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GRADED CRYSTALLIZATION OF CONTAINER FINISHES

The present invention is directed to containers of molded polymer construction, and more particularly to crystallization at the container neck finish.

Background and Summary of the Invention

5 Containers of crystallizable polymer construction - e.g., PET construction - are conventionally fabricated in an injection blow molding operation, in which a preform is fabricated by injection molding, and the preform is then subjected to a blow molding operation to form the container. The container finish is formed to final geometry or substantially final geometry in the injection molding operation, and generally is of amorphous polymer construction. The body of
10 the container is subjected to stretching during the blow molding operation so that the body is of oriented polymer construction. It has been proposed to strengthen and rigidify the finish portion of the container by crystallizing all or selected portions of the neck finish. See, for example, U.S. Patents 4,618,515, 4,928,835 and 6,217,818. The uncrystallized portions of the container body and finish are typically translucent, while the crystallized portion(s) of the finish contain spherulite
15 that has a milky opaque appearance.

The term "crystallizable polymer" in the present application refers to any polymer that is capable of being crystallized. These polymers include not only polyesters such as PET, which is the crystallizable polymer most typically used to make containers, but also polyolefins such as polyethylenes and polypropylenes, polycarbonates and polyamides such as nylons. Thus,
20 although specific embodiments of the invention are disclosed in conjunction with polyesters - i.e., PET - the invention is by no means limited specifically to this polymer or family of polymers.

Likewise, when referring in the present application to preforms or containers that are at least partly of crystallizable polymer construction, or to preforms or containers of crystallizable polymer construction, such language refers not only to containers that are entirely of crystallizable polymer construction, but also to multilayer containers in which inside and outside layers are of crystallizable polymer construction. Other intermediate layers of the container or preform may include barrier materials against migration of gases through the container walls, layers of process regrind and/or layers that include post consumer resin. These intermediate layers may be included only in the body of the container, such that the container finish is of unlayered polymer construction, or may extend into the finish of the container. See, for example, U.S. Patents 4,550,043, 4,609,516, 4,781,954, 4,990,301 and 5,098,274.

It has been proposed to crystallize the entire finish of a PET container to improve dimensional stability of the container finish. However, such complete crystallization may induce shrinkage of the finish as a result of crystallization, which is unacceptable in the threaded section of the finish to which a container closure will ultimately be secured. Conversely, a completely amorphous finish is subject to softening and movement as the container is hot-filled and capped because the temperature of the container may rise above the glass transition temperature of the plastic. It is therefore an object of the present invention to provide a technique for selectively crystallizing portions of the container finish that substantially reduces or eliminates shrinkage of the finish as a result of crystallization, provides desired stability in the finish sealing and thread area where the container closure will ultimately be secured, and/or that reduces consumption of energy as compared with crystallization of the entire finish area. Other and more specific objects of the invention are to provide a preform for blow molding a hollow plastic container, a hollow plastic container, and a method for forming a hollow plastic container in which the container finish is selectively crystallized as described above.

These and other objects are achieved in accordance with the present invention by selectively crystallizing the neck finish of the preform or container in such a way as to achieve substantial crystallization in at least a first portion of the finish, substantially no crystallization in a second portion of the finish, and graded crystallization between the first and second portions of the finish. The term "graded crystallization" refers to a gradual transition between substantial crystallization and substantially no crystallization, as distinguished from a sharp or distinct non-graded pattern of contrast between crystallized and uncrystallized portions of the neck finish. The gradation of crystallization is continuous, and may be either linear or non-linear with distance.

The present invention embodies a number of aspects, that may be implemented separately from or in combination with each other.

In accordance with a first aspect of the present invention, a finish on a hollow plastic container or preform has an integral body, a first end portion with an end surface spaced from the body, a second end portion adjacent to the body and a mid portion between the end portions. The first end and the mid portions form continuous inner and outer surfaces. The finish is crystallized at at least one of the end, inner and outer surfaces, and crystallization in the finish in a direction perpendicular to the one surface is graded from crystallization at the one surface to an essential absence of crystallization at a position within the finish spaced from the one surface.

Yet another aspect of the present invention provides a method of making a hollow plastic container, which includes molding a preform at least partially of crystallizable polymer construction and blow molding the preform to form the hollow plastic container. Either prior to or subsequent to blow molding the preform, the finish is crystallized in such a way that at least the first end portion of the finish is crystallized, and crystallization in the finish is graded from crystallization in the first end portion.

In accordance with a further aspect of the invention, a finish on a hollow plastic container or preform is at least partially of crystallizable polymer construction and is coupled to a body integral with the finish. The finish has an end portion remote from the body, a capping flange adjacent to the body, and a mid portion between the end portion and the capping flange. At least a portion of the end portion, the mid portion, or both the end portion and the mid portion is crystallized, and the capping flange is essentially free of crystallization.

Brief Description of the Drawings

The invention, together with additional objects, features and advantages thereof, will be best understood from the following description, the appended claims and the accompanying drawings in which:

FIG. 1 is a cross sectional view of a preform for blow molding a container in accordance with one aspect of the present invention;

FIG. 2 is a partially sectioned view of a container blow molded from the preform illustrated in FIG. 1;

FIG. 3 is an enlarged fragmentary sectional view of the neck finish in the preform of FIG. 1; and

FIGS. 4-11 are fragmentary sectional views similar to that of FIG. 3 but illustrating respective additional embodiments of the invention.

Detailed Description of Preferred Embodiments

FIGS. 1 and 3 illustrate a preform 20 in accordance with one aspect of the present invention as comprising a finish 22 and a body 24. Finish 22 and body 24 are integrally formed in an injection molding operation, for example, and are either of monolayer or multilayer construction as previously described. Patents noted above illustrate various automated techniques for fabricating preforms 20. Finish 22 of preform 20 includes a first end portion 26

remote from body 24, a mid portion 28, and a second end portion 30, which preferably includes a capping ring or flange 30, adjacent to body 24. First end portion 26 defines an end surface 32. First end portion 26 and mid portion 28 also define a continuous external surface 34 that includes at least one external thread for ultimate securement of a container closure, and an internal surface 36 that will form the mouth of the container. FIG. 2 illustrates a container 20a blow molded from preform 20. Container 20a includes finish 22 and a body 24a that is blow molded from preform body 24. The exemplary finish of FIGS. 1-3 (as well as the finishes of FIGS. 4-9) also have an external thread for later securement of a closure, and a retaining bead for cooperating with tamper-indicating structure on the closure.

Referring in particular to FIG. 3, and in accordance with one presently preferred embodiment of the invention, preform finish 22 (and therefore ultimately container finish 22) is selectively crystallized for enhanced dimensional stability of the thread and sealing surface areas of the finish. Crystallization in FIG. 3 (and in FIGS. 4-11) is illustrated by shading or stippling, with the density of the shading or stippling indicating the degree of crystallization, and with the absence of shading or stippling indicating an absence of substantial crystallization. Reference to an absence of crystallization, or to the fact that a portion of the finish is essentially uncrystallized or amorphous, means that there is an absence of intended crystallization, and that any crystallization is an unintended and insubstantial minor result of variations in the manufacturing process. The degree of crystallization will depend upon application. In other words, the darkest areas of the drawings may possess 50% crystallization, decreasing to substantially zero through the graded area.

In FIG. 3, there is substantial crystallization at the outside edge of first end portion 26 of finish 22, and graded crystallization from the upper outside edge of first end portion 26 both radially inwardly and axially downwardly with respect to finish 22. (Directional words such as

“axial” and “radial” are employed by way of description and not limitation with respect to the central axis of the container finish. Directional words such as “upper” and “downward” are employed by way of description and not limitation with respect to the upright orientations of the preforms and containers illustrated in the drawings.) In mid portion 28 of finish 22 in FIG. 3, there is some crystallization along outside surface 34, but an absence of crystallization along at least the lower portion of inside surface 36. Second end portion 30, including the capping flange, is essentially free of crystallization in this embodiment. Thus, in the embodiment of FIG. 3, there is heavy crystallization along outer surface 34 in first finish end portion 26 and the upper part of mid portion 28, graded crystallization radially inwardly to surface 36, where there is partial crystallization in first end portion 26 and the upper part of mid portion 28, and axially graded crystallization along surface 34 in the middle and lower sections of mid finish portion 28. In these mid and lower sections of mid portion 28, crystallization is graded radially inwardly to about the center of the finish thickness, and no crystallization at inner surface 36. (It will be understood that crystallization around the circumference of finish 22 is the same as illustrated in the cross section of FIG. 3 (as well as the cross sections of FIGS. 4-8) within manufacturing tolerance variations.)

FIG. 4 illustrates a finish 22a, in which crystallization is similar to that in FIG. 3. The uncrystallized inner area of mid portion 28 extends upwardly into first end portion 26, while the partially crystallized lower end of mid portion 28 extends to a position adjacent to second end 30. Again, the capping flange is essentially free of crystallization. FIG. 5 illustrates a finish 22b, in which there is full crystallization along outer surface 34 from first end portion 26 through mid portion 28, with second end portion 30 being essentially free of crystallization. Crystallization is graded from substantial crystallization at outer surface 34 to no crystallization at and near inner surface 36. Crystallization is also graded in the axial direction from substantial crystallization in

mid portion 34 to essentially no crystallization at second end 30. FIG. 6 illustrates a finish 22c that has full crystallization at inner surface 36 in both first end portion 26 and mid portion 28. Crystallization is graded in the radial direction from substantial crystallization at inner surface 36 to absence of crystallization at and adjacent to outer surface 34. Crystallization is also graded in the axial direction, with there being partial crystallization at inner surface 36 radially inwardly of the capping flange.

Controlled crystallization in the embodiments of FIGS. 3-6 (and FIGS. 7-8) can be obtained in any suitable manner, including for example directing heat from a quartz lamp onto the area to be crystallized while cooling the opposing area of the finish that is to remain uncrystallized. For example, in the embodiment of FIG. 3, hot air can be directed against the outside surface and the upper portion of the inside surface of the finish, while a chill plug or the like is employed to chill the lower portion of the inside surface. Heat shields can also be employed to prevent crystallization, as illustrated for example in above-noted U.S. Patent 4,928,835. Likewise, in the embodiment of FIG. 6, hot air can be directed onto the inside surface of the preform finish, while the interior of the preform body and the outside surface of the preform body are suitably shielded and/or cooled to prevent crystallization.

FIG. 7 illustrates a preform finish 22d in accordance with a modified embodiment of the invention, in which first end portion 26 of the finish is crystallized at and beneath end surface 32, while graded crystallization extends through mid portion 28 to a position at or slightly into second end portion 30. FIG. 8 illustrates a finish 22e in which first end portion 26 is crystallized at surface 32, and crystallization is axially graded from surface 32 to a substantial absence of crystallization in mid portion 28. The embodiments of FIGS. 7 and 8 are particularly useful for stabilizing only the sealing portion at the end of the container finish.

FIG. 9 illustrates a preform (or container) finish 22f in which first end portion 26 is essentially uncrystallized, while mid portion 28 and second end portion 30 are crystallized. Crystallization is graded axially between mid portion 28 and end portion 26, and is graded radially inwardly and axially downwardly from mid portion 28 radially inwardly of the capping flange.

5 FIG. 10 illustrates a finish 22g having an external snap bead rather than a external thread for securing a closure. First end portion 26 is crystallized throughout its thickness, and the upper part of mid portion 28 is crystallized at the outer surface where the closure-attachment bead is disposed. Crystallization is graded radially inwardly and axially downwardly from the upper part of mid portion 28, and second end portion 30, including the capping flange, is
10 essentially uncrystallized.

FIG. 11 illustrates implementation of the invention in a crown type finish 22h often used on beer bottles, for example. First finish portion 26, including the finish crown, is substantially crystallized throughout its thickness. The upper and outer surface portions of mid portion 28 are crystallized, while the radially inner part of mid portion 28 is graded axially
15 downwardly and radially inwardly. Second end 30 is essentially uncrystallized.

Although the preferred embodiments of the invention have been discussed in conjunction with crystallizing the finish of the preform, which is preferred for process handling purposes, it will be understood that the crystallization operation could take place in the neck finish after the container is blown to final form. Such a modification would be particularly useful
20 in situations in which the finish geometry is modified during the blow molding operation. Thus, crystallization in accordance with the present invention can be implemented on either amorphous or oriented finishes.

There has thus been described preforms, containers and methods of manufacture that fully implement all of the objects and aims previously set forth. The invention has been

disclosed in conjunction with a number of presently preferred embodiments, and several additional modifications and variations have been discussed. Other modifications and variations will readily suggest themselves to persons of ordinary skill in the art. The invention is intended to embrace all such modifications and variations as fall within the spirit and broad scope of the appended claims.

5

1.

1 A finish (22 or 22a or 22b or 22c or 22d or 22f or 22g or 22h) on a hollow plastic
2 container (20a) or preform (20) having an integral body (24a or 24),
3 said finish having a first end portion (26) with an end surface (32) spaced from said
4 body, a second end portion (30) adjacent to said body, and a mid portion (28) between said end
5 portions, said first end and mid portions forming continuous inner and outer surfaces (36, 34),
6 characterized in that said finish is crystallized at at least one of said end, inner and
7 outer surfaces, and crystallization in said finish in a direction perpendicular to said at least one
8 surface is graded from crystallization at said at least one surface to an essential absence of
9 crystallization at a position within said finish spaced from said at least one surface.

2.

1 The finish set forth in claim 1 wherein one of said inner and outer surfaces (36, 34)
2 is crystallized throughout its length and the other of said inner and outer surfaces includes at least
3 a portion that is essentially uncrystallized, and wherein crystallization in at least said mid portion
4 of said finish is graded between said crystallized surface and the uncrystallized portion of the other
5 surface.

3.

1 The finish set forth in claim 2 wherein said outer surface (34) is crystallized
2 throughout its length and at least a portion of said inner surface (36) is crystallized.

4.

1 The preform set forth in claim 2 wherein said inner surface (36) is crystallized
2 throughout its length and said outer surface (34) is essentially uncrystallized.

5.

1 The preform set forth in claim 1 having a capping flange at said second end portion
2 (30) of said finish, said capping flange being essentially uncrystallized.

6.

1 The finish set forth in claim 1 wherein said first end and mid portions form a
2 continuous outer surface (34) that is crystallized throughout its length, and a continuous inner
3 surface (36) at least a portion of which is essentially uncrystallized, and wherein crystallization
4 in at least said mid portion (28) of said finish is graded between said outer and inner surfaces and
5 between said mid portion and said second end portion.

7.

1 The finish set forth in claim 1 wherein at least said first end portion (26) of said
2 finish is crystallized, and crystallization in said finish is graded from crystallization at said first end
3 portion.

8.

1 The finish set forth in claim 3, 6 or 7 wherein said first end portion (26) of said
2 finish is crystallized throughout its thickness between said inner and outer surfaces (36, 34).

9.

1 The finish set forth in claim 8 wherein graded crystallization in said finish extends
2 into said mid portion (28) of said finish.

10.

1 The finish set forth in claim 3, 6 or 7 wherein crystallization in said first end
2 portion (26) of said finish is graded between said outer and inner surfaces (36, 34), being
3 crystallized at said outer surface (34) and essentially uncrystallized at said inner surface (36).

11.

1 The finish set forth in claim 7 wherein said first end and mid portions (26, 28) of
2 said finish form a continuous outer surface (34) and a continuous inner surface (36), one of said
3 inner and outer surfaces being crystallized throughout its length and the other of said inner and
4 outer surfaces including at least a portion that is essentially uncrystallized.

12.

1 The finish set forth in claim 11 wherein crystallization in at least said mid portion
2 (28) of said finish is graded between said surfaces.

13.

1 A method of making a hollow plastic container (24a), which includes the steps of:

2 (a) molding a preform (20) at least partially of crystallizable polymer
3 construction including a finish (22) and a body (24) integral with said finish, said finish having a
4 first end portion (26) remote from said body, a second end portion (30) adjacent to said body, and
5 a mid portion (28) between said end portions, said first end and mid portions forming continuous
6 inner and outer surfaces,

7 (b) blow molding said preform to form a hollow plastic container (20a), and

8 (c) either prior to or subsequent to said step (b), crystallizing said finish
9 characterized in that said step (c) is carried out in such a way that at least said first
10 end portion of said finish is crystallized, and crystallization in said finish is graded from
11 crystallization of said first end portion.

14.

1 The method set forth in claim 13 wherein said step (c) includes crystallizing said
2 finish at one of said inner and outer surfaces (36, 34) in such a way that said one surface is
3 crystallized throughout its length and the other of said inner and outer surfaces includes a portion
4 that is essentially uncrystallized, and such that crystallization in at least said mid portion (28) is
5 graded between said surfaces.

15.

1 The method set forth in claim 13 wherein said step (c) includes crystallizing said
2 finish in such a way that said outer surface (34) is crystallized throughout its length and at least
3 a portion of said inner surface (36) is essentially uncrystallized, and such that crystallization in at
4 least said mid portion (28) of said finish is graded between said outer and inner surfaces and
5 between said mid portion and said second end portion (30).

16.

1 A finish (22 or 22a or 22b or 22c or 22d or 22e or 22g or 22h) on a hollow plastic
2 container (20a) or preform (20), said finish being at least partially of crystallizable polymer
3 construction and being coupled to a body (24a or 24) integral with said finish,
4 said finish having an end portion (26) remote from said body, a capping flange
5 adjacent to said body, and a mid portion (28) between said end portion and said capping flange,
6 at least a portion of said end portion (26), said mid portion (28) or both said end
7 portion and said mid portion being crystallized,
8 characterized in that said capping flange is essentially free of crystallization.

17

1 The finish set forth in claim 16 wherein at least a portion of said crystallization is
2 graded.