

A CONTAINER OF THERMOPLASTIC MATERIAL

The present invention relates to a container of thermoplastic material.

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The container is moulded from a tubular blank of polystyrene terephthalate or similar material which is stretched axially to produce a preform, the preform then being converted to the container.

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In the production of containers made of a thermoplastic, where the material has a property that its strength and stability increase with orientation of the material, it is desirable that as large a proportion of the container as possible should consist of oriented material. The material is oriented by a stretching procedure, with biaxially stretched material giving the best utilisation of the available amount of material. Especially in the case of bottle-type containers it is, however, difficult to achieve stretching, and thereby create orientation, of, for example, the neck and orifice parts, and in certain cases even of the centrally located base parts.

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Swedish Patent Application No. SE 8004003.3 discloses how axial orientation of the material in the preform can be achieved by a mechanical procedure wherein a preform passes through one or more draw rings which reduce the wall thickness in the preform and thereby also the outer diameter of the preform. It has been shown that the best effect is achieved when the material in the preform, immediately prior to stretching, has a temperature within or below but near to the region of the glass transition temperature (TG) of the material. The axially oriented preform obtained by the process described is mechanically stable and the subsequent treatments for converting the stretched preform to a container must therefore be appropriate to this fact.

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- Exceptionally good mechanical properties are achieved with polyethylene terephthalate if the material, during stretching of the preform, is stretched at least about 3-fold. In this connection, an "over-stretching" of the material is easily achieved, resulting in the material in the preform shrinking during the heating of the preform to the moulding temperature, so that the preform reaches a length corresponding to that it would have reached on stretching about 3-fold.
- 10 On conversion of a preform, axially stretched as above, to a container, a problem arises in the form of fracture in the material if attempts are made to stretch the preform additionally to the stretching which the material has acquired through the axial orientation of the preform described above. During
- 15 conversion of the preform to the container, one therefore seeks to limit the axial stretching of the preform and generally let the conversion result in a stretching of the material only in the circumferential direction of the preform.
- 20 In certain applications, a particular combination of container length and container diameter is sought but it is not possible to produce such a container by known techniques because, during the conversion to a container, the material of the preform is stretched far too much in the axial direction of the preform.
- 25 This problem arises with a container having a relatively large diameter in relation to the container length. Containers with such dimensional characteristics are normally involved with bottles having a volume of less than 0.5 litres.
- 30 The present invention relates to a container where the problems described above have been reduced. The invention will be described especially in relation to polyethylene terephthalate, hereafter referred to as PET, but is in principle applicable to many other thermoplastics of the polyester or polyamide type.

Examples of such other materials are polyhexamethylene adipamide, polycaprolactam, polyhexamethylene sebacamide, polyethylene 2,6- and 1,5-naphthalate, polytetramethylene 1,2-dioxybenzoate and copolymers of ethylene terephthalate, ethylene isophthalate and other similar plastics polymers.

According to the present invention there is provided a container of thermoplastic material having a body portion, a base portion, and a neck portion defining an orifice, wherein the neck portion and the body portion consist of material having an axial orientation obtained by a monoaxial stretching of the material, the axial orientation of the material of said body portion and of the material of said neck portion being substantially the same, and wherein the material of said body portion also has a transverse orientation independent of and superimposed on said axial orientation, said transverse orientation being obtained by transversely stretching the axially oriented material of the body portion whilst preventing any substantial axial stretching of the material of the body and neck portions.

The ratio of the material thickness in the body portion to the material thickness in the neck portion is approximately equal to the ratio of the radius of the neck portion to the radius of the body portion in any plane at right angles to the axis of the container.

In a preferred embodiment of the invention a central area of the base portion of the container and/or an area surrounding the orifice of the container consist of thermocrystallised, opaque and dimensionally stable material.

In an embodiment, the oriented material in the neck portion has a crystallinity within the range of about 10% to 30%, and the

oriented material in the body portion has a crystallinity within the range of about 10% to 40%, whereby of the total crystallinity about 13% as a maximum, has been obtained by heat treatment, and wherein the material in a central area of the base portion either has a crystallinity in excess of about 10% or consists mainly of amorphous material having a crystallinity of less than 10%. Preferably, the oriented material in the neck portion has a crystallinity within the range of about 10% to 25%, and the oriented material in the body portion has a crystallinity within the range of about 10% to 35%.

In a preferred embodiment, the container is made of polyethylene terephthalate and said axial orientation is equivalent to a monoaxial stretching of about 3-fold, and said transverse orientation is equivalent to a transverse stretching of a maximum of about 3-fold.

Preferably, said container is formed as a jar or a bottle.

An embodiment of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a longitudinal section through a blowmould, with an axially stretched preform placed in the blowmould, and with a base portion of the blowmould in its lower position,

5 Figure 2 shows a corresponding longitudinal section of the blowmould of Figure 1 during conversion of the preform, the base portion having been moved towards the orifice portion of the preform,

10 Figure 3 shows a corresponding longitudinal section of the blowmould of Figure 1 showing the base portion in its upper position and with the preform converted to a container, and

Figure 4 shows a container produced in accordance with the invention.

15 Figures 1 to 3 illustrate a blowmould 12 which comprises two mould halves 10a and 10b which are movable in the direction of arrows A and B respectively to and fro from the position shown in the Figures. The mould halves 10a and 10b form the blowmould 12 conjointly
20 with a third mould portion in the form of a base portion 11. The base portion 11 is movable between a lower position shown in Figure 1 and an upper position shown in Figure 3 by way of drive means (not shown). In
25 its upper position, the base portion 11 together with the mould halves constitute the assembled blowmould.

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The base portion 11 is provided with a central mould portion 17 which is thermally insulated from the rest of the base portion. A number of channels 18 through which a fluid can flow are provided in the central portion 17. Channels 19 for fluid flow are located in the other parts of the base portion 11 and further channels 30 are provided in the mould halves 10a and 10b.

Gripping devices 13a and 13b are connected to the upper parts of the mould halves and cooperate with a mandrel 15 so as to hold a preform 20 at its orifice 22. The gripping devices are also provided with channels 31 through which a fluid can flow for temperature control.

15 The length of the mandrel 15 is chosen such that when the base portion 11 is in its upper position a space is defined between a lower shaping surface 16 of the mandrel and the central mould portion 17 of the base portion 11, the shape and thickness of this space corresponding to the intended shape and thickness, of the moulded container. In addition, in the lower position (Figure 1) of the base portion 11 in the inner height along the central axis of the blow-mould corresponds to the axial length s_1 of the preform, to allow the preform to be inserted into the blowmould.

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In the upper position (Figure 3) of the base portion 11, the inner height s_2 of the blowmould is less than the axial length of the preform.

5 The mandrel 15 has an axially extending main channel 14 for a pressure medium which communicates via side channels 33 with the surface of the mandrel and hence with the interior of the preform 20 on the mandrel 15.

10 As shown in Figure 1, the preform 20 is placed in the blowmould such that a central portion 24 of material of the base of the preform is in contact with the base portion 11 of the blowmould 12.

15 Figure 3 shows a container 21 moulded in the blowmould 12 from the preform 20 and Figure 2 shows an intermediate stage in the formation of the container 21 at which the preform has been converted into a body 23.

20 Figure 4 shows, in detail, a container 21 according to the invention. The container has a neck portion 25 the upper part of which forms a rim 22' surrounding the orifice. The actual container body 26 has in its base portion a central material portion 24. In the Figure, the radius and material thickness of the neck portion 25 are referenced r_1 and d_1 respectively, whilst r and d are the radius and material thickness of the container
25 body 26 in an arbitrary plane at right angles to the axis of the container.

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The material thickness d varies with the radius r of the container body such that the ratio of the material thickness d of the container body to the material thickness d_1 of the neck portion is approximately equal to the ratio of the radius r_1 of the neck portion to the radius r of the container body. The neck portion is formed of axially oriented material and the container body of biaxially oriented material.

In a preferred embodiment, the central material portion 24 and/or the rim 22' consist of thermocrystallised, opaque, dimensionally stable material.

In employing the invention, a tubular blank is stretched in its axial direction, for example, by passing it through one or more draw rings, such that the wall thickness of the blank is reduced and at the same time the outer circumference of the blank is decreased. Immediately prior to this stretching, the material of the blank is at a temperature within or preferably below the range of the glass transition temperature (TG) of the material.

The preform 20, produced by stretching the blank, is then heated to the moulding temperature and introduced into the blowmould 12. The mandrel 15 is introduced into its position within the preform thereby holding the orifice 22 of the preform against the gripping device

13. The base portion 11 of the blowmould is in its lower position. A heating medium is passed through the channels 18, 19, 30, 31 to bring the shaping surfaces of the blowmould to a predetermined temperature and
5 above all to heat up the surfaces of the gripping device 13 adjacent the orifice 22 of the preform.

Thereafter, the interior of the preform is placed under pressure by means of a pressure medium fed to the channel 14 of the mandrel and at the same time the
10 base portion 11 of the blowmould is moved towards the orifice of the preform, that is, upwardly as shown in Figures 1 to 3. As a result, the preform 20 is expanded and at the same time its axial length is reduced (see Figure 2), so that the material of the preform is
15 stretched substantially only in the circumferential direction of the preform. When the base portion 11 of the blowmould has reached its upper position as shown in Figure 3, all portions of the material of the preform have been brought into contact with the inner shaping
20 surfaces of the blowmould by means of the pressure medium, and the preform has been converted to the container 21.

In certain embodiments, pressure is maintained within the container produced for some time so that reliable contact with the shaping surfaces of the blowmould is
25 achieved. The shaping surfaces of the blowmould are

then at a temperature in the range between 110°C and 180°C, preferably between 130°C and 150°C, and as a result possible stresses in the material are released through the contact and at the same time a certain amount of thermal crystallisation takes place in the material. This mechanically stabilises the shape of the container, and the container can subsequently be heated up to the temperature at which the heat-stabilisation took place without major change of shape.

When the heat-stabilisation of the container is completed, the mould halves 10a and 10b are opened and the base portion 11 is moved to its lower position. The container is then removed from the blowmould.

In certain applications, there occurs cooling of the material of the preform and hence of the central base portion of the container, i.e. of the material which in this case is reshaped, and/or reduced in thickness, between the shaping surface 16 of the mandrel 15 and the central mould portion 17 of the base portion of the blowmould 11. This gives a container whose central base portion consists of amorphous material. In other applications, the material is heated as just described in connection with the heat-stabilisation of the container, with the shaping surface 16 of the mandrel 15

having a temperature within the range at which the amorphous material will crystallise, preferably, a temperature between 130°C and 160°C. In this way, the central base portion of the container is converted
5 to a thermo-crystallised, opaque, dimensionally stable area of material.

The invention has been described above in connection with a blowmould whose base portion travels in the axial
10 direction of the blowmould during the conversion of the preform to a container. However, in an alternative embodiment, the base portion 11 is fixed or is held in position and the gripping device 13 together with the mandrel 15 are moved in the axial direction of the
15 blowmould during the conversion of the preform.

A container according to the invention has a crystallinity in the neck portion 25 of the order of

10% to 30%, and in the container body 26 of the order of about 10% to 40%. In the embodiment where the central shaping portion 17 keeps the central base portion 24 at a temperature which does not cause thermally conditioned crystallisation, or causes this
5 crystallisation only to a slight extent (such a temperature being, for PET, below about 100°C), an amorphous central base portion 24 having a crystallinity of less than 10%, preferably less than 5%, is obtained. In the case where the central shaping
10 portion 17 holds the material at the crystallisation temperature (about 140°C for PET), a crystallised, opaque, dimensionally extremely stable central area of material having a crystallinity in excess of about 10%, is obtained. Similar conditions regarding crystallinity apply to the rim 22' of the orifice
15 depending on whether it has been cooled or heated to the temperature regions just mentioned, by the mandrel 15 and/or the gripping device 13.

The crystallinity values stated in the present application relate to the theories disclosed in the publication "Die Makromolekulare
20 Chemie" 176, 2459-2465 (1975).

A method and apparatus for moulding a container of thermoplastic material as described herein are described and claimed in our
25 copending application No. 8327132 divided out of the present application.



CLAIMS:

- 5 1. A container of thermoplastic material having a body portion, a base portion, and a neck portion defining an orifice, wherein the neck portion and the body portion consist of material having an axial orientation obtained by a monoaxial stretching of the material, the axial orientation of the material of said body portion and of the material of said neck portion being substantially the same, and wherein the material of said body
10 portion also has a transverse orientation independent of and superimposed on said axial orientation, said transverse orientation being obtained by transversely stretching the axially oriented material of the body portion whilst preventing any substantial axial stretching of the material of the body and neck
15 portions.
- 20 2. A container as claimed in Claim 1, wherein the ratio of the material thickness in the body portion to the material thickness in the neck portion is approximately equal to the ratio of the radius of the neck portion to the radius of the body portion in any plane at right angles to the axis of the container.
- 25 3. A container as claimed in Claim 1 or 2, wherein a central area of the base portion and/or an area surrounding the orifice of the container consist of thermo-crystallised, opaque, dimensionally stable material or of amorphous material.
- 30 4. A container as claimed in any preceding claim, wherein the oriented material in the neck portion has a crystallinity within the range of about 10% to 30%, and the oriented material in the body portion has a crystallinity within the range of about 10% to 40%, whereby of the total crystallinity about 13% as a maximum, has been obtained by heat treatment, and wherein the material in



a central area of the base portion either has a crystallinity in excess of about 10% or consists mainly of amorphous material having a crystallinity of less than 10%.

- 5 5. A container as claimed in Claim 4, wherein the oriented material in the neck portion has a crystallinity within the range of about 10% to 25%, and the oriented material in the body portion has a crystallinity within the range of about 10% to 35%.
- 10 6. A container as claimed in any preceding claim, made of polyethylene terephthalate, wherein said axial orientation is equivalent to a monoaxial stretching of about 3-fold, and wherein said transverse orientation is equivalent to a transverse stretching of a maximum of about 3-fold.
- 15 7. A container as claimed in any preceding claim formed as a jar or a bottle.
- 20 8. A container substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.
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