. For simplicity of presentation, only a few of the orifices are shown in each ring. Generally cylindrical casing or chimney 34 is spaced radially outward from spinneret assembly 36 and extends from a level above to a level well below assembly 36. Connection 38 is provided for injecting a heated gaseous evaporative medium (the aspiration gas)into casing or chimney 34. Ordinarily, an annular manifold 40 directs the medium through a diffusing screen 42, or the like, and down around assembly 36 and through the rings of filaments.

The spinning apparatus just described is well known in the art. While FIG. 1 shows only one form of dry-spinning apparatus, numerous other similar forms operate substantially the same way to accomplish dry-spinning. The apparatus of FIG. 1 is preferred, however, for use with the improvements described following.

Again with reference to FIG. 1, the improvement of this invention is a conduit 50 extending through the apparatus with a lower terminus 52 communicating with the space inside chimney or casing 34. Lower terminus 52 is concentric with the circle of orifices 30 (shown in FIG. 5) and has a diameter less than the diameter 44 of the opening in annular cup-spinneret 22 (again see FIG. 5). The upper terminus of conduit 50 communicates with external means for exhausting gas, e.g., vacuum manifold 54. Also a part of the improvement of this invention is a cup-shaped deflector 56 mounted so as to concentrically surround lower terminus 52 of conduit 50 and to provide space (denoted by 48) for gas flow between its upper surface and terminus 52. The diameter of deflector 56 should be smaller than the diameter of the smallest circle of orifices 30 (see FIG. 5 again), much larger than the inside diameter of terminus 52, and ordinarily about equal to diameter 44 of FIG. 5. The rim or periphery 58 of cup-shaped deflector 56 is spaced less than 1 inch, preferably about 0.5 inch, below the level of the exit-face 32 of spinneret 22. Line 60 generally indicate filaments being formed by dry-spinning using this improved apparatus.

FIG. 2 depicts the performance of a spinning apparatus that does not contain the improvements of this invention, i.e., when no gas is exhausted through conduit 50 and when deflector 56 is not in place. In FIG. 2, hot gas from manifold 40 (see FIG. 1) flows past filaments 60 as generally indicated by arrows 62. Both because the hot gas is cooled by evaporation of solvent from outer filaments 60–A and because the moving filaments 60 deflect the hot gas downwardly, the inner filaments 60–B retain excessive solvent and become progressively more slack. Thus, they contact one another while still moist and tacky, causing disruptive interfilament adhesion.

FIG. 3 shows operation analogously to FIG. 2 except that injected hot gas (arrows 62) is partly evacuated via conduit 50 (arrow 64). It is found that, when enough hot gas is evacuated to dry the inner filaments 60–B, some of these filaments are also drawn up into conduit 50. Paths of the remaining filaments 60 are also strongly deflected. Thus, with the conduit operating in the absence of the deflector, disruptive performance is experienced.

FIG. 4 depicts the stable operation of the spinneret using the improvements of this invention. Filaments 60 proceed from exit-face 32 of spinneret 22 along initially straight and parallel paths. No interfilament contact or adhesion occurs while any filaments 60 remain tacky. By causing the aspiration gas (arrow 64) to pass through the filament bundle perpendicularly to their direction of travel and *closely adjacent* to exit-face 32 of spinneret 22, adequate evaporation of solvent from the inner filaments is obtained without in any way disturbing their lines of travel.

As described in connection with FIG. 1, deflector 56 has a circularly symmetrical cup-shaped upper surface. It is preferred that deflector 56 be deeply cup-shaped, and that conduit 50 have its lower terminus 52 within the lip or edge of the cup. The cup should have a very small hole in its center to drain condensed solvent out of it which condenses when gas flow is started through the relatively cool cup. Without this hole gas flow could be shut off by the liquid head accumulated in the cup. A hole of about ⅛ inch diameter provides adequate drainage. Threadline stability of the emerging filaments progressively diminishes as the vertical spacing between exit-face 32 and edge 58 of deflector 56 exceeds 1 inch. Optimum performance is obtained when this spacing is about 0.5 inch. Deflectors having no points on the upper surface at a level higher than the circular outer edge 58 are suitable as are circular plates but they are not as effective as the cup-shaped deflectors of this invention.

As indicated previously, the productivity of any given spinning apparatus measured, for example, as pounds of polymer extruded per unit of time is limited to a maximum at which continuity and uniformity can be maintained. When the improvements of this invention are employed in the spinning apparatus, it is found that substantially doubled productivity results without any deleterious effects. This means that, with all other variables constant, twice as many filaments can be extruded simultaneously from the spinning apparatus. Best results are obtained when the amount of aspiration gas removed via conduit 50 is less than one-half the total flow from manifold 40 (refer to FIG. 1). Preferably the flow so removed should be less than or about one quarter of the total flow. Since the amount by which total flow should be increased with aspiration varies from system to system, it should be determined by test for each.

When using the improved apparatus of this invention, it is found that further increase in productivity results if the aspiration gas is also withdrawn from levels well below deflector 56. This can be most readily effected by providing a second smaller conduit within conduit 50 but extending through deflector 56 to a portion or attachment with perforated cylindrical walls. The volume of gas so removed should be less than that removed via deflector 56. Alternatively, conduit 50 itself can be extended below deflector 56 with valve arrangements for selecting relative volumes of gas removed from above and below the deflector.

It is further preferred that clamping member 46 (or a separate member fastened to it) be extended downward as a shroud outside annular cup-spinneret 22. Such protection of the outer rings of orifices is found to permit a slight increase in temperature of the polymer solution being extruded. Extension of such a shroud below exit-face 32 should be by less than 1 inch and preferably of the order of about 0.5 inch.

Polymers which are ordinarily prepared by dry spinning and which therefore can be prepared at increased productivity using the improved apparatus of this invention, include segmented elastomers, polyacrylonitrile, and aromatic polyamides.

The foregoing detailed description has been given for clearness of understanding only and no unnecessary limitations are to be understood therefrom. The invention is not limited to the exact details shown and described for obvious modifications will occur to those skilled in the art.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Process for removing polymer solvent from filaments emerging from an annular spinneret in a dry-spinning apparatus which comprises directing hot, inert gas perpendicularly across the line of travel of the emerging filament bundle at a point closely adjacent the exit-face of the spinneret, and removing the hot gas by means of a vacuum applied within the smallest ring of orifices of the annular spinneret, while preventing emerging filaments from being forced in the vacuum.

2. In a dry-spinning apparatus which comprises in combination:

a container for containing a heated polymer solution,

an annular spinneret having multiple passageways extending from entrance-face to exit-face arranged in spaced concentric rings,

means for feeding the polymer solution from the container to the entrance-face of the spinneret,

a cylindrical casing surrounding said spinneret, said casing being closed at its end adjacent to and above the spinneret by abutment with the spinneret assembly, and being open at its other end, said casing having gas inlet means positioned adjacent to and above said spinneret and arranged to direct hot gas downwardly onto filaments emerging from the exit-face passageways of the spinneret;

the improvement which comprises:

a longitudinal conduit located within the annular spinneret and having a common axis with that of said annular spinneret, said conduit having one terminus connected to external means for exhausing gas, and having a second terminus communicating with the casing interior at said exit-face within the innermost ring of passageways in said annular spinneret, and

a deflector device having a symmetrical cup-shaped upper surface mounted in the casing interior adjacent the second terminus of the conduit so as to concentrically surround said second terminus, said device being positioned so that the open cavity formed by the cup faces the second terminus of the conduit and spaced sufficiently from said terminus to provide a passage for the flow of said hot gas therebetween, said deflector having a circular periphery that is less in diameter than the diameter of the smallest spaced concentric ring formed by the passageways of the spinneret, but greater than the inside diameter of the second terminus.

3. The apparatus of claim 2 wherein the periphery of the cup is spaced less than one inch below the level of said exit-face.

4. The apparatus of claim 2 wherein the second terminus of the conduit extends below the periphery of the cup.

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JAY H. WOO, Primary Examiner

U.S. Cl. X.R.

264—205; 425—72