Synthetic resin bottle having a gradation pattern, and process for injection molding the preform for use in such a bottle

Title

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Related Art
EP 1332861
SYNTHETIC RESIN BOTTLE HAVING A GRADATION PATTERN, AND
PROCESS FOR INJECTION MOLDING THE PREFORM FOR USE IN
SUCH A BOTTLE

Abstract

A process for molding a preform for use in biaxial drawing and blow
molding comprises: giving a primary injection (J1) of colored resin (32) in the state
of a short shot to cavity (4) of mold (1) by way of gate (5) located at a position
opposed to the center of bottom (107); after a lapse of waiting time (Ht) from end
point of the primary injection (J1), giving successively a secondary injection (J2) of
main resin (31), i.e., the major material forming the preform; adjusting this waiting
time so that the main resin from the secondary injection is allowed to flow through
the cavity in a manner in which the main resin penetrates central part of the colored
resin located inside the cavity (4) of the mold (1) in the short shot state; forming
colored resin layers made of the colored resin in the shape of double cylinders at
positions near the inner surface and outer surface of the preform; and thus forming
color-gradated portions (110) where the thickness of colored resin layers are reduced
in the upward direction of the preform.
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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

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Invention Title: Synthetic resin bottle having a gradation pattern, and process for injection molding the preform for use in such a bottle

The following statement is a full description of this invention, including the best method of performing it known to me/us:

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SYNTHETIC RESIN BOTTLE HAVING A GRADATION PATTERN, AND PROCESS FOR INJECTION MOLDING THE PREFORM FOR USE IN SUCH A BOTTLE

TECHNICAL FIELD

This invention relates to a synthetic resin bottle decorated with a gradation pattern, and to a process for injection molding the preform to be biaxially drawn and blow molded into this bottle.

BACKGROUND ART

Bottles made of the polyethylene terephthalate (PET) resin are utilized in various fields, including drinks, foods, and cosmetics. Methods of decorating the bottles are also wide-ranging with an intention to differentiate the merchandise. In many cases, bottles are decorated with printed shrink film. Patent document 1 describes a bottle obtained by blow-molding a preform having a laminar structure in which a colored intermediate layer has been formed intermittently.

-Inventors of this invention worked on the development of a technology for bottle decorations by changing color density in the upward or downward directions in a biaxially drawn, blow-molded transparent bottle made of a PET resin to create color gradations caused by a change in color density. It was found from their tests that the process described in the patent document 1 was unsatisfactory from a point of view of decorativeness because gradations in color were limitative, though possible, when a preform was provided with the intermediate layer of a colored resin and was biaxially drawn and blow molded into the bottle.

More specifically, the colored resin layer in the above-described conventional technology has a structure in which its thickness is increased or decreased in a continued manner. The color gradation created as a color pattern is the gradation inside the color-decorated area formed by this colored resin layer. Therefore, it is difficult to put an emphasis on the gradation.
Especially in light colors, a problem arises from the difficulty in creating a gradation pattern.

As another problem, the flow of a molding resin material is widely changed when the material is injected into the mold by the injecting machine. Therefore, any increase or decrease in the thickness of the layer of an injected colored resin that has been formed inside the injecting machine is not always reflected on the change in the thickness of the layer of the colored resin formed inside the mold. For this reason, it is difficult to obtain a decoration based on the color gradation. Even if such a decoration is obtained, the form of color decoration is not constant, and it is quite difficult to commercialize a bottle having such a decoration.

Still another problem is that the control of the injecting machine operation is troublesome and difficult. The injecting behavior of a main resin is affected by the changes in the injection rate for the colored resin. Thus, it is necessary to precisely align the injecting behavior of the main resin with that of the colored resin. Such alignment is difficult.

The technical problem to be solved by the invention is to utilize a tendency of gradual decrease in the thickness of the layer of the colored resin caused by the flow of the main resin inside the preform mold when the main resin and the colored resin are injected into the mold and to change the thickness of the intermediate layer or the colored resin layer of the preform gradually in the upward or downward direction.

It is also a technical problem of this invention to form a preform having multiple colored layers of a laminar structure, in which each layer is made of a colored resin of a different color shade and to change the thickness of these colored layers gradually in the upward or downward direction.

**OBJECT OF THE INVENTION**

It is the object of the present invention to substantially overcome or ameliorate one or more of the disadvantages of the prior art.
SUMMARY OF THE INVENTION

According to an aspect of the present invention, there is disclosed a process for molding a preform for use in biaxial drawing and blow molding, which comprises:

- giving a primary injection of colored resin in the state of a short shot to cavity of mold by way of gate located at a position opposed to the center of bottom;

- after a lapse of waiting time from end point of the primary injection, giving successively a secondary injection of main resin, i.e., the major material forming the preform;

- adjusting this waiting time so that the main resin from the secondary injection is allowed to flow through the cavity in a manner in which the main resin penetrates central part of the colored resin located inside the cavity of the mold in the short shot state;

- forming colored resin layers made of the colored resin in the shape of double cylinders at positions near the inner surface and outer surface of the preform;

- thus forming color-gradated portions where the thickness of colored resin layers are reduced in the upward direction of the preform.

Preferably, extent of color gradation caused by the thickness of colored resin layers is controlled by a combination of the waiting time, the speed of secondary injection, and the injection pressure.

Preferably, the main resin that has been colored is used as the colored resin.

Preferably, the colored resin has a relatively low molten viscosity than that of the main resin.

Preferably, both the main resin and the colored resin are transparent resin materials.

Preferably, a preliminary injection of the main resin is given in a predetermined amount before the primary injection.

According to another aspect of the present invention, there is disclosed in the successive injection process in which multiple resins including at least one
colored resin are successively injected into cavity of mold by way of a gate located at a position opposed to the center of bottom, a process for injection molding a preform to be used in biaxial drawing and blow molding, which comprises:

- injecting initially a short shot of a colored resin into the cavity of the mold;
- then injecting a second resin and letting the second resin wedge its way through central part of the earlier injected colored resin to form laminated layers;
- and forming a color-gradated portion wherein thickness of the colored resin layer made of the colored resin injected earlier is gradually reduced toward the bottom.

Preferably, the extent of gradation associated with the thickness of the colored resin layer made of the previously injected colored resin is controlled by a combination of injection speed and pressure of the subsequently injected resin.

Preferably, the resins are successively injected in 3 steps.

Preferably, the colored resin to be injected earlier has a lower molten viscosity than the later injected resin has.

Preferably, each resin is transparent.

According to another aspect of the present invention, there is disclosed a preform for use in biaxial drawing and blow molding, which is a preform molded by the successive injection process, in which multiple resins including at least one colored resin are successively injected into a cavity of a mold by way of a gate located at a position opposed to the center of a bottom, wherein said preform has a color-gradated portion formed by a colored resin layer made of earlier injected colored resin, with thickness of the colored resin layer in this portion being gradually reduced toward the bottom by the flow action of a second resin that wedges its way through central part of the earlier injected colored resin.

According to another aspect of the present invention, there is disclosed a synthetic resin bottle obtained by biaxially drawing and blow molding a preform which is molded by the successive injection process in which multiple resins
including at least one colored resin are successively injected into a cavity of a mold by way of a gate located at a position opposed to the center of a bottom, said preform having a color-gradated portion formed by a colored resin layer made of earlier injected colored resin, with thickness of the colored resin layer in this portion being gradually reduced toward the bottom by flow action of a second resin that wedges its way through central part of the earlier injected colored resin, wherein said bottle is decorated with color gradations created by gradual change toward the bottom in thickness of the colored resin layer made of the earlier injected colored resin and by subsequent change in color density, color shade, or both, which is caused to occur in a continuous manner.

Preferably, gradations are created by the continuous and gradual changes in color density and color shade that occur in three colored resin layers made of three differently colored resins.

There is also disclosed a process for injection molding a preform in the shape of a test tube to be used in biaxial drawing and blow molding, which comprises:

flowing molten synthetic resins through at least three layer-forming channels consisting of a cylindrical inner flow channel, a middle flow channel, and a cylindrical outer flow channel;

flowing the resins through a confluence disposed downstream of these layer-forming channels and through a joined flow channel;

passing the resins through a gate disposed at a position opposed to center of bottom; and

injecting the resins into mold to form a preform;

and which also comprises:

supplying the inner flow channel and the outer flow channel with a main resin for the preform from at least one loader at a predetermined time span, pressure, or velocity;
supplying the middle flow channel with a colored resin from another loader at a predetermined pressure and/or velocity during a predetermined time within said time span;

allowing the colored resin to join the main resin from the inner flow channel and the outer flow channel at a confluence in such a manner that the layer of colored resin is sandwiched between the two layers of the main resin;

forming a multi-layered molten resin fluid having an intermediate layer of the colored resin between the layers of main resin within the joined flow channel over a certain span of time;

adjusting injection pattern including the time of starting and ending the supply of colored resin, pressure and/or velocity profiles; and

reducing the thickness of this intermediate layer at an upstream or downstream point of the flow gradually in the upstream or downstream direction so as to form a color-gradated portion caused by the change in thickness.

Preferably, the middle flow channel is also disposed coaxially as a cylindrical channel together with the inner and outer flow channels.

Preferably, supply pressure and/or velocity is gradually reduced at the time when the supply of the colored resin comes to an end, so that a color-gradated portion is formed at the upstream end of the intermediate layer.

Preferably, the colored resin is allowed to remain in the vicinity of the confluence where the colored resin joins the main resin, at the time when the supply of the colored resin comes to an end and wherein this remaining colored resin is dragged by the flow of the main resin in the downstream direction to form a color-gradated portion at the upstream end of the intermediate layer.

Preferably, the supply pressure and/or velocity is gradually increased at the time when the supply of colored resin is started, so that a color-gradated portion is formed at the downstream end of the intermediate layer.

Preferably, the colored resin has a molten viscosity that is lower than the viscosity of the main resin so that the intermediate layer of the multi-layered molten
resin fluid is deformed to assume the shape of a gradually narrowing thread at either upstream or downstream end.

Preferably, a valve to open or close the colored resin channel is disposed between the colored resin loader and the middle flow channel and wherein the color-gradated portion is formed at either downstream or upstream end of the intermediate layer of the multi-layered molten resin fluid, depending on the type of this valve or the switching method.

Preferably, use is made of two loaders and three layer-forming channels consisting of the inner flow channel, the middle flow channel, and the outer flow channel, wherein the main resin from one loader is supplied to both the inner flow channel and the outer flow channel, and wherein the colored resin, i.e., colored main resin, from the other loader is supplied to the middle flow channel.

Preferably, both the main resin and the colored resin are transparent materials.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred form of the present invention will now be described by way of example with reference to the accompanying drawings wherein:
Fig 1 is an overall view of the bottle in the first embodiment of this invention, with a part of the wall layer shown in an enlarged vertical section.

Fig. 2 is a front elevational view of the preform in the first embodiment of this invention, with the irregularly cut right half portion being shown in a vertical section.

Fig. 3 is a front elevational view of the preform in the second embodiment of this invention, with the irregularly cut right half portion being shown in a vertical section.

Fig. 4 is an overall view of the bottle in the second embodiment of this invention, which is obtained by biaxially drawing and blow molding the preform of Fig. 3.

Fig. 5 is a front elevational view of the preform in the third embodiment of this invention with the irregularly cut right half portion shown in a vertical section.

Fig. 6 is an overall view of the bottle in the third embodiment of this invention, which is obtained by biaxially drawing and blow molding the preform of Fig. 5.

Fig. 7 is a vertical section showing an example of multiple nozzle section to be used in the molding process of this invention.

Fig. 8 is a vertical section showing the multiple nozzle section of Fig. 7 in the state in which a hot runner block has been fitted to this section.

Fig. 9 is an explanatory diagram showing the first example of the injection pattern for molding the preform of this invention.

Fig. 10 is an explanatory diagram showing the steps of filling the mold cavity with molten resins in the injection pattern of Fig. 9.

Fig. 11 is a front elevational view of the preform in the fourth embodiment of this invention, molded according to the injection pattern of Fig. 9, with a part being shown in the vertical section.

Fig. 12 is a front elevational view of the bottle in the fourth embodiment of this invention, obtained by biaxially drawing and blow molding the preform of Fig. 11.

Fig. 13 is an explanatory diagram showing the second example of the injection pattern for molding the preform of this invention.

Fig. 14 is a front elevational view of the preform in the fifth embodiment, molded according to the injection pattern of Fig. 13, with a part being shown in the vertical section.

Fig. 15 is a front elevational view of the bottle in the fifth embodiment, obtained by biaxially drawing and blow molding the preform of Fig. 14.
Fig. 16 is a schematic explanatory diagram showing the third example of the injection pattern for molding the perform of this invention.

Fig. 17 is a vertically-sectional front elevational view showing an example of the mold for use in the preform molding.

Fig. 18 is a cross-sectional plan view taken along the line A-A in Fig. 17.

Fig. 19 is a schematic explanatory diagram showing the process steps of filling the mold cavity with molten resins according to the injection pattern of Fig. 16.

Fig. 20 is a front elevational view of the preform in the sixth embodiment of this invention, molded by the injection pattern of Fig. 16, with a part shown in a vertical section.

Fig. 21 is a front elevational view of the bottle in the sixth embodiment, obtained by biaxially drawing and blow molding the preform of Fig. 20.

Fig. 22 is a schematic diagram showing the fourth example of the injection pattern for molding the perform of this invention.

Fig. 23 is a schematic diagram showing the fifth example of the injection pattern for molding the perform of this invention.

Fig. 24 is a series of schematic diagrams showing the steps of filling the mold cavity with molten resins according to the injection pattern of Fig. 23.

Fig. 25 is a front elevational view of the preform in the seventh embodiment of this invention, molded by the injection pattern of Fig. 23, and shown partly in vertical section.

Fig. 26(a) is a front elevational view of a bottle in the seventh embodiment of this invention, obtained by biaxially drawing and blow molding the preform of Fig. 25. Fig. 26(b) is a vertical section of bottle wall, partly enlarged in the lateral direction.

EXPLANATION OF CODES

1. Mold
2. Core mold
3. Cavity mold
4. Cavity
5. Gate
11. Multiple nozzle section
12a. Feed channel for the main resin
12b. Feed channel for the colored resin
14a1, 14a2, 14b. Manifold
15. Inner flow channel
16. Middle flow channel
17. Outer flow channel
18. Confluence
19. Joined flow channel
20. Shut-off pin
21. Hot runner block
   22a. Main resin feed port
   22b. Colored resin feed port
23a. Main resin channel
   23b. Colored resin channel
25. Check valve
   A. Main resin loader
   B. Colored resin loader
31. Main resin
32 (32f, 32s, 32t). Colored resin
32a, 32b, 32fa, 32fb. Mold surface vicinity
32c, 32fc. Central part of the cavity
33. Forefront
101. Preform
102. Main resin layer
20 103 (103f, 103s, 103t). Colored resin layer
   103e. Thick end
   103d. Downstream end
   103u. Upstream end
   103m. Intermediate layer
25 104. Neck
105. Neck ring
106. Body
107. Bottom
108. Downstream end
30 109. Upstream end
   110 (110f, 110s). Color-gradated portion
   110a. Base
   201. Bottle
202. Main resin layer
35 203 (203f, 203s, 203t). Colored resin layer
   203e. Thick end
   203m. Intermediate layer
204. Neck
205. Neck ring
40 205a. Shoulder
PREFERRED EMBODIMENTS OF THE INVENTION

This invention is further described with respect to the preferred embodiments of the preform-molding process, the preform, and the bottle, now referring to the drawings. The first embodiment (Fig. 2), the second embodiment (Fig. 3), and the third embodiment (Fig. 5) of the preform of this invention, as well as the first embodiment (Fig. 1), the second embodiment (Fig. 4), and the third embodiment (Fig. 5) of the bottle of this invention, are described, referring to Figs. 1 to 6.

Fig. 1 is an overall view of the bottle 201 in the first embodiment of this invention, with a part of the wall layer shown in an enlarged vertical section, which bottle has been biaxially drawn and blow molded from the preform in the first embodiment of this invention. The bottle 201 comprises a body 206 in a bottomed cylindrical shape, shoulder 205a at the upper end of the body 206, and a neck 204 having screw thread notched on the outer peripheral wall and having a brim-like neck ring 205 at the lower end of the neck 204. The lower half of the body 206 has a laminar structure in which the main resin layer 202 is laminated with the colored resin layer 203. The area at the upper end of the color-decorated portion 209 created by the colored resin layer 203 in the lower half of the body 206 is the color-gradated portion 210 created in the thin boundary area 203e.

As shown in the embodiment of Fig. 1, the color-gradated portion 210 is disposed in the central area of the body 206, and the gradated decoration is quite effectively displayed.
Fig. 2 is a front elevational view of the preform 101 in the first embodiment of this invention, with about a half shown irregularly in a vertical section. This preform 101 comprises a cylindrical body 106 closed at its lower end by a semi-spherical bottom 107 having a gate imprint at the bottom center and a cylindrical neck 104 having a screw thread notched on the outer peripheral wall and having a brim-like neck ring 105 at the boundary between the neck 104 and the body 106. The colored resin layer 103 is formed by a colored resin when a clear and colorless main resin and a clear and colored resin are injected. The thin boundary area 103e is designed to take a position on the body 106 at the upper end of the colored resin layer 103.

The lower end of the colored resin layer 103 is slightly reduced in thickness, but since the lower end is disposed at the bottom 107, this portion does not serve as a color-decorated portion in the overall appearance of the bottle 106. Since the bottom 107 of the preform 101 is hardly drawn and deformed, it is kept from accelerated wall thinning movement caused by the elongational deformation. Thus, the bottom 107 has no effective function as a decorative portion.

Fig. 3 is a front elevational view of the preform 101 in the second embodiment of this invention, with about a half shown irregularly in a vertical section. The second embodiment is similar to the first embodiment in its basic structure, but the preform 101 is injected in the order of a main resin, a colored resin, and again the main resin. By setting the injection rates of the first main resin and the colored resin, it is possible to set the positions of both the upper and lower end portions of the colored resin layer 103, and especially the position of the thin boundary area 103e that is the upper end portion of the colored resin layer 103 on the body 106.

In this second embodiment, the colored resin layers 103 are formed on both the outer and inner peripheral wall surfaces of the body 106. The colored resin layer 103 on the outer surface is not covered by the main resin layer 102, but is laid in the exposed state. As a result, even if the same colored resin is used, the second embodiment gives stronger expression of color than the first embodiment does.

Fig. 4 is an overall front elevational view of the bottle 201 of this invention, made from the preform 101 shown in Fig. 3. The color-decorated portion 209 derived from the colored resin layer 103 of the preform 101 is created in the lower half of the molded body 206. A color-gradated portion 210
is formed at the upper end of the color-decorated portion 209 to show the decorative effect of color gradation in that area where the color density gradually becomes light in the upward direction.

Fig. 5 is a front elevational view of the preform 101 in the third embodiment of this invention. The colored resin layer 103 extends from the upper end face of the neck 104, i.e., the upper end of the preform 101, to the central portion of the body 106 where there is the thin boundary area 103e in the lower end portion of the colored resin layer 103.

In the third embodiment of the preform 101, the thin boundary area 103e is accurately positioned on the body 106 by setting the timing of injecting the colored resin.

Fig. 6 is an overall front elevational view of the biaxially drawn, blow-molded bottle 201 in the third embodiment, made from the preform 101 shown in Fig. 5. The color-decorated portion 209 derived from the colored resin layer 103 of the preform 101 is created in the upper half of the bottle 201 thus molded. The color-gradated portion 210 is disposed at the lower end of the color-decorated portion 209 at the center of the body 206 where the color density becomes light in the downward direction. Thus, the color-decorated portion 209 created on the bottle 201 takes the position that is upside-down from that of the bottle 201 in the embodiment shown in Fig. 4.

Reference is made to Figs. 7 to 15 to describe the injection molding device (Figs. 7 and 8) involved in the preform-molding process of this invention, the first example (Figs. 9 and 10) and the second example (Fig. 13) of the injection molding pattern used with this device, the preform 101 in the fourth embodiment (Fig. 11) of this invention and the bottle 202 in the fourth embodiment (Fig. 12), the preform 101 in the fifth embodiment (Fig. 14) and the bottle 202 in the fifth embodiment (Fig. 15), all of which are molded by this injection molding pattern. The first and second examples of the injection molding pattern relate to a simultaneous molding process in which the main resin and the colored resin are injected at the same time.

Figs. 7 and 8 schematically show an example of the injection molding device to be used in the preform molding process of this invention. Fig. 7 is a vertical section showing an example of multiple nozzle section 11, which shows mold 1 fitted to the downstream side of this section. Fig. 8 is a vertical section showing the multiple nozzle section 11 of Fig. 7 in the state in which a hot
runner block 21 has been fitted to the upstream side of this section.

Main resin is fed into the feed port 22a from the main resin loader A and is passed through the main resin channel 23a inside the hot runner block 21. Colored resin is fed into the feed port 22b from the colored resin loader B and is passed through the colored resin channel 23b. These resins are supplied to the multiple nozzle section 11 at a predetermined timing, are joined together in the multiple nozzle section 11, and are allowed to fill the cavity 4 of the mold 1.

Each of the above-described resin loaders A and B is provided with an extruder of the screw type or an accumulator having a plunger fitted to the head of the extruder.

A check valve 25 is disposed in the colored resin channel 23b near the connection to the multiple nozzle section 11, and this check valve has a backflow prevention function by the action of a ball valve. This check valve 25 can also be installed inside the multiple nozzle section 11.

Inside the multiple nozzle section 11 there are three cylindrical layer-forming channels of inner flow channel 15, middle flow channel 16, and outer flow channel 17, which are concentrically disposed from inside to outside. The main resin is passed through the main resin channel 23a and a main resin feed channel 12a connected to the main resin channel 23a, and is distributed between the inner flow channel 15 and the outer flow channel 17 through two manifolds 14a1 and 14a2, respectively. The colored resin is passed through the colored resin channel 23b and a colored resin feed channel 12b connected to the colored resin channel 23b, and is sent to the middle flow channel 16 through a manifold 14b.

At the confluence 18, the colored resin from the middle flow channel 16 is flowed between main resin layers from the inner flow channel 15 and the outer flow channel 17. A multi-layered molten resin fluid is formed concentrically within the joined flow channel 19, with the colored resin being sandwiched as the intermediate layer between the main resin layers over a certain time span. The joined fluid is injected into cavity 4 of the mold 1 to fill the cavity.

Figs. 9-12 show in a series the preform-molding process described in Figs. 7 and 8, the preform obtained by this process, and the bottle obtained by
biaxially drawing and blow molding the preform. Fig. 9 is a schematic diagram showing the first example of the injection pattern to be used in the preform-molding process of this invention employing the molding device described above, taking time as the horizontal axis and injection pressure as the vertical axis. Fig. 10 includes schematic diagrams showing the resin flow movement in the cavity 4 caused by this injection pattern. This invention will be described below, using as an example a PET resin as the main resin and the same PET resin colored with a pigment as the colored resin.

This injection pattern is one of the so-called simultaneous injection molding patterns. The main resin is injected at a certain pressure for a predetermined time span (from point C to point D). The colored resin is injected alongside with the main resin at a certain pressure for a certain period of time (from point E to point F) within this predetermined time span. In this embodiment, the injection of both resins starts at the same time, and the injection of colored resin comes to an end on the way at point F.

Figs. 10(a), 10(b), and 10(c) show the flow state at points F, M, and D, respectively. At point F, approximately a third of the cavity 4 has been filled, and the fluid in the laminar structure has been formed by the intermediate layer 103m of the colored resin, which is sandwiched between inner and outer layers 102 of the main resin. Since the supply of colored resin starts at point E simultaneously with the supply of the main resin which starts at point C, the downstream end 103d of the intermediate layer 103m of the colored resin is positioned at the forefront of the fluid. (See Fig. 10(a)).

The supply of colored resin is stopped at point F, and from that point on, only the main resin is supplied. At that time, a part of the colored resin remaining near the confluence 18 of the middle flow channel 16 is pulled by the flow of the main resin coming from the inner flow channel 15 and the outer flow channel 17. As a result, the thickness of the intermediate layer 103m is reduced slowly so that the intermediate layer 103m has the shape of a gradually narrowing thread extending in the upstream direction at the upstream end 103u, as shown in Fig. 10(b). When only the main resin is further supplied, the preform thus obtained takes the shape shown in Fig. 10(c) at point D.

In the case of the device shown in Fig. 8, a check valve 25 having a back-flow prevention function by means of a ball valve is disposed between the colored resin feed channel 12b and the colored resin channel 23b (See Fig. 8).
If the supply of colored resin from the resin loader B is stopped, then the ball of this check valve 25 moves in a moment and works to block the flow channel. As a result, the pressure of the colored resin inside the colored resin feed channel 12b drops in a short period of time, and the supply of colored resin to the confluence 18 comes to an end. The colored resin near the confluence 18 inside the middle flow channel 16 deforms and extends and moves to the joined flow channel 19, passing through the confluence 18. The joined resin flows into the cavity 4. As shown in Fig. 10(b), the thickness of the intermediate layer 103m is reduced at the upstream end 103u in the upward direction to assume the shape of a gradually narrowing thread.

This check valve 25 enables the colored resin to be stopped with high precision as previously determined for each shot. Thus, the colored resin can be formed into the intermediate layer 103m at a predetermined location of the preform at predetermined distribution of layer thickness. From the viewpoint of precision in each shot, the colored resin should not have a long channel from the check valve 25 to the confluence 18, but preferably should be as short as possible. If the channel were long, it would take much time for the pressure transmission, or the pressure would be deviated greatly because of a viscoelastic effect of the resin.

If a valve used does not work at once but has time lag to shut off the channel completely, as is the case with spool valve, then gradation caused by the change in thickness will show a different pattern. The injection pattern can be combined with the valve type and the switching pattern arbitrarily to form various gradation patterns for any purpose.

Fig. 11 is a front elevational view of the preform 101 in the fourth embodiment of this invention that has been molded by the injection pattern of Fig. 9, using the device of Figs. 7 and 8, with a part of the preform shown in a vertical section. The intermediate layer 103m of colored resin spreads over the entire wall, due to a fountain flow effect, at the upper end of the neck 104. The intermediate layer 103m has roughly the same thickness in the height range, h1, from the neck 104 to the upper portion of the body 106. On the contrary, in the height range, h2, beneath h1, down to a level near the bottom 107, the layer thickness decreases to assume the shape of a gradually narrowing thread, thus forming a color-gradated portion 110 caused by the change in thickness of the intermediate layer 103m.
In this embodiment, the color-gradated portion 110 has the length, L, of 54 mm (with the total length of the preform 101 being 100 mm). At the base level 110a of the color-gradated portion 110, the intermediate layer 103m has the thickness, t1, of 0.9 mm. As an index for the extent of color gradation, the preform has an L/t1 of 60. This embodiment was successful in accomplishing a new type of color gradation caused by the change in layer thickness to assume the gradually narrowing thread shape.

Fig. 12 shows the bottle 201 having the cylindrical body 206, which has been biaxially drawn and blow molded from the preform 101 of Fig. 11. The bottle is deeply colored in the height range h1 from the top of the neck to the level beneath the neck ring 205. In the height range h2, below h1 where color is dark, the extent of coloration changes slowly to the colorless, transparent state to form a color-gradated portion 210. The bottom 207 and its neighborhood are a clear colorless area.

In the preform 101 of Fig. 11, the intermediate layer 103m has an almost uniform thickness in the upper portion of the body 106 in the height range h1. This portion corresponds exactly to the shoulder 205a of the bottle 201. Because the lateral draw ratio increases gradually in the downward direction in the shoulder 205a, the color-gradated portion 210 also includes this shoulder 205a of the bottle 201.

Like Figs. 9-12, Figs. 13-15, too, show in a series the preform-molding process described in Figs. 7 and 8, the preform obtained by this process, and the bottle obtained by biaxially drawing and blow molding the preform.

Fig. 13 is a schematic diagram showing the second example of the injection pattern to be used in the preform-molding process of this invention. This injection pattern is also one of the simultaneous injection patterns. The main resin is injected at a predetermined pressure in a specified time span (from point C to point D). The colored resin is injected alongside with the main resin at a certain pressure for a certain period of time (from point E to point F) within this time span (from point C to point D).

Fig. 14 is a front elevational view of the preform 101 in the fifth embodiment of this invention that has been molded by the injection pattern of Fig. 13, with a part shown in a vertical section. The intermediate layer 103m has roughly the same thickness in the height range h1, starting from the lower portion of the body 106. In the height range h2, above h1, the thickness
decreases in the shape of a wedge in the upward direction, thus forming a color-gradated portion 110 caused by the change in thickness.

This color-gradated portion 110 is presumably formed in the neighborhood of the confluence at point E where the injection of colored resin begins as shown in the injection pattern of Fig. 13. At point E, the colored resin starts being brought in through the middle flow channel 16. When the colored resin flows in between the layers of main resin coming from the inner flow channel 15 and the outer flow channel 17, the forefront is found to assume the shape of a wedge.

Fig. 15 shows the bottle 201 having the cylindrical body 206 in the fifth embodiment of this invention, which has been obtained by biaxially drawing and blow molding the preform 101 of Fig. 14. In the height range h1, the body wall is colored almost uniformly. In the height range h2, the coloration gradually changes to the colorless and transparent state, and forms the color-gradated portion 210. In the area above the height range h2, the wall is colorless and clear.

The extent of color gradation of the bottle 201 in the fifth embodiment described above does not change so gradually as in the fourth embodiment. However, the change in thickness of the intermediate layer 103m in the color-gradated portion 110 of the preform 101 can be made more gentle as by giving the colored resin a lower level of viscosity than the main resin, by raising the pressure further gradually at point E of the injection pattern, or by employing a check valve that can be opened gradually.

Reference was made to Figs. 7-15 to describe the preform-molding process related to the simultaneous injection molding, and the embodiments of the preform and the bottle. But it is to be understood by those skilled in the art that this invention is not limited to these embodiments. The synthetic resin to be used in this invention is not limited to the PET resin, but it is also possible to utilize the PP resin and the like, which have been used in conventional biaxially drawn, blow molded bottles. The molten viscosity of the colored resin can be changed for any purpose. The resins used in this invention need not necessarily be of the same type, but other types of resins can also be used. For example, a resin having a high gas barrier property, such as a nylon resin, can be utilized as the colored resin to provide a bottle having the high gas barrier property, in addition to the sophisticated decorations caused by color gradation.
In the foregoing description of preferred embodiments shown in Figs. 7-15, the color-gradated portion was formed at either upstream or downstream end. However, depending on the purpose, it is also possible to form the color-gradated portions at both ends. Even multiple color-gradated portions can be formed in the upward and downward directions of the bottle, by injecting colored resins intermittently more than once within the predetermined time span, in which the main resin is injected. The above-described embodiments employed a molding device provided with a multiple nozzle section that passes 2 resin groups through 3 layer-forming channels. Another middle flow channel can be added for use by an additional intermediate layer. Colored resins of different colors can be supplied to these two middle flow channels to form color-gradated portions having different colors on the upstream and downstream sides or to superimpose the colors. It should be noted here that the main resin is not limited to colorless, transparent materials, but can be colored and transparent or opaque, depending on the purpose.

The middle flow channel for the colored resin is not limited to a cylindrical shape, but the cross-section may have the shape of a thin rectangle. In this case, the bottle is decorated with the intermediate layer having vertical strips of color-gradated portion in a predetermined area of the bottle.

Now reference is made to Figs. 16-22 to describe the third example (Figs. 16 and 19) and the fourth example (Fig. 22) of the injection molding pattern, the preform in the sixth embodiment (Fig. 20) of this invention molded by the third example of the injection molding pattern, and the bottle 201 in the six embodiment (Fig. 21) obtained by biaxially drawing and blow molding this preform 101. The third and fourth examples of the injection molding pattern are used in the successive molding process in which the main resin and the colored resin are injected successively.

Fig. 16 is a schematic explanatory diagram showing the third example of the successive injection pattern to be applied to the preform-molding process of this invention. Figs. 17 and 18 are sectional views of the mold used in the preform-molding process of this invention.

The mold 1 shown in Figs. 17 and 18 comprises a core mold 2 and a cavity mold 3, which are combined with each other to form a cavity 4 in the shape of a test tube. A gate 5 is disposed at the position opposed to the central part of bottom 107 of the preform 101 (See also Fig. 20). Molten resins are
supplied from this gate 5, and are injected into the central part of bottom 107 (See also Fig. 16) of the preform 101 according to the injection pattern shown in Fig. 16. The injected resins move thorough the cavity 4 toward the portion corresponding to the neck 104 to fill the cavity 4.

Fig. 16 schematically shows an example of the successive injection pattern. The primary injection J1 of the colored resin 32 is given for a period ranging from t1 to t2. After a lapse of waiting time Ht ranging from t2 to t3, the secondary injection J2 of the main resin 31 is given successively for a period ranging from t3 to t5.

Figs. 19(a), 19(b), and 19(c) are schematic diagrams showing the conditions of resins at time points t2, t4, and t5, respectively, of the above-described injection pattern. At point t2, about a fourth of the cavity 4 upward from the bottom has been filled with a short shot of colored resin 32 (See Figs. 17, 18, and 19(a)).

Then, the supply of colored resin is brought to a halt at point t2 under the above-described filling condition. With the progress of the waiting time Ht (from t2 to t3), the short shot of the injected colored resin 32 starts to cool on the surfaces and in the vicinities of the cavity mold 3 and the core mold 2 (32a, 32b) (See an enlarged view in Fig. 8), and the cooling/solidification of the resin or an increase in the molten viscosity goes on in these parts.

The secondary injection J2 of the main resin 31 is successively given under this cooled condition. As schematically shown in Fig. 19(b), the main resin 31 in the molten state is passed through the gate 5 located at the position opposed to the center of the bottom 107 of the preform 101 and through the high-temperature portion of the colored resin 32 in the central part 32c of the cavity 4 (See the enlarged view of the cavity in Fig. 18). Then, the main resin 31 breaks through the forefront 33 of the colored resin 32, and goes on to move toward the portion corresponding to the upper part of the neck 104 (See outline arrows in Fig. 19(b)), while deforming and dragging a part of the colored resin 32 together. The main resin 31 further flows in and goes into the state shown in Fig. 19(c) at point t5.

At that time, the colored resin 32 located quite near the mold surfaces hardly flows, but remains at the position of primary injection J1. On the other hand, the colored resin 32 located at the center 32c deforms and flows as it is dragged in the flow direction. In this example, the main resin 31 breaks
through the forefront 33 of the colored resin 32, as shown in Fig. 19(b), but the forefront 33 need not be necessarily broken through. Depending on the purpose of decoration, the main resin 31 can be flowed without breaking through the forefront 33.

Fig. 20 is a front elevational view, with partly a vertical section, of the preform 101 in the sixth embodiment, molded by the above-described successive injection molding process, using the main resin 31 made of a PET resin and the colored resin 32 made of the same PET resin except that it is colored. This preform 101 has colored layers 103 in the shape of double cylinders in the inner- and outer-surface vicinities. The colored layers have an almost constant thickness in the height range h1 corresponding roughly to the lower half of the preform 101. In the height range h2, the thickness changes to assume the shape of a gradually narrowing thread, thus creating color-gradated portions 110 caused by reducing the thickness gradually in the upward direction.

Fig. 21 shows a bottle 201 having cylindrical body 206 in the sixth embodiment of this invention, which is obtained by biaxially drawing and blow molding the preform 101 of Fig. 20. The bottle is deeply colored in almost the same color density in the height range h1 from the bottom 207 to roughly half the body height. In the height range h2, above h1, up to the level directly beneath the neck ring 205, there appears a color-gradated portion 210 caused by the change in color density, where the extent of coloration changes slowly to the colorless, transparent state. The uppermost area including the neck 204 is a clear colorless area.

This invention has been described with respect to the preform-molding process involving the successive injection molding, and the preferred embodiments of the preform and the bottle while referring to Figs. 16-22, but it is to be understood by those skilled in the art that this invention is not limited to these embodiments. The synthetic resin to be used in this invention is not limited to the PET resin, but it is also possible to utilize the PP resin and the like, which have been used in conventional biaxially drawn, blow molded bottles. The molten viscosity of the colored resin can be changed for any purpose. The colored resin used in this invention need not necessarily be of the same type, but other types of resins can also be used. The main resin need not be colorless and transparent, but can be colored, and transparent, translucent, or opaque.
In addition to the injection pattern described in Fig. 16 and used in the successive injection molding, other injection patterns can be utilized for any purpose. Fig. 22 shows the fourth example of the injection pattern that can be applied to this invention. In this pattern, a preliminary injection $J_p$ of the main resin $31$ is given in a predetermined amount before the primary injection $J_1$. This preliminary injection $J_p$ of the main resin makes it possible to raise the lower end position of each colored resin layer $103$ in response to the injected amount of the main resin and to change the position of colored resin layers $103$, depending on the purpose of decoration for the bottle $201$, without limiting the lower end to the level shown in the embodiment of Fig. 20 where the lower end is set at the bottom $107$.

Furthermore, at the time of primary injection $J_1$ of colored resin after the preliminary injection $J_p$, the colored resin is forced to pass through the central part of a short shot of the main resin that has been injected preliminarily, while dragging this main resin over the mold surfaces. In this manner, both the outer surface (outermost layer) and the inner surface (innermost layer) can be configured with this main resin, depending on the condition of injection. Since the contents of the bottle do not come in direct contact with the colored resin, the user feels at ease in utilizing the bottle.

Reference is made to Figs. 23-25 to describe the fifth example of the injection molding pattern (Figs. 23), the preform $101$ in the seventh embodiment (Fig. 25) of this invention, which is molded according to the fifth example of the injection pattern, and the bottle $201$ in the seventh embodiment (Fig. 26) obtained by biaxially drawing and blow molding this preform $101$. The fifth example of the injection molding pattern is based on the successive molding process in which multiple resins are successively injected.

Fig. 23 is a schematic diagram explaining the fifth example of the successive injection pattern which is applied to the preform-molding process of this invention. The preform is molded by using the mold shown in Figs. 17 and 18.

The mold $1$ shown in Figs. 17 and 18 comprises a core mold $2$ and a cavity mold $3$. A cavity $4$ corresponding to the preform in the shape of a test tube is formed inside the mold $1$. Gate $5$ is located at the position opposed to the central part of bottom $107$ (See also Fig. 25.) of the preform $101$. Molten resins are supplied through this gate $5$ and are injected according to the
injection pattern shown in Fig. 23. The first injected resin flows through the cavity 4 toward the portion corresponding to the neck 104 to fill the cavity 4.

The injection pattern schematically shown in Fig. 23 is an example of the successive injection pattern, in which colored resins 32f, 32c, and 32t are successively injected into the cavity in 3 steps of primary J1 (from time t1 to time t2), secondary J2 (from time t2 to time t3), and tertiary J3 (from time t3 to time t4).

Figs. 24(a), 24(b), and 24(c) are schematic diagrams explaining the injection pattern at the time points of t2, t3, and t4, respectively. At point t2, a third of the cavity 4 has been filled with the colored resin 32f that was injected through the gate 5 in the state of a short shot (See Figs. 24(a)).

The primary injection J1 is brought to a halt at point t2 under the above-described filling condition, and the supply of the colored resin 32f is shut off. Then, the secondary injection J2 is subsequently started, and the colored resin 32s flows into the cavity 4 through the gate 5. The second resin 32s wedges its way through the central part of the first resin 32f, and moves through the cavity 4 toward the portion corresponding to the neck 104. At point t3 when the secondary injection J2 is brought to a halt, the two resins are in such a state as shown in Fig. 24(b).

As a result of the flow of the colored resin 32s that has been injected at the time of the secondary injection J2, the colored resin 32f from the primary injection J1 assumes the shape of double cylinders together with the colored resin 32s over the range of Wf1 shown in Fig. 24(b). In this range, the thickness of the colored resin 32f decreases gradually in the upstream direction (toward the position of the gate 5).

A tertiary injection J3 is then started subsequently, and a colored resin 32t flows into the cavity 4 through the gate 5. This time, the colored resin 32t wedges its way through the central part of the colored resin 32s and moves through the cavity 4 toward the portion corresponding to the neck 104. At point t4 when the tertiary injection J3 is brought to a halt, the three resins are in such a state as shown in Fig. 24(c).

As a result of the flow of the colored resin 32t that has been injected at the time of the tertiary injection J3, the colored resin 32s from the secondary injection J2 assumes the shape of double cylinders together with the colored
resin 32t over the range of $W_s$ shown in Fig. 24(c). In this range, the layer thickness of the colored resin 32s decreases gradually in the upstream direction. At the same time, the portion of the colored resin 32f in the double cylinders further extends over the range of $W_f2$.  

Fig. 25 is a front elevational view, partly a vertical section, of the preform in the seventh embodiment of this invention, in which the same PET resin has been used in the primary injection $J_1$, the secondary injection $J_2$, and the tertiary injection $J_3$, but in different colors: yellow, pale blue, and light red for the colored transparent resins 32f, 32s, and 32t, respectively. The preform 101 was molded by the successive molding process described above.

The preform comprises, from top to bottom, a yellow layer 103f, a pale blue layer 103s, and a light red layer 103t. In the height range $h_f$, the colored resin layer 103f assumes the shape of double cylinders, and forms a color-gradated portion 110f caused by the change in layer thickness, which is gradually reduced toward the bottom 107. In the height range $h_s$, the colored resin layer 103s also assumes the shape of double cylinders, and forms a color-gradated portion 110s caused by the change in layer thickness, which is gradually reduced toward the bottom 107.

Fig. 26(a) shows a bottle 2 having a cylindrical body 206 in the seventh embodiment of this invention, which was obtained by biaxially drawing and blow molding the preform 101 of Fig. 25. Fig. 26(b) is a vertical section of the body wall which has been partially enlarged in the lateral direction to explain the laminar structure of the colored resin layers 203. In the bottle 201, the laminated layers 203f, 203s, and 203t, which are colored respectively in yellow, pale blue, and light red, are the counterparts of the three colored resin layers 103f, 103s, and 103t of the preform 101 shown in Fig. 25, and are formed by biaxially drawing and blow molding the preform 101 of Fig. 25.

As a whole, the bottle 201 is transparent, but color gradations caused by the changes in color density and color shade have been created in the wall of the bottle 201. In more details, the area from the neck 204 to the shoulder 205a is yellow-colored and transparent. Gradations associated with color density appear in the shoulder 205a, with color density beginning to dilute downward because of the drawing that changes the wall thickness in the shoulder 205a. In the height range $h_1$, the yellow-colored layer 203f and pale blue colored layer 203s overlap, and the color changes in this body portion gradually from green to pale blue in the downward direction.
The height range h2 beneath the height range h1 corresponds to the area where the height range hs of the preform 101 was drawn. In this range h2, the pale blue colored layer 203s and the light red colored layer 203t overlap, and a purple color becomes more of a red color gradually in the downward direction. Although the yellow colored layer 103f also extends to the height range h2, the layer thickness is already quite thin, and there is little effect of 103f on the color shade. If the colored resins 32s and 32t were given a higher color density, then in the height range h1, for example, there would be a larger effect of the colored resin 32s, and the gradation caused by the shades of yellow and blue would not be created vibrantly. Therefore, in this embodiment, the colored resins 32s and 32t had a pale blue color and a light red color, respectively.

This invention has been described with respect to the preform-molding process of this invention involving the successive injection molding, and the preferred embodiments of the preform and the bottle while referring to Figs. 23-26, but it is to be understood by those skilled in the art that this invention is not limited to these embodiments.

The synthetic resins to be used are not limited to the PET resin, but those resins that are conventionally used in the biaxially drawn, blow molded bottles, such as the PP resins, can also be utilized. The molten viscosity of colored resins can be changed, depending on the purpose of use. The resins need not be of the same type, and the resins of other types can be used.

In the above-described embodiment, resins were injected successively in three steps. However, resins can also be injected in two or four steps, depending on the purpose. In the successive 3-step injections, various resins can be combined in addition to a combination of a colored transparent resin, a transparent resin of a different color, and a transparent resin of still another color. For example, combinations described below can be utilized.

1) A colorless transparent resin / A colored transparent resin / A colorless transparent resin
2) A colored transparent resin / A colorless transparent resin / A transparent resin of the same color
3) A colored transparent resin / A colorless transparent resin / A transparent resin of a different color
4) A colored transparent resin / A transparent resin of a different color / A colorless transparent resin
INDUSTRIAL APPLICABILITY

The preform-molding process of this invention can be used to provide a bottle having new decorativeness in which highly sophisticated gradations caused by the changes in color density, color shade, or both are created by the colored resin layer or layers. This process enables the bottle products to be differentiated from other bottle products, and therefore, wide use applications are expected.
The claims defining the invention are as follows:

1. A process for molding a preform for use in biaxial drawing and blow molding, which comprises:
   giving a primary injection of colored resin in the state of a short shot to cavity of mold by way of gate located at a position opposed to the center of bottom;
   after a lapse of waiting time from end point of the primary injection, giving successively a secondary injection of main resin, i.e., the major material forming the preform;
   adjusting this waiting time so that the main resin from the secondary injection is allowed to flow through the cavity in a manner in which the main resin penetrates central part of the colored resin located inside the cavity of the mold in the short shot state;
   forming colored resin layers made of the colored resin in the shape of double cylinders at positions near the inner surface and outer surface of the preform;
   and thus forming color-gradated portions where the thickness of colored resin layers are reduced in the upward direction of the preform.

2. The preform-molding process according to claim 1 wherein extent of color gradation caused by the thickness of colored resin layers is controlled by a combination of the waiting time, the speed of secondary injection, and the injection pressure.

3. The preform-molding process according to claim 1 or 2 wherein the main resin that has been colored is used as the colored resin.

4. The preform-molding process according to claim 1 or 2 wherein the colored resin has a relatively low molten viscosity than that of the main resin.

5. The preform-molding process according to any one of claims 1 to 4, wherein both the main resin and the colored resin are transparent resin materials.
6. The preform-molding process according to any one of claims 1 to 5, wherein a preliminary injection of the main resin is given in a predetermined amount before the primary injection.

7. In the successive injection process in which multiple resins including at least one colored resin are successively injected into cavity of mold by way of a gate located at a position opposed to the center of bottom, a process for injection molding a preform to be used in biaxial drawing and blow molding, which comprises:

- injecting initially a short shot of a colored resin into the cavity of the mold;
- then injecting a second resin and letting the second resin wedge its way through central part of the earlier injected colored resin to form laminated layers;
- and
- forming a color-gradated portion wherein thickness of the colored resin layer made of the colored resin injected earlier is gradually reduced toward the bottom.

8. The preform-molding process according to claim 7 wherein the extent of gradation associated with the thickness of the colored resin layer made of the previously injected colored resin is controlled by a combination of injection speed and pressure of the subsequently injected resin.

9. The preform-molding process according to claim 7 or 8, wherein the resins are successively injected in 3 steps.

10. The preform-molding process according to any one of claims 7 to 9, wherein the colored resin to be injected earlier has a lower molten viscosity than the later injected resin has.

11. The preform-molding process according to any one of claims 7 to 10, wherein each resin is transparent.

12. A preform for use in biaxial drawing and blow molding, which is a preform molded by the successive injection process, in which multiple resins including at least one colored resin are successively injected into a cavity of a mold
by way of a gate located at a position opposed to the center of a bottom, wherein
said preform has a color-gradated portion formed by a colored resin layer made of
earlier injected colored resin, with thickness of the colored resin layer in this portion
being gradually reduced toward the bottom by the flow action of a second resin that
wedges its way through central part of the earlier injected colored resin.

13. A synthetic resin bottle obtained by biaxially drawing and blow
molding a preform which is molded by the successive injection process in which
multiple resins including at least one colored resin are successively injected into a
cavity of a mold by way of a gate located at a position opposed to the center of a
bottom, said preform having a color-gradated portion formed by a colored resin layer
made of earlier injected colored resin, with thickness of the colored resin layer in
this portion being gradually reduced toward the bottom by flow action of a second
resin that wedges its way through central part of the earlier injected colored resin,
wherein said bottle is decorated with color gradations created by gradual change
toward the bottom in thickness of the colored resin layer made of the earlier injected
colored resin and by subsequent change in color density, color shade, or both, which
is caused to occur in a continuous manner.

14. The synthetic resin bottle according to claim 13 which is made of a
polyethylene terephthalate resin, wherein gradations are created by the continuous
and gradual changes in color density and color shade that occur in three colored
resin layers made of three differently colored resins.

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Yoshino Kogyosho Co., Ltd.
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON
A: Injection of main resin
B: Injection of colored resin
(a) Flow state of point F

(b) Flow state of point M

(c) Flow state of point D
[Fig.14]
[Fig. 16]
(a) Flow state at the time point of t2

(b) Flow state at the time point of t4

(c) Flow state at the time point of t5
(a) Flow state at the time point of t2

(b) Flow state at the time point of t3

(c) Flow state at the point of t4