

Description

This invention relates to methods of making thermoplastic tubular articles which are dimensionally stable up to a specific elevated temperature from crystallisable polymers, and to the apparatus for making such articles, which articles are particularly tubular bodies of saturated linear polyester materials such as polyethylene terephthalate, intended for processable food and beverage containers.

It is known that biaxial drawing of a thermoplastic saturated linear polyester material, such as polyethylene terephthalate, can improve its mechanical properties while inducing a degree of biaxial orientation and crystallisation, without impairing the clarity of the material. The material will, however, shrink if heated above the temperature at which it was drawn. It is known that the tendency of biaxially drawn polyester film material to shrink can be decreased by annealing the material under restraint, utilising temperatures in the range 150°C to 230°C, the process being known as heat setting. Biaxial drawing is also effected, for example, in the stretch-blow moulding of polyethylene terephthalate bottles. Another method of forming biaxially oriented tubular articles which may be used as bodies for processable food containers is disclosed in our copending U.K. Patent Specification, No. 2089276A. The forming process described therein involves longitudinal stretching and radial expansion under internal fluid pressure within a mould and is normally carried out at a temperature in the range from 75°C to 120°C. The tubular bodies thereby produced are dimensionally stable up to the temperatures encountered in many container filling operations, but a heat-setting treatment is necessary if the containers are to be filled with hot product (e.g. at 80°C to 100°C) or are to be subjected to pasteurisation (at about 60°C to 100°C) or sterilisation (at about 120°C). Without such a heat-setting treatment, the thermoplastic linear polyester material (e.g. polyethylene terephthalate) would shrink and distort to an unacceptable degree during the hot filling or processing, as a result of relaxation of strained portions of the material back into their preferred state in which the molecular chains are coiled rather than extended. In the heat-setting treatment described in Specification 2089276A, the tubular articles were held for a time at a temperature at least equal to, and preferably somewhat greater than, the sterilisation or pasteurisation temperature whilst restraining them from shrinking beyond their desired circumferential and longitudinal dimensions. The restraint was provided by internal fluid pressure, so as to set the strained, oriented amorphous portions of the polyester material by at least partial crystallisation and relaxation. Internal fluid pressure cannot be conveniently used when the tubes have been cut so as to be open at both ends, and it is not convenient to combine the heat-setting with the forming process of our Specification No.

2089276A because it would involve additional complication and extended process times.

European patent application published under No. 0081451, which has a priority date earlier than, but a publication date later than, the priority date of the present application, discloses a heat-setting process and apparatus for making closed-ended containers from PET. The process comprises deep-drawing a pre-heated sheet of PET into a heated female mould by means of a male plug, which is at a temperature below the glass transition temperature (T_g) of the PET. The mould is kept at a temperature above T_g , typically 140°C. Air pressure introduced around the plug is used to blow the plug-formed article into contact with the mould for heating it above T_g . When it has been in contact with the mould for long enough to be heat-set, it is allowed to shrink back into contact with the plug which restrains it from further shrinkage and cools it to a temperature below the heat-set temperature. Contact between the heat-set article and the plug can be released by forcing air through an axial passage in the plug. In this process the heat-setting is essentially carried out while the article is held against the female mould by internal gas pressure, rather than when it is restrained from axial shrinkage by the plug. The heat-set operation cannot be carried out independently of the biaxial drawing, and is clearly not applicable for heat-setting open-ended tubes.

GB—A—953734 (Covington), to which the first part of claim 1 is related, discloses a method of making tubular articles, such as shotgun cartridge cases, from high density polyethylene, in which a tube is forced over a step on a mandrel and is then drawn along the mandrel thereby inducing in the tube biaxial orientation, the tube then being held on that same mandrel to restrain it against axial or radial shrinkage while being heated to a temperature below the crystalline melting point of the polymer in an oven or in a liquid bath to heat-set it. The tube is then removed from the mandrel by a stripping device, in particular a device comprising external gripping means. Thus the mandrel is used for the orientation of the tube as well as for the heat-setting operation, and external heating means are used, resulting in extended process times and possible wear of the mandrel as a result of the tube stretching step. Removal of the tube from the mandrel by external gripping means may also involve problems.

According to the present invention, a method of making a thermoplastic tubular article, of crystallisable polymer including heat-setting the article so that it will be dimensionally stable up to a specific elevated temperature by heating it to a temperature higher than the said specific elevated temperature while restraining it from axial and radial shrinkage by means of a mandrel, and then cooling the tube and removing it from the mandrel, is characterised by the steps of fitting an at least partly biaxially oriented tube of the crystallisable polymer having at least one open end over a mandrel the temperature of which is below

the glass transition temperature of the polymer and the outer diameter of which is slightly less than the internal diameter of the tube, clamping the tube to restrain axial shrinkage thereof, heating the mandrel internally to heat the tube to a temperature higher than the said specific elevated temperature so that, whilst restrained against axial shrinkage, the tube shrinks radially into contact with the mandrel but is restrained thereby from further radial shrinkage, maintaining the tube at said higher temperature for a time sufficient to ensure the required degree of dimensional stability, cooling the tube to a temperature below the said specific elevated temperature, releasing contact between the tube and mandrel by forcing fluid under pressure from inside the mandrel through a plurality of apertures in its surface to form a fluid cushion between the tube and mandrel, and removing the tube from the mandrel while the fluid cushion is in existence.

The heat-setting operation is thus effected independently of the forming operation and does not cause problems therein. Furthermore, internal heating of the mandrel as the means for heating the polymer tube provides an efficient and controllable heat transfer to the polymer tube. A residual linear shrinkage of up to 3% is usually found after heat-setting, but it can be eliminated by a further step of re-heating the article to the specific elevated temperature without internal restraint against shrinkage. Such residual shrinkage may be used to eliminate or reduce head space in a container having a body heat-set by the method of the invention.

Where the polymer is a saturated linear polyester, the temperature to which the tube is heated on the mandrel is preferably at least 60° higher than the specific elevated temperature, and in particular, where polyethylene terephthalate is used, the specific elevated temperature is preferably about 120°C and the tube is heated to at least 180°C on the mandrel.

The degree of dimensional stability which is achieved depends on the temperature to which the tube is heated on the mandrel (the "heat-setting temperature") and the time for which the tube is maintained at this temperature, and it may be adjusted to the particular requirements for which the tubular articles are made. For example, if it is desired that the linear dimensions of the article should not alter by more than 3% when it is heated to a specific elevated temperature of 120°C, the tube may be heated at 180°C for a period of 1 to 5 minutes, or preferably, at 240°C for 12 to 15 seconds.

The tubular article may be given a shape which departs from that of a plain cylindrical tube by providing the mandrel with a complementary shape, which is adopted by the tube as it shrinks on to the mandrel. For example, the tubular article may be formed with circumferential beads by providing the mandrel with corresponding circumferential projections. Other shapes may be produced in this manner, such as tapered, barrel-

led or waisted tubes, or tubes of rectangular, oval or other cross-sections.

When making a tubular article which is open at both ends, the clamping is preferably effected by circumferentially clamping both ends of the tube. The tube may then be cut into individual lengths before its contact with the mandrel is released. For example, the tube may be cut by knives which penetrate through the tube material into circumferential grooves in the mandrel as the mandrel is rotated.

When making a tubular article which is closed at one end, preferably a mandrel is used which has a correspondingly shaped closed end and clamping is effected by clamping the other, open end of the tube. The open end of the tube may be clamped axially against a radially extending flange on the mandrel. Preferably the closed end of the tube is additionally clamped axially against the closed end of the mandrel.

In a preferred embodiment of the invention, using a plurality of vertical hollow mandrels of high thermal conductivity, each mandrel is indexed past operating stations at which:—

(a) the tube is fitted over the mandrel, whose temperature is below the glass transition temperature of the polymer,

(b) clamps are applied to the tube to restrain it axially,

(c) a heating element is introduced into the interior of the mandrel to heat it to a temperature at least 60°C higher than the specific elevated temperature,

(d) the said higher temperature is maintained for a time sufficient to ensure the required degree of dimensional stability,

(e) the heating element is removed, and the tube is cooled to below the specific elevated temperature,

(f) the clamps are released,

(g) the ends of the mandrel are sealed and air under pressure is introduced into it and forced out through small holes in its surface to release contact between the tube and the mandrel, and

(h) the tube is removed from the mandrel.

Where the tube is long enough to make several open-ended articles (e.g. container bodies), it is convenient to arrange that, after cooling of the tube, the mandrel is rotated and knives are brought into contact with the tube to cut it into individual lengths.

The invention also resides in apparatus for making a thermoplastic tubular article of a crystallisable polymer which is heat-set so as to be dimensionally stable up to a specific elevated temperature, comprising a mandrel being adapted to restrain a tube of said polymer from axial and radial shrinkage, and heating means, characterised in that the heating means are adapted to heat the mandrel internally and thereby to heat the article to a temperature higher than the specific elevated temperature; and in that the outer diameter of the mandrel is slightly less than the inner diameter of the tube and in that clamping means are provided for clamping

an at least partly biaxially oriented tube of the crystallisable polymer to restrain axial shrinkage of the tube; and in that a pressurised fluid supply means is provided for supplying fluid under pressure from inside the mandrel through a plurality of apertures in its surface to release contact between the mandrel and the tube shrunk thereon.

The invention further resides in a food container comprising an open-ended cylindrical body and end closure means at each end of said body forming with said body a closed container, characterised in that said body is made of a crystallisable polyethylene terephthalate material, said body material being biaxially oriented and the container body having been heat-set, whilst restrained against radial and axial shrinkage, at a temperature between about 180°C and about 240°C, whereby said container is able to withstand hot-filling, pasteurisation or sterilisation temperatures of up to about 120°C without undergoing shrinkage of its linear dimensions by more than 3%.

Specific embodiments of the invention will now be described in more detail by way of example and with reference to the accompanying drawings in which:—

Figure 1 is a diagrammatic perspective view of apparatus including a mandrel for use in heat-setting tubular bodies for making multiple container bodies by the method of the invention,

Figure 2 is a diagrammatic sectional view of a modified form of the mandrel, showing a heating element inserted therein,

Figure 3 is a view similar to Figure 2 of a further form of mandrel for heat-setting single container bodies,

Figure 4 is a perspective view of a thermally processable container with a body heat-set by the method of the invention on a mandrel as shown in any one of Figures 1 to 3, and

Figure 5 is a diagrammatic sectional view of another form of mandrel for use in heat-setting tubular bodies which are closed at one end.

The embodiments of the invention illustrated in Figures 1 to 4 are particularly concerned with the production of tubular bodies of biaxially oriented polyethylene terephthalate (PET) for thermally processable food containers as illustrated in Figure 5, which have end closures seamed to the ends of the body. The tubular bodies, open at both ends, are made from tubes of at least partly biaxially oriented PET produced by the process disclosed in our prior British Patent Specification No. 2089276A. As explained above, it is necessary to carry out a heat-setting treatment on the oriented PET tube to ensure that the containers will be able to withstand hot-filling, pasteurisation or sterilisation processes at temperatures of from 60°C to 120°C, without unacceptable shrinkage. In practice, it is a requirement that the container bodies have sufficient dimensional stability to match the end closures in a precise manner for the production of gas-tight seams and to avoid stressing the seams excessively through subsequent shrinkage.

Figure 1 illustrates apparatus including a mandrel on which the heat-setting process can be

carried out in accordance with the invention. The cylindrical mandrel body 10 is hollow and it ends are closed by end plugs 11 and 12 carried by rotatable shafts 111 and 121 which can be shifted axially to enable the mandrel to be removed. Plug 12 and shaft 121 have an inlet passage 14 and control valve 141 for compressed air. The mandrel body 10 is provided with a plurality of small holes 16 in its surface. At each end, it is provided with a circumferential clamp member, e.g. in the form of a snap-action clip or clamping band 20. Circumferential grooves 22, approximately 1 mm. in width, are formed in the surface of the mandrel body 10 at intervals corresponding to the length of the container bodies to be produced. A shaft 15 carrying rotary knives 17 is mounted parallel to the mandrel 10 on pivotal brackets 19 so as to be capable of being shifted towards the mandrel so that the knives 17 can enter into the grooves 22.

Figure 2 illustrates an alternative form of mandrel body 101 in the vertical position. The foot of the body 101 has a flange 24 to support a tube 26 of at least partially biaxially oriented PET resin. The outer diameter of the mandrel body 101 is clearly shown to be only very slightly less than that of the PET resin tube 26, so that the latter can be fitted thereover without excessive friction but also without substantial play. In this embodiment, the mandrel body 101 is made of a material of high thermal conductivity but is sufficiently thin in section to have a small thermal capacity. The interior of the mandrel body 101 is slightly tapered towards the top so as to make contact with a correspondingly shaped heating element 28 when the latter is inserted from below, as shown in Figure 2, to fill the interior of the mandrel.

Figure 3 illustrates a mandrel body 102 which is similar to that of Figure 2 but of lesser height, for production of single container bodies. In this case, a circumferential groove 18 is provided at the upper end of the mandrel body 102 to co-operate with clamping members 201 in the form of laterally movable half-rings.

In use of the mandrels of Figures 1 to 3, when a PET tube 26 has been fitted over the mandrel body 10, 101 or 102, and the ends of the tube 26 have been clamped by means of clamp members 20, the temperature of the mandrel and tube is raised, e.g. by introduction of the heating member 28 of Figures 2 and 3, from an initial temperature below the glass transition temperature of the resin to a temperature which is at least 60°C above the specific elevated temperature, up to which the can bodies are to be dimensionally stable. The temperature to which the mandrel is heated may range from 125°C to 240°C, for heat-setting the PET tube up to specific elevated temperatures ranging from 65°C to 180°C, but it is preferably from 180°C to 240°C, at which the rate of annealing of the PET resin is sufficiently high to obtain rapid heat-setting. Using a temperature of 240°C, it is only necessary to ensure that the whole of the PET resin attains this temperature for about 12 to 15 seconds. Temperatures above 240°C should preferably not be used because the material can

become cloudy and embrittled. The PET tube 26 shrinks radially into contact with the mandrel 10, 101, or 102 but is restrained from any substantial radial or axial shrinkage by the mandrel and the clamps 20, 201. The supply of heat is then stopped, *e.g.* by withdrawing the heating member 28, and the tube and mandrel are then allowed to cool to a temperature below the said specific elevated temperature (*i.e.* the temperature to which the tube has been heat-set).

In the cases of Figures 1 and 2, the mandrel bodies 10, 101 are now rotated and the knives 17 (Figure 1) are brought into contact with the rotating PET tube 26 so as to penetrate through the tube material into the circumferential grooves 22 and thereby cut the tube into individual can body lengths. In the case of Figure 3 this step is unnecessary, but the groove 18 and clamp members 201 form a circumferential groove in the top of the body to facilitate subsequent seaming of an end closure to it.

Finally the clamp members 20, 201 are released, the ends of the mandrel body 10, 101, 102 are sealed, *e.g.* by the end plugs 11, 12 of Figure 1, and compressed air is admitted into the mandrel body, *e.g.* through the valve 141 and inlet 14, being then forced out of the holes 16 so as to release contact between the tube and the mandrel by an air cushion effect. The can body or body sections are then removed from the mandrel.

As shown in Figure 4, can ends 30, 31, *e.g.* of metal, can conveniently be seamed to the ends of the heat-set tubular can body 26 to form a processable container.

In production, a plurality of mandrel bodies 101 or 102 are arranged vertically on an indexing platform so as to be indexed past stations at which the various operations are carried out, as follows:—

(a) a PET tube 26 is fitted over a mandrel body 101 or 102 while the temperature of the mandrel is below the glass transition temperature of the resin,

(b) the circumferential clamps 20, 201 are applied to each end of the PET tube 26,

(c) the heating element 28 is introduced from below into the interior of the mandrel body so as to make contact with it and to heat it rapidly by conduction to a temperature of 180°C to 240°C,

(d) this temperature is maintained for long enough to ensure the required heat-setting,

(e) the heating element 28 is removed and the PET tube 26 is allowed to cool to below 140°C,

(f) where a multiple-length mandrel body 101 is used, the mandrel body is rotated and knives are brought into contact with the tube 26 to cut it into individual lengths,

(g) the ends of the mandrel body 101 or 102 are sealed and compressed air is introduced to release contact between the tube 26 and mandrel body, and

(h) the can body sections are removed from the mandrel body.

The method of the invention can also be employed for heat-setting thermoplastic tubular

articles which are closed at one end. Figure 5 illustrates the heat-setting of a PET container tube 34 which is formed with a recessed bottom 36. The tube 34 is shown inverted on a tubular mandrel 104 which has a closed end 38 whose shape corresponds with that of the container bottom 36. The clamping means in this case comprise a clamp ring 202 which is movable axially of the mandrel to clamp a flange 40 on the end of the tube 34 against a base plate 42, and a pressure member 203 with an end shaped to correspond with the shape of the container bottom 36, which is movable axially to clamp the container bottom against the closed end 38 of the mandrel body.

The mandrel body 104 is formed with air holes 16 as in the embodiments of Figures 1, 2 and 3 for removal of the heat-set container. Heating may be effected by a heating element 28 as before.

Alternative means of heating the PET tube may be used in any of the embodiments described above, such as inductive heating of a metal mandrel, using an induction coil within the mandrel.

Other alternatives are heating of the interior of the mandrel by flame, and interior or exterior heating by hot air or by live steam.

The mandrel need not be cylindrical but could for example be oval or rectangular in section, so as to use the heat-setting shrinkage for accurate dimensioning of shaped tubes.

Claims

1. A method of making a thermoplastic tubular article, of crystallisable polymer including heat-setting the article so that it will be dimensionally stable up to a specific elevated temperature by heating it to a temperature higher than the said specific elevated temperature while restraining it from axial and radial shrinkage by means of a mandrel (10, 101, 102, 104), and then cooling the tube (26, 34) and removing it from the mandrel, characterised by the steps of fitting an at least partly biaxially oriented tube (26, 34) of the crystallisable polymer having at least one open end over a mandrel (10, 101, 102, 104) the temperature of which is below the glass transition temperature of the polymer and the outer diameter of which is slightly less than the internal diameter of the tube, clamping the tube (26, 34) to restrain axial shrinkage thereof, heating the mandrel (10, 101, 102, 104) internally to heat the tube to a temperature higher than the said specific elevated temperature so that, whilst restrained against axial shrinkage, the tube shrinks radially into contact with the mandrel but is restrained thereby from further radial shrinkage, maintaining the tube (26, 34) at said higher temperature for a time sufficient to ensure the required degree of dimensional stability, cooling the tube (26) to a temperature below the said specific elevated temperature, releasing contact between the tube (26) and mandrel (10, 101, 102, 104) by forcing fluid under pressure from inside the mandrel

become cloudy and embrittled. The PET tube 26 shrinks radially into contact with the mandrel 10, 101, or 102 but is restrained from any substantial radial or axial shrinkage by the mandrel and the clamps 20, 201. The supply of heat is then stopped, *e.g.* by withdrawing the heating member 28, and the tube and mandrel are then allowed to cool to a temperature below the said specific elevated temperature (*i.e.* the temperature to which the tube has been heat-set).

In the cases of Figures 1 and 2, the mandrel bodies 10, 101 are now rotated and the knives 17 (Figure 1) are brought into contact with the rotating PET tube 26 so as to penetrate through the tube material into the circumferential grooves 22 and thereby cut the tube into individual can body lengths. In the case of Figure 3 this step is unnecessary, but the groove 18 and clamp members 201 form a circumferential groove in the top of the body to facilitate subsequent seaming of an end closure to it.

Finally the clamp members 20, 201 are released, the ends of the mandrel body 10, 101, 102 are sealed, *e.g.* by the end plugs 11, 12 of Figure 1, and compressed air is admitted into the mandrel body, *e.g.* through the valve 141 and inlet 14, being then forced out of the holes 16 so as to release contact between the tube and the mandrel by an air cushion effect. The can body or body sections are then removed from the mandrel.

As shown in Figure 4, can ends 30, 31, *e.g.* of metal, can conveniently be seamed to the ends of the heat-set tubular can body 26 to form a processable container.

In production, a plurality of mandrel bodies 101 or 102 are arranged vertically on an indexing platform so as to be indexed past stations at which the various operations are carried out, as follows:—

(a) a PET tube 26 is fitted over a mandrel body 101 or 102 while the temperature of the mandrel is below the glass transition temperature of the resin,

(b) the circumferential clamps 20, 201 are applied to each end of the PET tube 26,

(c) the heating element 28 is introduced from below into the interior of the mandrel body so as to make contact with it and to heat it rapidly by conduction to a temperature of 180°C to 240°C,

(d) this temperature is maintained for long enough to ensure the required heat-setting,

(e) the heating element 28 is removed and the PET tube 26 is allowed to cool to below 140°C,

(f) where a multiple-length mandrel body 101 is used, the mandrel body is rotated and knives are brought into contact with the tube 26 to cut it into individual lengths,

(g) the ends of the mandrel body 101 or 102 are sealed and compressed air is introduced to release contact between the tube 26 and mandrel body, and

(h) the can body sections are removed from the mandrel body.

The method of the invention can also be employed for heat-setting thermoplastic tubular

articles which are closed at one end. Figure 5 illustrates the heat-setting of a PET container tube 34 which is formed with a recessed bottom 36. The tube 34 is shown inverted on a tubular mandrel 104 which has a closed end 38 whose shape corresponds with that of the container bottom 36. The clamping means in this case comprise a clamp ring 202 which is movable axially of the mandrel to clamp a flange 40 on the end of the tube 34 against a base plate 42, and a pressure member 203 with an end shaped to correspond with the shape of the container bottom 36, which is movable axially to clamp the container bottom against the closed end 38 of the mandrel body.

The mandrel body 104 is formed with air holes 16 as in the embodiments of Figures 1, 2 and 3 for removal of the heat-set container. Heating may be effected by a heating element 28 as before.

Alternative means of heating the PET tube may be used in any of the embodiments described above, such as inductive heating of a metal mandrel, using an induction coil within the mandrel.

Other alternatives are heating of the interior of the mandrel by flame, and interior or exterior heating by hot air or by live steam.

The mandrel need not be cylindrical but could for example be oval or rectangular in section, so as to use the heat-setting shrinkage for accurate dimensioning of shaped tubes.

Claims

1. A method of making a thermoplastic tubular article, of crystallisable polymer including heat-setting the article so that it will be dimensionally stable up to a specific elevated temperature by heating it to a temperature higher than the said specific elevated temperature while restraining it from axial and radial shrinkage by means of a mandrel (10, 101, 102, 104), and then cooling the tube (26, 34) and removing it from the mandrel, characterised by the steps of fitting an at least partly biaxially oriented tube (26, 34) of the crystallisable polymer having at least one open end over a mandrel (10, 101, 102, 104) the temperature of which is below the glass transition temperature of the polymer and the outer diameter of which is slightly less than the internal diameter of the tube, clamping the tube (26, 34) to restrain axial shrinkage thereof, heating the mandrel (10, 101, 102, 104) internally to heat the tube to a temperature higher than the said specific elevated temperature so that, whilst restrained against axial shrinkage, the tube shrinks radially into contact with the mandrel but is restrained thereby from further radial shrinkage, maintaining the tube (26, 34) at said higher temperature for a time sufficient to ensure the required degree of dimensional stability, cooling the tube (26) to a temperature below the said specific elevated temperature, releasing contact between the tube (26) and mandrel (10, 101, 102, 104) by forcing fluid under pressure from inside the mandrel



through a plurality of apertures (16) in its surface to form a fluid cushion between the tube and mandrel, and removing the tube from the mandrel while the fluid cushion is in existence.

2. A method according to Claim 1, characterised in that the tube (26, 34) is subsequently re-heated to the specific elevated temperature without restraint to remove residual shrinkage.

3. A method according to Claim 1 or 2, characterised in that the polymer is a saturated linear polyester and the temperature to which the tube (26, 34) is heated on the mandrel (10, 101, 102, 104) is at least 60°C higher than the specific elevated temperature.

4. A method according to Claim 3, wherein the polymer is polyethylene terephthalate, the specific elevated temperature is about 120°C, and the tube (26, 34) is heated to at least 180°C on the mandrel (10, 101, 102, 104).

5. A method according to Claim 4, characterised in that the tube (26, 34) is heated to about 240°C on the mandrel (10, 101, 102, 104) for a period not exceeding 15 seconds.

6. A method according to any one of the preceding Claims, characterised in that the tubular article is given a shape which departs from that of a plain cylindrical tube by providing the mandrel with a complementary shape, which is adopted by the tube (26, 34) as it shrinks on to the mandrel (10, 101, 102, 104).

7. A method according to Claim 6, characterised in that the tubular article is formed with circumferential beads by providing the mandrel (10, 101, 102, 104) with corresponding circumferential projections (24).

8. A method according to any one of the preceding Claims of making a tubular article which is open at both ends, characterised in that the clamping is effected by circumferentially clamping both ends of the tube (26).

9. A method according to Claim 8, characterised in that the tube (26) is cut into individual lengths before its contact with the mandrel (10, 101, 102) is released.

10. A method according to Claim 9, characterised in that the tube is cut by knives (17) which penetrate through the tube material into circumferential grooves (22) in the mandrel (10, 101, 102) as the mandrel is rotated.

11. A method according to any one of Claims 1 to 7 of making a tubular article (34) which is closed at one end (36), characterised in that a mandrel (104) is used which has a correspondingly shaped closed end (38) and clamping is effected by clamping the other open end of the tube.

12. A method according to Claim 11, characterised in that the open end of the tube is clamped axially against a radially extending flange (42) on the mandrel (104).

13. A method according to Claim 11 or 12, characterised in that the closed end (36) of the tube (34) is additionally clamped axially against the closed end (38) of the mandrel (104).

14. A method according to Claim 3, or any one

of Claims 6 to 13 as appendant to Claim 3, using a plurality of vertical hollow mandrels (101, 102) of high thermal conductivity, characterised in that each mandrel is indexed past operating stations at which:—

(a) the tube (26) is fitted over the mandrel (101, 102) whose temperature is below the glass transition temperature of the polymer,

(b) clamps (20, 201) are applied to the tube (26) to restrain it axially,

(c) a heating element (28) is introduced into the interior of the mandrel to heat it to a temperature at least 60°C higher than the specific elevated temperature,

(d) the said higher temperature is maintained for a time sufficient to ensure the required degree of dimensional stability,

(e) the heating element (28) is removed, and the tube (26) is cooled to below the specific elevated temperature,

(f) the clamps (20, 201) are released,

(g) the ends of the mandrel (101, 102) are sealed and air under pressure is introduced into it and forced out through small holes (16) in its surface to release contact between the tube (26) and mandrel (101, 102), and

(h) the tube (26) is removed from the mandrel (101, 102).

15. A method according to Claim 14, characterised in that after cooling of the tube (26), the mandrel (101) is rotated and knives (17) are brought into contact with the tube (26) to cut it into individual lengths.

16. Apparatus for making a thermoplastic tubular article of a crystallisable polymer which is heat-set so as to be dimensionally stable up to a specific elevated temperature, comprising a mandrel (10, 101, 102, 104) being adapted to restrain a tube (26, 34) of said polymer from axial and radial shrinkage and heating means (28), characterised in that the heating means are adapted to heat the mandrel (10, 101, 102, 104) internally and thereby to heat the article to a temperature higher than the specific elevated temperature; and in that the outer diameter of the mandrel is slightly less than the inner diameter of the tube (26, 34); and in that clamping means (20, 201) are provided for clamping an at least partly biaxially oriented tube (26, 34) of the crystallisable polymer to restrain axial shrinkage of the tube; and in that a pressurised fluid supply means (14, 141) is provided for supplying fluid under pressure from inside the mandrel (10, 101, 102, 104) through a plurality of apertures (16) in its surface to release contact between the mandrel and the tube shrunk thereon.

17. Apparatus as claimed in claim 16, characterised in that the mandrel (10, 101, 102, 104) is hollow and is made of a material of high thermal conductivity, and the heating means comprises a heating element (28) which can be inserted into the hollow mandrel.

18. Apparatus as claimed in Claim 17, characterised in that the interior of the mandrel (101) is slightly tapered towards one end so as to make



contact with a correspondingly shaped heating element (28) inserted from the other end.

19. Apparatus as claimed in any of Claims 16 to 18, characterised in that the mandrel (10, 101, 102, 104) is provided with circumferential projections so as to form circumferential beads in the shrunk tube.

20. Apparatus as claimed in any of Claims 16 to 19, for making multiple container bodies, characterised in that the surface of the mandrel (10, 101) is provided with a plurality of circumferential grooves (22) and is mounted for rotation about its axis, the apparatus further comprising a set of parallel knives (17) which can be moved towards the mandrel (10, 101) and received within said grooves (22), for cutting a polymer tube (26) which is on the mandrel.

21. A food container comprising an open-ended cylindrical body (26) and end closure means (30, 31) at each end of said body forming with said body a closed container, characterised in that said body is made of a crystallisable polyethylene terephthalate material, said body material being axially oriented and the container body having been heat-set, whilst restrained against radial and axial shrinkage, at a temperature between about 180°C and about 240°C, whereby said container is able to withstand hot-filling, pasteurisation or sterilisation temperatures of up to about 120°C without undergoing shrinkage of its linear dimensions by more than 3%.

Patentansprüche

1. Verfahren zur Herstellung von thermoplastischen Rohrkörpern aus kristallisierbarem Polymer, bei welchem der Körper warmgehärtet wird, so daß er bis zu einer bestimmten erhöhten Temperatur dimensionsstabil ist, indem er auf eine höhere Temperatur als die bestimmte erhöhte Temperatur erwärmt wird, während er durch die Einrichtung eines Kerns (10, 101, 102, 104) an axialer oder radialer Schrumpfung gehindert wird, und dann das Rohr (26, 34) abgekühlt und vom Kern entfernt wird, dadurch gekennzeichnet, daß ein zumindest teilweise biaxial orientiertes Rohr (26, 34) aus dem kristallisierbaren Polymer mit mindestens einem offenen Ende auf einen Kern (10, 101, 102, 104) gezogen wird, dessen Temperatur unter der Glasübergangstemperatur des Polymers liegt und dessen äußerer Durchmesser wenig kleiner als der innere Durchmesser des Rohrs ist, das Rohr (26, 34) festgeklemmt wird, um es an axialer Schrumpfung zu hindern, der Kern (10, 101, 102, 104) von innen erwärmt wird, um das Rohr auf eine über der bestimmten erhöhten Temperatur liegende Temperatur zu erwärmen, so daß das Rohr während es an axialer Schrumpfung gehindert wird, radial bis zur Berührung mit dem Kern schrumpft, aber durch denselben an weiterer radialer Schrumpfung gehindert wird, das Rohr (26, 34) genügend lang bei der genannten höheren Temperatur gehalten wird, um den erforderlichen Grad von Dimensionsstabilität sicherzustellen, das Rohr (26) auf eine Temperatur unter der

bestimmten erhöhten Temperatur abgekühlt wird, die Berührung zwischen dem Rohr (26) und dem Kern (10, 101, 102, 104) gelöst wird, indem Flüssigkeit unter Druck von innerhalb des Kerns durch eine Mehrzahl von Öffnungen (16) in dessen Oberfläche gedrückt wird, um ein Flüssigkeitskissen zwischen dem Rohr und dem Kern zu bilden, und das Rohr vom Kern entfernt wird, während das Flüssigkeitskissen besteht.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das Rohr (26, 34) nachfolgend ohne Schrumpfungsbehinderung wieder auf die bestimmte erhöhte Temperatur erwärmt wird, um eine Restschrumpfung zu beseitigen.

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß das Polymer ein gesättigtes lineares Polyester ist und daß die Temperatur, auf die das Rohr (26, 34) auf dem Kern (10, 101, 102, 104) erwärmt wird, mindestens 60°C höher ist als die bestimmte erhöhte Temperatur.

4. Verfahren nach Anspruch 3, wobei das Polymer Polyethylenterephthalat ist, die bestimmte erhöhte Temperatur etwa 120°C beträgt und das Rohr (26, 34) auf dem Kern (10, 101, 102, 104) auf mindestens 180°C erwärmt wird.

5. Verfahren nach Anspruch 4, dadurch gekennzeichnet, daß das Rohr (26, 34) auf dem Kern (10, 101, 102, 104) für eine Dauer, die 15 Sekunden nicht überschreitet, auf etwa 240°C erwärmt wird.

6. Verfahren nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß man dem Rohrkörper eine Form gibt, die von der eines einfachen zylindrischen Rohrs abweicht, indem man den Kern mit einer komplementären Form versieht, welche vom Rohr (26, 34) angenommen wird, indem es auf den Kern (10, 101, 102, 104) schrumpft.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß der Rohrkörper mit Umfangswülsten ausgebildet ist, indem man den Kern (10, 101, 102, 104) mit entsprechenden Umfangsvorsprüngen (24) versieht.

8. Verfahren nach einem der vorangehenden Ansprüche zur Herstellung eines Rohrkörpers, der an beiden Enden offen ist, dadurch gekennzeichnet, daß das Festklemmen durchgeführt wird, indem man beide Enden des Rohrs (26) am Umfang festklemmt.

9. Verfahren nach Anspruch 8, dadurch gekennzeichnet, daß das Rohr (26) in einzelne Abschnitte zerschnitten wird, bevor seine Berührung mit dem Kern (10, 101, 102) gelöst wird.

10. Verfahren nach Anspruch 9, dadurch gekennzeichnet, daß das Rohr von Messern (17) zerschnitten wird, die durch das Rohrmaterial in Umfangsrillen (22) im Kern (10, 101, 102) eindringen, indem der Kern gedreht wird.

11. Verfahren nach einem der Ansprüche 1 bis 7 zur Herstellung eines Rohrkörpers (34), der an einem Ende (36) geschlossen ist, dadurch gekennzeichnet, daß ein Kern (104) verwendet wird, der ein entsprechend geformtes geschlossenes Ende (38) aufweist, und das Festklemmen wird durchgeführt, indem man das andere offene Ende des Rohrs festklemmt.



12. Verfahren nach Anspruch 11, dadurch gekennzeichnet, daß das offene Ende des Rohrs axial gegen einen radial sich erstreckenden Flansch (22) am Kern (104) geklemmt wird.

13. Verfahren nach Anspruch 11 oder 12, dadurch gekennzeichnet, daß das geschlossene Ende (36) des Rohrs (34) zusätzlich axial gegen das geschlossene Ende (38) des Kerns (104) geklemmt wird.

14. Verfahren nach Anspruch 3, oder einem der Ansprüche 6 bis 13, rückbezogen auf Anspruch 3, bei welchem eine Mehrzahl von vertikalen Hohlkernen (101, 102) mit hoher Wärmeleitfähigkeit verwendet werden, dadurch gekennzeichnet, daß jeder Kern durch Arbeitsstationen geschaltet wird, an denen:

(a) das Rohr (26) auf den Kern (101, 102), dessen Temperatur unter der Glasübergangstemperatur des Polymers liegt, gezogen wird,

(b) Klemmen (20, 201) am Rohr (26) angebracht werden, um es axial einzuspannen,

(c) ein Heizelement (28) in das Innere des Kerns eingeführt wird, um denselben auf eine Temperatur zu erwärmen, die um mindestens 60°C höher ist als die bestimmte erhöhte Temperatur,

(d) die genannte höhere Temperatur genügend lang aufrechterhalten wird, um den erforderlichen Grad von Dimensionsstabilität sicherzustellen,

(e) das Heizelement (28) entfernt und das Rohr (26) unter die bestimmte erhöhte Temperatur abgekühlt wird,

(f) die Klemmen (20, 201) gelöst werden,

(g) die Enden des Kerns (101, 102) abgedichtet werden und Druckluft in diesen eingelassen und durch kleine Löcher (16) in seiner Oberfläche hinausgedrückt wird, um die Berührung zwischen dem Rohr (26) und dem Kern (101, 102) zu lösen, und

(h) das Rohr (26) vom Kern (101, 102) entfernt wird.

15. Verfahren nach Anspruch 14, dadurch gekennzeichnet, daß der Kern (101) nach der Abkühlung des Rohrs (26) gedreht wird und Messer (17) in Kontakt mit dem Rohr (26) gebracht werden, um dieses in einzelne Abschnitte zu zerschneiden.

16. Vorrichtung zur Herstellung eines thermoplastischen Rohrkörpers aus einem kristallisierbaren Polymer, welcher warmgehärtet ist, um bis zu einer bestimmten erhöhten Temperatur dimensionsstabil zu sein, mit einem Kern (10, 101, 102, 104), der geeignet ist, ein Rohr (26, 34) aus dem Polymer an axialer und radialer Schrumpfung zu hindern, und einer Heizeinrichtung (28), dadurch gekennzeichnet, daß die Heizeinrichtung geeignet ist, den Kern (10, 101, 102, 104) von innen zu erwärmen und damit den Körper auf eine höhere Temperatur als die bestimmte erhöhte Temperatur zu erwärmen; und daß der äußere Durchmesser des Kerns etwas kleiner ist als der innere Durchmesser des Rohrs (26, 34) und daß eine Festklemmeinrichtung (20, 201) zum Festklemmen eines wenigstens teilweise biaxial orientierten Rohrs (26, 34) aus dem kristallisierbaren Polymer vorgesehen ist, um das Rohr an axialer Schrumpfung zu hindern; und daß eine Zufüh-

rungseinrichtung von unter Druck stehender Flüssigkeit (14, 141) zur Zuführung von Flüssigkeit unter Druck von innerhalb des Kerns (10, 101, 102, 104) durch eine Mehrzahl von Öffnungen (16) in dessen Oberfläche zuführt, vorgesehen ist, um die Berührung zwischen dem Kern und dem darauf geschrumpften Rohr zu lösen.

17. Vorrichtung nach Anspruch 16, dadurch gekennzeichnet, daß der Kern (10, 101, 102, 104) hohl ist und aus einem Material mit hoher Wärmeleitfähigkeit hergestellt ist und daß die Heizeinrichtung ein Heizelement (28) aufweist, welches in den hohlen Kern eingeführt werden kann.

18. Vorrichtung nach Anspruch 17, dadurch gekennzeichnet, daß sich das Innere des Kerns (101) gegen ein Ende zu leicht verjüngt, um Kontakt mit einem entsprechend geformten Heizelement (28), das vom anderen Ende eingeführt wird, herzustellen.

19. Vorrichtung nach einem der Ansprüche 16 bis 18, dadurch gekennzeichnet, daß der Kern (10, 101, 102, 104) Umfangsvorsprünge aufweist, um Umfangswulste an dem geschrumpften Rohr zu bilden.

20. Vorrichtung nach einem der Ansprüche 16 bis 19 zur Herstellung von mehreren Behälterkörpern, dadurch gekennzeichnet, daß die Oberfläche des Kerns (10, 101) eine Mehrzahl von Umfangsrillen (22) aufweist und so angebracht ist, daß er sich um seine Achse drehen kann, wobei die Vorrichtung weiter einen Satz paralleler Messer (17) aufweist, die gegen den Kern (10, 101) bewegt werden können und in die Rillen (22) aufgenommen werden können, um ein Polymerrohr (26), welches auf dem Kern ist, zu schneiden.

21. Lebensmittelbehälter mit einem zylindrischen Körper (26), der offene Enden aufweist, und eine Endverschlußeinrichtung (30, 31) an jedem Ende des Behälters, um mit dem Körper einen geschlossenen Behälter zu bilden, dadurch gekennzeichnet, daß der Körper aus einem kristallisierbaren Polyethylenterephthalat-Material hergestellt ist, wobei das Körpermaterial biaxial orientiert ist und der Behälterkörper bei einer Temperatur zwischen etwa 180°C und etwa 240°C warmgehärtet worden ist, während er an radialer und axialer Schrumpfung gehindert wurde, wobei der Behälter Heißbefüllungs-, Pasteurisierungs- oder Sterilisationstemperaturen von bis zu etwa 120°C aushalten kann, ohne eine Schrumpfung seiner linearen Dimensionen um mehr als 3% zu erleiden.

Revendications

1. Procédé de fabrication d'un article tubulaire en polymère cristallisable, comportant le thermofixage de l'article opéré de façon que celui-ci soit dimensionnellement stable jusqu'à une température élevée spécifique en le portant à une température supérieure à ladite température élevée spécifique tout en l'empêchant de se contracter axialement et radialement au moyen d'un mandrin (10, 101, 102, 104) puis en refroidissant le tube (26, 34) et en le retirant du mandrin, caracté-



risé par les étapes consistant à enfiler un tube (26, 34) en polymère cristallisable orienté biaxialement en partie au moins, présentant au moins une extrémité ouverte sur un mandrin (10, 101, 102, 104) dont la température est inférieure à la température de transition vitreuse du polymère et dont le diamètre extérieur est légèrement inférieur au diamètre intérieur du tube, à serrer le tube (26, 34) pour l'empêcher de se contracter axialement, à chauffer intérieurement le mandrin (10, 101, 102, 104) pour porter le tube à une température supérieure à ladite température élevée spécifique de façon que, tout en étant empêché de se contracter axialement, le tube entre, par retrait radial, en contact avec le mandrin mais soit empêché par celui-ci de poursuivre son retrait radial, à maintenir le tube (26, 34) à ladite température supérieure pendant un temps suffisant pour assurer le degré voulu de stabilité dimensionnelle, à refroidir le tube (26) jusqu'à une température inférieure à ladite température élevée spécifique, à interrompre le contact entre le tube (26) et le mandrin (10, 101, 102, 104) en refoulant du fluide sous pression à partir de l'intérieur du mandrin à travers une série de trous (16) prévus dans sa surface pour constituer un coussin de fluide entre le tube et le mandrin, et à retirer le tube du mandrin pendant que le coussin de fluide est établi.

2. Procédé selon la revendication 1, caractérisé en ce que le tube (26, 34) est ultérieurement réchauffé jusqu'à la température élevée spécifique sans contrainte pour l'élimination d'un retrait résiduel.

3. Procédé selon la revendication 1 ou 2, caractérisé en ce que le polymère est un polyester linéaire saturé et la température à laquelle le tube (26, 34) est porté sur le mandrin (10, 101, 102, 104) est supérieure d'au moins 60°C à la température élevée spécifique.

4. Procédé selon la revendication 3, dans lequel le polymère est le polytéraphthalate de polyéthylène, la température élevée spécifique est d'environ 120°C, et le tube (26, 34) est porté à une température d'au moins 180°C sur le mandrin (10, 101, 102, 104).

5. Procédé selon la revendication 4, caractérisé en ce que le tube (26, 34) est porté à une température d'environ 240°C sur le mandrin (10, 101, 102, 104) pendant un temps ne dépassant pas 15 secondes.

6. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce qu'on donne à l'article tubulaire une forme qui s'écarte de celle d'un tube cylindrique simple en conférant au mandrin une forme complémentaire, que le tube (26, 34) adopté en s'appliquant par retrait contre le mandrin (10, 101, 102, 104).

7. Procédé selon la revendication 6, caractérisé en ce qu'on façonne sur l'article tubulaire des moulures périphériques en prévoyant sur le mandrin (10, 101, 102, 104) des saillies périphériques correspondantes (24).

8. Procédé selon l'une quelconque des revendications précédentes de fabrication d'un article

tubulaire ouvert aux deux extrémités, caractérisé en ce qu'on assure le serrage du tube (26) en le serrant circonférentiellement à ses deux extrémités.

9. Procédé selon la revendication 8, caractérisé en ce qu'on découpe le tube (26) en tronçons individuels avant que son contact avec le mandrin (10, 101, 102, 104) ne soit interrompu.

10. Procédé selon la revendication 9, caractérisé en ce que le tube est découpé par des couteaux (17) qui pénètrent à travers le matériau du tube à l'intérieur de rainures périphériques (22) du mandrin (10, 101, 102) pendant la rotation du mandrin.

11. Procédé selon l'une quelconque des revendications 1 à 7 de fabrication d'un article tubulaire (34) fermé à une extrémité (36), caractérisé en ce qu'on utilise un mandrin (104) qui présente une extrémité fermée de forme correspondante (38) et l'on assure le serrage en serrant l'autre extrémité ouverte du tube.

12. Procédé selon la revendication 11, caractérisé en ce que l'extrémité ouverte du tube est serrée axialement contre un collet (42) s'étendant radialement sur le mandrin (104).

13. Procédé selon la revendication 11 ou 12, caractérisé en ce que l'extrémité fermée (36) du tube (34) est en outre serrée axialement contre l'extrémité fermée (38) du mandrin (104).

14. Procédé selon la revendication 3, ou l'une quelconque des revendications 6 à 13, utilisant une série de mandrins creux verticaux (101, 102) à haute conductibilité thermique, caractérisé en ce que chaque mandrin franchit par indexage des postes actifs auxquels:

a) le tube (26) est enfilé sur le mandrin (101, 102) dont la température est inférieure à la température de transition vitreuse de polymère,

b) des moyens de serrage (20, 201) sont appliqués sur le tube (26) pour l'immobiliser axialement,

c) un élément chauffant (28) est introduit dans l'intérieur du mandrin pour le porter à une température supérieure d'au moins 60°C à la température élevée spécifique,

d) ladite température supérieure est maintenue pendant un temps suffisant pour assurer le degré voulu de stabilité dimensionnelle,

e) l'élément chauffant (28) est retiré, et le tube (26) est refroidi jusqu'au-dessous de la température élevée spécifique,

f) les moyens de serrage (20, 201) sont relâchés, g) les extrémités du mandrin (101, 102) sont rendues étanches et de l'air sous pression est introduit dans celui-ci et refoulé à l'extérieur à travers de petits trous (16) de sa surface pour interrompre le contact entre le tube (26) et le mandrin (101, 102), et

h) le tube (26) est retiré du mandrin (101, 102).

15. Procédé selon la revendication 14, caractérisé en ce que, après refroidissement du tube (26), le mandrin (101) est entraîné en rotation et des couteaux (17) sont amenés en contact avec le tube (26) pour le découper en tronçons individuels.

16. Appareil pour la fabrication d'un article



tubulaire thermoplastique en un polymère cristallisable qui est thermofixé de façon à être dimensionnellement stable jusqu'à une température élevée spécifique, comprenant un mandrin (10, 101, 102, 104) agencé pour empêcher un tube (26, 34) en polymère cristallisable de se contracter axialement et radialement, et un moyen de chauffage (28) caractérisé en ce que les moyens chauffants sont propres à chauffer le mandrin (10, 101, 102, 104) intérieurement et à porter par là l'article à une température supérieure à la température élevée spécifique; et en ce que le diamètre extérieur du mandrin est légèrement inférieur au diamètre intérieur du tube et en ce que des moyens de serrage (20, 201) sont prévus pour serrer un tube (26, 34) en polymère cristallisable, orienté biaxialement en partie au moins, pour empêcher le tube de se contracter axialement; et en ce qu'un moyen d'amenée de fluide sous pression (14, 141) est prévu pour faire arriver du fluide sous pression depuis l'intérieur du mandrin (10, 101, 102, 104) à travers une série de trous (16) percés dans sa surface pour interrompre le contact entre le mandrin et le tube appliqué par retrait sur lui.

17. Appareil selon la revendication 16, caractérisé en ce que le mandrin (10, 101, 102, 104) est creux et en un matériau à haute conductibilité thermique, et le moyen de chauffage est un élément chauffant (28) qui peut être inséré à l'intérieur du mandrin creux.

18. Appareil selon la revendication 17, caractérisé en ce que l'intérieur du mandrin (101) s'amenuise légèrement vers une extrémité de façon à entrer en contact avec un élément chauffant de

forme correspondante (28) inséré par l'autre extrémité.

19. Appareil selon l'une quelconque des revendications 16 à 18, caractérisé en ce que le mandrin (10, 101, 102, 104) présente des saillies périphériques de manière à façonner des moulures périphériques dans le tube contracté.

20. Appareil selon l'une quelconque des revendications 16 à 19, pour la fabrication de corps de récipient multiples, caractérisé en ce que le mandrin (10, 101) présente en surface une série de rainures périphériques (22) et est monté pour tourner autour de son axe, l'appareil comprenant encore un jeu de couteaux parallèles (17) qui peuvent être déplacés vers le mandrin (10, 101) et reçus à l'intérieur desdites rainures (22), pour découper un tube en polymère (26) situé sur le mandrin.

21. Récipient pour aliment comprenant un corps cylindrique ouvert aux extrémités (26) et, à chaque extrémité du corps, des moyens de fermeture d'extrémité (30, 31) constituant avec ledit corps un récipient fermé, caractérisé en ce que ledit corps est en un polytéréphtalate d'éthylène cristallisable, ledit matériau du corps étant orienté biaxialement et le corps du récipient ayant été thermofixé, tout en étant empêché de se contracter radialement et axialement, à une température d'environ 180 à environ 240°C, de sorte que ledit récipient est apte à supporter des températures de remplissage à chaud, de pasteurisation et de stérilisation allant jusqu'à une température d'environ 120°C sans subir, sur ses dimensions linéaires, de retrait supérieur à 3%.

