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3,210,451

SPINNERETTES

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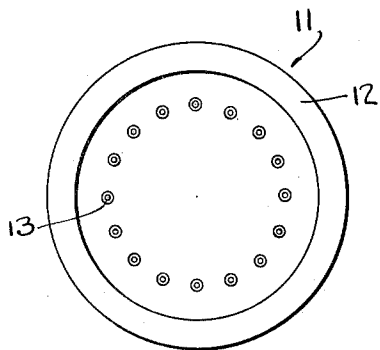


Fig. 1.

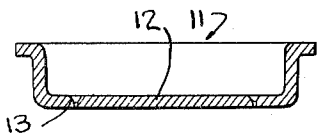


Fig. 2.

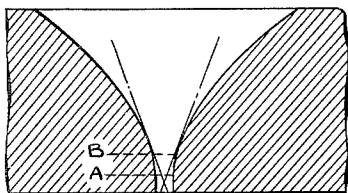


Fig. 3.

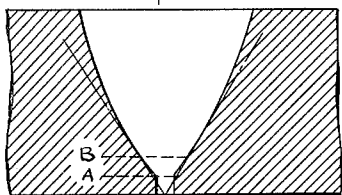


Fig. 4.

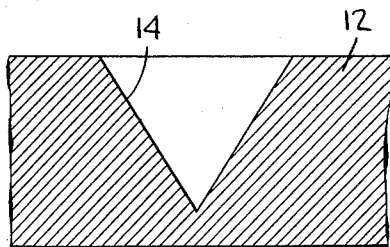


Fig. 5.

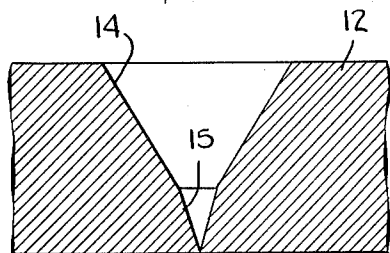


Fig. 6.

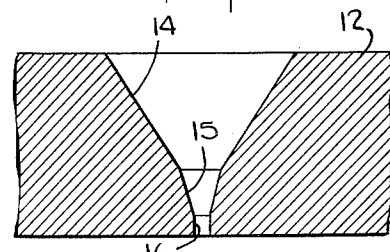


Fig. 7.

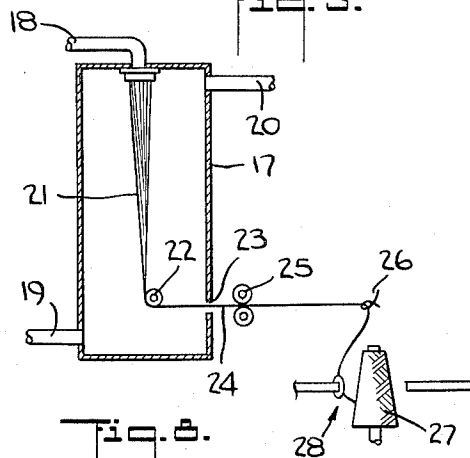


Fig. 8.

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SPINNERETTES

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6 Claims. (Cl. 264-200)

The present invention relates to novel jets or spinnerettes for the spinning of synthetic filaments.

In the wet or dry spinning of synthetic filaments, viscous solutions of filament-forming material are extruded through a jet or spinnerette provided with extremely fine capillary orifices having diameters of less than a few dozen microns. The manufacture of such jets requires great care and precision and is quite costly.

It is accordingly an object of the present invention to provide an improved process for the manufacture of jets provided with fine capillary orifices.

A further object of the invention is to provide novel jets and processes for the extrusion of particular solutions through said jets to achieve improved results.

Other objects and advantages of the invention will become apparent from the detailed description of the invention which follows taken in conjunction with the appended claims, wherein all parts are by weight unless otherwise specified.

In accordance with one aspect of the present invention, it has been found that when spinning solutions of cellulose triacetate in a solvent principally comprising a halogenated hydrocarbon such as methylene chloride through a jet having orifices less than about 0.02 mm.² in minimum area, best results are achieved if the jet thickness is small, e.g., desirably less than about 1500 microns and preferably less than about 1000 microns, if the orifice adjacent the outlet side of the spinnerette is cylindrical, i.e. generated by a line parallel to the axis, advantageously for a distance ranging from about 0.25 to 5 and preferably from about 0.5 to 1.5 times the diameter of the outlet, and if the cylindrical portion merges smoothly with a section divergent toward the inlet side and meeting the cylindrical portion at a small angle, advantageously less than about 60° and preferably less than about 35°. The meeting angle is twice the angle between the orifice axis and a tangent to the divergent section at a location spaced interiorly of the interior end of the cylindrical portion by a distance equal to 100% of the diameter of the cylindrical portion. By so selecting the location at which the meeting angle is measured, account is taken of changes in curvature of the divergent section, as where it is hyperbolic or parabolic.

If the jet thickness is significantly greater than specified it becomes exceedingly difficult to produce the orifices since the punching or drilling bits are so small that they break easily; since a jet for spinning even a very light weight, i.e., low denier, yarn contains dozens of orifices it will be appreciated that a jet production operation which results in frequent breakage will be quite costly. If the orifice is not cylindrical adjacent the outlet side of the spinnerette, it will then be essential that a tapered drill, for example, penetrate the face of the jet by an exact distance since variations in the extent of penetration will result in variations in the hole diameters; by utilizing a cylindrical outlet greater latitude in manufacture is permitted since the exact depth to which the non-cylindrical element enters the metal of the jet is not critical because the size and shape of the orifice is the same all along the cylindrical portion. This, of course, applies whether the cylindrical portion has a circular cross-section, i.e., a

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right-circular cylinder, a triangular cross-section, a square cross-section, etc.

If the meeting angle is increased beyond the indicated values the properties of the resulting cellulose triacetate filaments will be affected adversely, i.e., the tenacity and elongation will be lower. Even when spinning low denier fibers the linear speed of extrusion can exceed about 450 and often 550 meters per minute. For a given level of physical properties and wear of the jet the novel jet permits the spinning speed to be increased at least 25% and usually in excess of 50% as contrasted with jets having meeting angles greater than about 65°; the capacity of the equipment is thus increased with obvious advantage. Equally important, both wear and corrosion of the jet are reduced, the life of a jet being multiplied several times. Not only does this effect a saving in jets but it reduces the number of times the equipment must be shut down to change jets. That the meeting angle has this effect is most surprising since in spinning acetone dopes, e.g., conventional secondary cellulose acetate, it makes relatively little difference whether the meeting angle is large or small and large angles have accordingly been preferred commercially because of the greater likelihood of breaking sharply tapered bits and punches needed for making the small angles.

As employed herein "cellulose triacetate" has reference to cellulose acetate having fewer than about 0.29 and preferably fewer than about 0.12 free hydroxyl group per anhydroglucose unit of the cellulose molecule, i.e., an acetyl value calculated as combined acetic acid by weight of at least about 59% and preferably at least about 61%. Advantageously its intrinsic viscosity ranges from about 1.5 to 2.5 and is preferably about 2 and it is present in the dope to a concentration ranging from about 20 to 25%. In place of methylene chloride, the dope solvent may comprise other halogenated lower alkanes such as ethylene dichloride or propylene chloride. Advantageously, up to about 15% by weight of the dope solvent comprises a lower alkanol such as methanol, ethanol, isopropanol, etc. The preferred dope solvent is methylene chloride-methanol in the proportions of 90-10 by weight.

In accordance with another aspect of the present invention, it has been found that beyond the point at which the meeting angle is determined, the shape of the divergent section no longer has such a marked effect on yarn properties, spinning speed and jet life. In addition, if it is desired to employ a constant narrow angle all the way from the cylindrical portion to the inlet face of the jet, experiments have shown that the necessarily sharply pointed tool breaks frequently in penetrating the full metal thickness. Accordingly, the section of small meeting angle is preferably spaced from the jet inlet face by a section of larger meeting angle which can be produced with less breakage.

The sequence in which the sections are formed in the metal is from largest diameter to smallest diameter. In this manner the most pointed, weakest tools need operate upon a minimum thickness of metal. Thus, for example, a conical punch of wide angle, e.g., about 30 to 100° and preferably about 50° to 60°, is pressed into the metal. Then the narrower angle punch is pressed into the metal to the requisite distance so that the subsequently produced cylindrical section will be of the desired height. It will be noted that by proceeding in this manner each depression serves as a seat to ensure proper positioning of the tool for producing the next depression. This technique is applicable even for orifices with relatively wide meeting angles; advantageously the difference between the meeting angles of successive sections is at least about 20° although close spacing of holes may sometimes render it impractical to observe this preference.

If desired, two or more of these steps may be performed simultaneously by employing a suitably profiled tool, e.g., a tool having a frusto-conical portion surmounted by a smaller angle conical portion and/or a cylindrical portion. In place of two portions which are straight sided, such as cones, there may be substituted for either or for both, individually or jointly, a curved portion having, for example, a hyperbolic or parabolic profile. This curved portion could also be surmounted by a cylindrical portion, if desired. It will be appreciated that where two or more portions are included on a single tool, the leading portion necessarily will have to penetrate a greater thickness of metal than when individual tools are employed with the tools applied in sequence starting with the widest.

In accordance with another aspect of the invention, it has been found that when spinning solutions containing large amounts of corrosive liquids such as methylene chloride, surprisingly the jet life is increased if the customary plating step is omitted. Omission of the plating step obviously also effects a considerable saving in the cost of manufacturing jets. The jet can be made of any of the usual materials, conventional stainless steels such as 304 and particularly 316 being especially satisfactory.

The invention will be further described with reference to the accompanying drawing, wherein:

FIG. 1 is a plan view of a spinnerette in accordance with the present invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1;

FIGS. 3, 4, and 5 are sectional views showing the sequence in forming the orifices in the spinnerette of FIG. 1;

FIGS. 6 and 7 are sectional views showing how to determine the meeting angle for countersinks which are not conical; and

FIG. 8 is a schematic illustration of a dry spinning operation.

Referring now more particularly to the drawing, in FIG. 1 there is shown a spinnerette or jet 11 comprising a stainless steel cup 12 provided with orifices or apertures 13. As shown in FIGS. 3, 4 and 5, the apertures are formed by punching or drilling a conical countersink 14 to the desired depth in the metal of cup 12 (FIG. 3). With the apex of countersink 14 as a guide, a second more pointed countersink 15 is formed (FIG. 4). With the apex of countersink 15 as a guide, a cylindrical portion 16 is punched through to the outlet face of the jet 11 (FIG. 5) to produce the orifice 13; the cylindrical portion can also be formed by punching or broaching.

The exact depths to which the apices of countersinks 14 and 15 project are not the controlling features since it is the location of the demarcation zones in FIG. 5 which is important. Thus, for example, countersink 15 in FIG. 4 could extend all the way through the face of the jet 11; the lowermost portion thereof would be eliminated when forming the cylindrical portion 16. The demarcation between countersinks 14 and 15 will generally be spaced from the inlet face of the jet by a distance ranging from about 50 to 90% and preferably about 70 to 85% of the jet thickness; since the apex will be cut away, the depth of countersink 14 in FIG. 3 will be somewhat greater than these ranges, e.g. about 60 to 100% and preferably about 75 to 95% of the metal thickness. The height of section 15 in FIG. 5 generally ranges from about 5 to 30% and preferably from about 10 to 20% of the jet thickness; its exact height will be somewhat dependent on the diameter of portion 16, generally being at least 0.5 and preferably about 2 to 4 times the diameter of portion 16.

Where the countersinks 14 and 15 are conical their meeting angles are obviously easy to measure. FIGS. 6 and 7 show how the meeting angles are measured for non-conical countersinks, whether hyperbolic (FIG. 6)

or parabolic (FIG. 7). The elevation A at which the orifices ceases to be cylindrical is marked. The width of the orifice at elevation A is determined and 100% of this width is marked above A as plane B perpendicular to the axis of the orifice. Tangents are drawn at the two points where B intersects the outline of the orifice and the meeting angle α is the angle between these tangents.

In FIG. 8 there is shown a dry spinning cabinet 17 to which dope is supplied through a pipe 18, being extruded through spinnerette 11 of FIG. 5 with no intervening plating of the spinnerette. Hot air is admitted to the cabinet 17 at 19 and is exhausted at 20 along with vapors of the dope solvent. The filaments 21 leaving spinnerette 11 pass about a guide 22 and leave the cabinet at 23 being pulled as a yarn 24 by draw rolls 25. The yarn 24 passes through a guide 26 and is twisted and taken up on a bobbin 27 by a conventional collector such as ring spinner 28.

The invention will be further described in the following illustrative example.

Example

A 22% solution of cellulose triacetate, acetyl value 61% and intrinsic viscosity of 2, in 91–9 methylene-chloride methanol is extruded through a 316 stainless steel spinnerette having 15 orifices as shown in FIG. 5. Cup 12 is 790 microns thick, frusto-conical countersink 14 has an angle of 65° and extends into the metal a distance of 680 microns, frusto-conical countersink 15 has an angle of 33° and is 85 microns high and cylindrical portion 16 has a diameter of 36 microns and a height of 25 microns. The resulting filaments pass through air at 74° C., are withdrawn from the cabinet at a linear speed of 550 meters per minute and are taken up on a bobbin. As contrasted with yarn spun at about 300 meters per minute from a jet in which countersink 15 is omitted, the novel yarn has a 5% greater tenacity and a 10% greater elongation; if yarn is spun at about 300 meters per minute with the novel jet, the physical properties are further improved. In addition, the life of the jet is increased several thousand percent. Similar results are achieved with variations in the shape of countersink 14 but the orifices are more difficult to produce.

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

Having described our invention what we desire to secure by Letters Patent is:

1. The process which comprises extruding a solution of cellulose triacetate in a solvent principally comprising a halogenated hydrocarbon in the form of a stream having a confined section less than about 1500 microns long and including a cylindrical portion adjacent its downstream end and a section divergent toward its upstream end and communicating with said cylindrical portion, the meeting angle of said divergent section being less than about 60° and the cross-sectional area of said cylindrical portion being about 0.02 mm.².

2. The process which comprises extruding a solution of cellulose triacetate in a solvent principally comprising a halogenated hydrocarbon in the form of a stream having a confined section less than about 1500 microns long and including at its downstream end a cylindrical portion having a cross-sectional area of less than about 0.02 mm.² and about 0.25 to 5 times its diameter in length and a section divergent toward the upstream end of said confined section and communicating with said cylindrical portion at a meeting angle of less than about 60°, the linear extrusion speed of said solution being at least about 450 meters per minute.

3. The process which comprises extruding a solution of cellulose triacetate in a solvent comprising methylene chloride and up to about 15% by weight of a lower alkanol in the form of a stream having a confined section less than about 1000 microns long having at its down-

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stream end a cylindrical portion having a cross-sectional area of less than about 0.02 mm.² and about 0.5 to 1.5 times its diameter in length and a section divergent toward the upstream end of said confined section and communicating with said cylindrical portion, the meeting angle of said divergent section being less than about 35° and the linear extrusion speed of said solution being at least 450 meters per minute.

4. An article of manufacture comprising a spinnerette less than about 1000 microns thick and provided with at least one orifice extending therethrough, said orifice including a cylindrical portion adjacent the outlet face of said spinnerette having a height ranging from about 0.25 to 5 times its diameter, a first frustoconical section divergent toward the inlet face of said spinnerette and communicating with said cylindrical portion, said first frustoconical section having an apex angle of less than about 60° and ranging in height from about 5 to 30% of the thickness of said spinnerette, and a second frustoconical section divergent toward the inlet face of said spinnerette and communicating with said first frustoconical section, said second frustoconical section having an apex angle of at least about 20° greater than said first frustoconical section and ranging in height from about 50 to 90% of the thickness of said spinnerette.

5. The process which comprises extruding a solution of cellulose triacetate in a solvent comprising methylene chloride and up to about 15% by weight of a lower alkanol in the form of a stream having a confined section less than about 1000 microns long including at its downstream end a cylindrical portion with a cross-sectional area of less than about 0.02 mm.² and about 0.5 to 1.5 times its diameter in length, a first frustoconical portion divergent toward the upstream end of said confined section and communicating with said cylindrical portion, said first frustoconical portion having an apex angle less than about 60° and ranging in length from about 5 to 30% of the thickness of said confined section, and a sec-

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ond frustoconical portion divergent toward the upstream end of said confined section and communicating with said first frustoconical portion, said second frustoconical portion having an apex angle of at least about 20° greater than that of said first frustoconical portion and ranging in length from about 50 to 90% of the length of said confined section, the linear extrusion speed of said solution being at least about 450 meters per minute.

6. An article of manufacture comprising a spinnerette having a thickness of less than about 1000 microns and provided with at least one orifice extending therethrough, said orifice including a cylindrical portion adjacent the outlet face of said spinnerette having a height ranging from about 0.5 to 1.5 times its diameter, a first frustoconical section divergent toward the inlet face of said spinnerette and communicating with said cylindrical portion, said first frustoconical section having an apex of less than about 35° and ranging in height from about 10 to 20% of the thickness of said spinnerette, and a second frustoconical section divergent toward the inlet face of said spinnerette and communicating with said first frustoconical section, said second frustoconical section having an apex angle at least about 20° greater than said first frustoconical section and ranging in height from about 70 to 85% of the thickness of said spinnerette.

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