

SPECIFICATION

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TITLE OF THE INVENTION

INJECTION ORIENTATION BLOW MOLDING METHOD

BACKGROUND OF THE INVENTIONField of the Invention

This invention relates to a molding method for continuously performing orientation blow molding from injection molding of a preform made of synthetic resin to a thin-wall hollow molded article.

Prior Art

As one of molding methods generally called injection orientation blow molding, there is a 3-station molding method in which a mouth portion of an injection molded preform is held by a lip mold and the preform is immediately transferred to a blow mold for orientation blow molding.

In a molding method of a 3-station system disclosed in Japanese Patent Application Laid-Open No. 63-296921, orientation blow molding is carried out after inner and outer temperatures of a preform released at a high temperature are made uniform by internal heat of the preform itself to eliminate a temperature difference therebetween.

A technical idea for releasing a preform at a high temperature is already disclosed in a molding method of 4-station system.

This molding method comprises releasing a preform



made of injection molded polyethylene terephthalate in a range of temperature at which shape is maintained at a high temperature, making uniform a temperature difference between inner and outer surfaces and an internal center portion in the same plane section of the preform, and thereafter adjusting the temperature of the preform to a high temperature in excess of 95°C by external energy to effect blow molding.

In the 3-station system of which molding steps comprise three steps, "injection molding of a preform - orientation blow molding - removal of a molded article", a step of adjusting a temperature to be carried out immediately before orientation blow molding which is unavoidable in the 4-station system requiring four steps, "injection molding of a preform - temperature adjustment - orientation blow molding - removal of a molded article" is not required.

Therefore, a temperature adjusting device for a preform and other accessorial devices used in the 4-station system can be omitted, and in addition, there is a merit in construction that the number of neck molds also serving as a transfer member for a preform is reduced by one. Moreover, there is economically advantageous in that molding cycle time is also shortened and cost of machines is reduced.

However, molded articles molded by use of the 3-station system tends to be limited to wide-mouth containers. This is because of the fact that an aperture of a preform



is so large that there involves no technical difficulty in designing a draft or taper from an injection mold, a core and the like, and releasing at high temperature is easily carried out.

In molding of narrow-mouth containers such as bottles which are extremely small in aperture of a preform and long in oriented portion and require a large orientation magnification, the 4-station system capable of controlling temperature immediately before blow molding has been used in terms of difficulty of temperature control of a preform and limitation of draft.

The difficulty of temperature control of a preform in the 3-station system is that there is no means for correctly detecting a state that a surface layer is heated by internal heat, and the temperature of the preform becomes uniform.

Therefore, orientation blow timing is determined making rough estimation from a lapse of time after release, and repeating a trial at that time. It requires experiences and time to effect the trial. In the case where resin as a material is polypropylene, it is often that the molding condition somewhat differs according to the manufacture lot. Therefore, the condition has to be set as needed, thus inevitably increasing a loss of products.

SUMMARY OF THE INVENTION

This invention has been contemplated in order to solve the task of the high temperature release in molding



involved in the 3-station. An object of this invention is to provide a new injection orientation blow molding which can mold narrow-mouth synthetic resin containers such as bottles, similarly to the case of wide-mouth containers, without being subjected to limitations of the shape, a draft, a wall-thickness distribution and the like of a preform, despite the fact that a preform made of a crystalline resin is released at a high temperature.

It is a further object of this invention to provide a new injection orientation blow molding which can mold, by three stations, bottle-like containers which are less in stress and strain which are liable to occur when a low temperature preform is orientation blow molded, which are hard to expose to shrinkage deformation at the time of filling at a high temperature caused by the stress and strain, and which are transparent and orderly in distribution of wall-thickness.

It is another object of this invention to provide a new injection orientation blow molding which can carry out the temperature adjustment of various parts of a preform at the time of injection molding whereby the orientation blow molding can be materially shortened as compared with prior art to increase a production quantity per hour.

According to a first feature of this invention for achieving the aforesaid objects, in injecting and filling molten resin into an injection mold to form it into a preform as required, holding a mouth portion of said preform by



a lip mold to transfer it from the injection mold to a blow mold, and orientation blow molding the preform into a thin-wall hollow molded article as required, releasing of said preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and the orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

According to a second feature of this invention, releasing of a preform made of polyethylene terephthalate from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 60°C but below 70°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 80°C but below 95°C.

According to a third feature of this invention, releasing of a preform made of polypropylene from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 90°C but below 100°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a



peak temperature in a temperature region above 100°C but below 122°C. A preform made of thermoplastic synthetic resin such as polyethylene, polycarbonate, etc. other than the aforementioned resins as a crystalline resin can be orientation molded by similar means.

According to a fourth feature of this invention, internal heat of various portions of an oriented portion of a preform is controlled by a temperature of a mold maintained at a predetermined temperature and an intentionally adjusted wall-thickness distribution of the preform, and an orienting condition of an oriented portion is controlled by a difference of heat quantity which differs with the wall thickness to thereby make it unnecessary to adjust the temperature after release.

A bottle-like container obtained by orientation blow molding according to this invention has less stress and strain which are liable to occur when a low temperature preform is orientation blow molded. Accordingly, shrinkage and deformation during high-temperature filling to be caused by the stress and strain are hard to occur. Containers made of polyethylene terephthalate have an increased heat resistance.

Since a preform is oriented when the interior thereof is in a half molten state, there is hardly affected by unevenness of temperature. Since molding is finished before the interior of a preform is crystallized, a thin-wall container which is transparent and without one-sided wall



thickness may be obtained.

Furthermore, since a skin layer is formed by quick cooling, releasing can be made even if the interior of a preform is soft. Even a bottle-like narrow-mouth container which has been difficult to be released at an adequate temperature and which has been required to adjust a temperature in terms of draft of a preform can be molded easily even in a 3-station similarly to the case of a wide-mouth container.

Moreover, time required for orientation blow molding is materially short as compared with prior art, thus quickening a molding cycle and increasing a production amount per hour.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a high-temperature preform.

FIG. 2 is a graph showing a change by passage of time of a high-temperature preform obtained by injection molding a crystalline resin.

FIG. 3 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 1 obtained by injection molding a polyethylene terephthalate.

FIG. 4 is a graph showing a change by passage of time of the surface temperature of a high-temperature of sample No. 2 obtained by injection molding a polyethylene terephthalate.



FIG. 5 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 3 obtained by injection molding a polyethylene terephthalate.

FIG. 6 is a graph showing a change by passage of time of the surface temperature when a preform made of polyethylene terephthalate is orientation blow molded.

FIG. 7 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 4 obtained by injection molding a polypropylene.

FIG. 8 is a graph showing a change by passage of time of the surface temperature when a preform made of polypropylene is orientation blow molded.

FIG. 9 is a graph showing a change by passage of time of the surface temperature when two preforms which are different in wall thickness are orientation blow molded.

DETAILED DESCRIPTION OF THE INVENTION

Molten resin is injected and filled into a mold to injection mold a preform 11 having a sectional construction shown in FIG. 1, and the preform is released while maintaining a temperature as high as possible from an injection mold. When the preform is left as it is at a room temperature, the surface temperature of the preform changes as shown in FIG. 2.

The change by passage of time of the surface temperature has a difference to some extent in time till



it reaches a peak temperature but most thermoplastic resins used to mold containers indicate similar progress. A rise of initial surface temperature is caused by the fact that in a preform released at a high temperature, the surface of cavity of a mold or the surface of a preform in contact with a core is solidified by cooling the mold to form a skin layer but internal cooling is not yet finished and temperature is high which is in a half-molten state, and cooling is cut off by releasing after which the skin layer is heated from inside.

Of course, in such a state, the temperature of the preform is not uniform except a mouth portion completely cooled and solidified at the time of release. When orientation blow molding takes place in a state where a temperature difference between inner and outer portions of a preform is present, white turbidity due to crystallization or crazing occurs. Therefore, in the aforementioned conventional method, the temperature of the preform is made uniform before orientation blowing.

According to the researches by the present inventor, the white turbidity of a molded article in the orientation blow molding often results from the temperature of orientation blow molding rather than a temperature difference between inner and outer portions.

According to experiments so far conducted, in case of polyethylene terephthalate, when the surface temperature of a preform is less than 80°C, the white turbidity tends



to occur. It was also found that when the surface temperature of a preform immediately after release is 80°C or more and orientation blow molding takes place after passage of very short time, crazing rarely occurs.

It has been also found however that even such a case, when cooling time is long and the temperature immediately after release is less than 60°C, the white turbidity tends to occur in an article injection blow molded even if the orientation blow molding temperature is 80°C or more.

In case of polyethylene terephthalate, when cooling time is set shortly and the surface temperature immediately after release is set to be 70°C or more, the peak temperature is often 95°C or more. In molding under such a set condition as described, one-sided wall thickness tends to occur, and rigidity is lost.

Accordingly, cooling time of a preform in an injection mold is limited within a certain predetermined time. However, cooling is different according to wall thicknesses even in case of the same resin and further different according to temperatures of cooling water to be used therefor. An allowable range with the same wall thickness is more or less one second in case of polyethylene terephthalate. It is possible to obtain a surface temperature immediately after release capable of molding a narrow-mouth container which is transparent and well ordered in shape within the aforesaid allowable range.

Similarly, with respect to a preform made of



polypropylene, the surface temperature rapidly rises from a temperature at the time of release at a room temperature and reaches a peak, after which the peak temperature is maintained for a long period of time and gradually lowers.

Time at which temperature of the whole preform is made uniform due to the internal temperature is obscure from the change by passage of time of the surface temperature. However, in conventional orientation blow molding of a high-temperature wide-mouth preform, orientation blow molding is carried out about 17 seconds after release. Therefore, orientation blow molding was tried around the diagonal line with such a time as described used as a standard. For a preform for a wide-mouth container, it was possible to mold a thin-wall wide-mouth container of which body portion is transparent in about 17 seconds.

However, in case of a preform for a narrow-mouth container which is large in orientation magnification than the case of a wide-mouth container, even those which are so large in draft as to be easily released, one-sided wall thicknesses and defective molding of a bottom often occur, failing to provide a molded article.

However, even in the case of polypropylene, when the surface temperature immediately after release is 90°C or more and the temperature of orientation blow molding is 110°C or more, a narrow-mouth container can be molded. The allowable range of cooling time with the same wall thickness was more or less 3 seconds.

It is apparent from an attempt of orientation blow molding that when orientation blow molding is carried out after passage of a given time for the purpose of making a temperature of a preform uniform after release, the preform is subjected to gradual cooling, and therefore, whiteness caused by crystallization tends to occur. Naturally, it becomes difficult to mold a narrow-mouth container.

Accordingly, hardness or ease of orientation blow molding of a preform released at a high temperature is not only affected by unevenness of temperature but greatly affected by a composition of a high-temperature preform which changes by passage of time, orientation blow timing, etc.

The high-temperature preform 11 after release is low in surface temperature as can be seen in FIG. 1 immediately after it is released from the injection mold, and therefore, the surface thereof forms a skin layer 12 having a hardness. However, the forming condition of the skin layer 12 is different according to the cooling speed.

In the high-temperature release, a central portion is not cooled, and the internal resin 13 has a fluidity to some extent at a high temperature. A draw-down is prevented by the skin layer 12 of the surface, and even after release, the form of the preform 11 is maintained.

The internal temperature is released outside as time passes and at the same time the skin layer 12 forming the surface is heated from inside. Therefore, the surface



temperature abruptly rises, and the skin layer 12 becomes softened whereas the internal temperature lowers. Therefore, the flowing portion is reduced toward the center portion.

The skin layer 12 whose surface temperature reaches a peak is thin to a degree that forms a skin, and the interior thereof is in a half hardened state.

After the peak, the surface temperature slowly lowers as time passes. As for the whole preform, the temperature becomes uniform and at the same time, crystallization progresses.

In the high-temperature preform till the surface temperature reaches a peak, even if the surface is solidified to form the skin layer 12, the skin layer 12 is softened in the vicinity of the peak temperature, which is in the state where orientation can be made.

A thick-wall portion which is high in internal heat of the skin layer 12 is first softened by heat received from inside. There is a temperature difference between a thick wall portion and a thin wall portion till some time passes after the surface temperature reaches the peak, and the aforesaid difference is evident particularly before peak.

When orientation blow molding takes place in such a state as described, the skin layer on the side of the thick wall portion where much heat is present, that is, on the side in which surface temperature is high is first oriented in the state where internal resin is a softened

state is embraced.

Naturally, the surface area increases due to the orientation, and as the result, the radiant surface becomes large and the temperature lowers to eliminate a temperature difference from the thin wall side. Furthermore, the temperature on the thin wall side relatively rises, and subsequently, orientation of the thin wall portion precedes. Such a mutual orientation is repeatedly carried out for an extremely short period of time, and the internal temperature with much heat amount during that period lowers to a temperature suitable for orientation. And, the internal resin 13 so far oriented while being accompanied by the skin layer 12 is thinly oriented similarly to the skin layer 12 halfway, whereby a molded article having a uniform distribution of wall thickness is formed.

Accordingly, in the injection molding of the preform 11, first, orientation amount of various portions of the preform 11 is taken into consideration in advance from the shape of a container 14 to be a molded article whereby the wall-thickness distribution of the various portions is intentionally adjusted whereas the temperature of the injection mold is maintained constant, and preferably, cooling of the preform 11 molded by being injected and filled in the cavity is uniformly carried out at any portion.

For the high-temperature preform 11 formed with the skin layer 12 by quick cooling, the best result was obtained by molding at the time before the surface



temperature reaches the peak. At the time seemed to have reached the peak, one-sided wall thickness tends to occur, failing to obtain a good result.

The surface temperature when orientation blow molding takes place was 80°C or more and 110°C or more for polyethylene terephthalate and polypropylene, respectively, and time after release was more or less 8 seconds and more or less 14 seconds for the former and the latter, respectively.

However, it is apparent from the foregoing attempts that the better result cannot be obtained unless the skin layer 12 is formed by quick cooling. This seems to have resulted from a difference of a crystalline state produced in the skin layer 12 by cooling. A crystal due to quick cooling forms a fine crystal. In case of gradual cooling, a crystal greatly grows, and joining of crystals with each other is weaker than the fine crystal.

More preferably, orientation blow molding is carried out in the range of temperature capable of adapted to wall thicknesses of any portion of the preform 11.

According to the attempt by the present inventor, most conveniently, if a difference of wall thickness is 0.25 mm or so, there is no much difference in the peak temperature and the time till the peak is reached even if a difference of surface temperature immediately after release is present. Moreover, there involves no much technical difficulty to timely grasp the temperature range to make orientation blow molding for both possible.



In the case where heat amount of various portions is controlled in the injection mold with a difference of wall thickness intentionally provided as a means for controlling an orientation degree of various portions of the preform from the shape of a molded article, the difference of wall thickness is very minute and is mostly within the allowable time including the difference of wall thickness in case of a flat container which is materially different in orientation degree between lateral and longitudinal portions thereof.

Accordingly, there involves not much technical difficulty in that the internal heat of various portions of the oriented portion of the preform is controlled by the temperature of the mold maintained at constant temperature and the intentionally adjusted wall thickness distribution of the preform, and the orienting condition of the oriented portion is controlled by the difference of heat amount different according to the wall thickness.

Embodiment 1

Molten resin of polyethylene terephthalate was injected and filled into an injection mold to form a narrow-mouth preform 11 as shown in FIG. 1 by quick cooling.

Three examples of preforms different in wall thickness were injection molded changing cooling time sample by sample, and the change by passage of time of the surface temperature was measured.



The preform is prepared for one-litre container whose overall length is 124 mm. Temperatures of the preform were measured at three points, 30 mm, 60 mm, and 100 mm upwardly from the bottom, and temperatures to be measured were an average value.

As a temperature measuring unit, a digital radiation thermometer IR-AHOT (made by K.K. Chino) was used.

The injection molding conditions are as follows:

Weight of material	33 gr
Injection temperature	275°C
Mold temperature	13°C
Draft	1.5°
Injection and filling time	5.3 sec.

Note: The mold temperature means a cooling water temperature of a cavity mold and a core mold.

FIGS. 3 to 5 show the change by passage of time (average value) of the surface temperatures of the following samples at a room temperature (22°C), main points of which are as given in Table 1 below.

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TABLE 1

Preform Wall thickness (mm)		Cooling Time (sec)	Preform Temperature (°C) 1 sec after release Peak		Peak Time (sec)
Sample No.1 2.80	1	3.0	72.0	96.0	11
	2	3.5	68.7	88.0	10
	3	4.0	68.0	86.0	9
	4	4.5	66.9	83.0	9
	5	5.0	62.3	79.8	7
Sample No.2 3.05	1	3.6	71.3	96.2	12
	2	3.9	65.1	87.9	11
	3	4.2	63.8	86.3	13
	4	4.5	62.5	83.8	9
	5	4.8	60.3	81.5	10
	6	5.5	57.0	80.2	10
Sample No.3 3.30	1	3.5	70.5	92.8	11
	2	4.9	67.4	87.9	12
	3	5.2	63.2	85.7	10
	4	5.5	62.6	83.9	9
	5	5.8	60.5	82.2	9
	6	6.5	58.0	77.0	11

Cooling time is time after passage of injection and filling time.

For the above-described samples, orientation blow molding was carried out under blow air pressure of 14 kg/cm² to form a bottle-like container 14 as indicated by the



broken line in FIG. 1. It has been found that the best result was obtained when orientation blow molding was carried out within the time shown in FIG. 6, that is, within time t between time t_1 before the surface temperature reaches the peak and time t_2 seemed to have reached the peak. However, in case of a preform whose surface temperature immediately after release is outside the range of 60°C to 70°C at a normal temperature or a preform whose surface temperature at the time of orientation blowing molding is outside the temperature region of 80°C to 95°C, satisfactory molded articles were not obtained as shown in Table 2 below.

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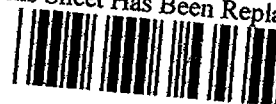
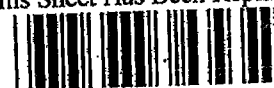


TABLE 2

Preform wall thickness (mm)	Temperature 1 sec. after release	Temperature at orientation blow molding	Time of passage (sec.)	Molded state of molded articles. Wall thickness of body portion: 0.3 mm
Sample No.1 2.80	72.0	91.5	9.0	Bad, short of rigidity, one-sided wall thickness
	68.7	87.9	7.0	Good
	68.0	85.5	8.0	Good
	66.9	82.8	7.5	Good
	62.3	79.5	6.0	Bad, short of rigidity, one-sided wall thickness
Sample No.2 3.05	71.3	92.0	8.0	Bade, short of rigidity one-sided wall thickness
	65.1	86.8	7.0	Good
	63.8	85.0	7.5	Good
	62.5	82.8	8.0	Good
	60.3	81.4	8.0	Good
	57.0	76.3	7.5	Bad, white turbidity, large one-sided wall thickness
Sample No.3 3.30	70.5	91.0	8.0	Bad, short of rigidity, one-sided wall thickness
	67.4	88.8	8.5	Good
	63.2	85.7	9.5	Good
	62.6	83.0	6.5	Good
	60.5	82.4	6.5	Good
	58.0	80.0	8.5	Bad, white turbidity, large one-sided wall thickness



In Table 2, the time of passage is time from release of a preform to start of orientation blow molding. The results obtained by molding a few samples in the range of more or less one second on the time of passage were shown in the molded state.

Embodiment 2

Molten resin of polypropylene was injected and filled into an injection mold to form a narrow-mouth preform 11 as shown in FIG. 1 similar to the case of Embodiment 1 by quick cooling.

Eight preforms having the same wall thickness were injection molded changing cooling time, and the change by passage of time of the surface temperatures thereof at room temperature were measured.

The injection molding conditions are as follows:

Weight of material	40 gr
Injection temperature	240°C
Mold temperature (cooling water)	13°C
Draft	3.0°
Injection and filling time	6.0 sec.

FIG. 7 shows the change by passage of time (average value) of the surface temperatures of the following samples at a room temperature (22°C), main points of which are as given in Table 3 below.



TABLE 3

Preform wall thickness (mm)		Cooling Time (sec)	Preform Temperature (°C) 1 sec after release Peak		Peak Time (sec)
Sample No. 4 4.10	1	1.5	105.0	124.0	19
	2	2.0	95.5	121.4	18
	3	2.5	93.0	118.0	18
	4	3.0	92.5	117.6	16
	5	3.5	91.6	113.5	18
	6	4.5	91.0	113.3	17
	7	6.0	90.5	111.8	18
	8	5.5	89.0	110.5	17

For the above-described sample No. 4, orientation blow molding was carried out under blow air pressure of 12 kg/cm^2 within the time shown in FIG. 6 similar to the case of polyethylene terephthalate to form a bottle-like container 14 as indicated by the broken line in FIG. 1. It has been found that the best result was obtained when orientation blow molding was carried out within the time shown in FIG. 8, that is, within time t between time t_1 before the surface temperature reaches the peak and time t_2 seemed to have reached the peak.

However, in case of a preform whose surface temperature immediately after release is outside the range of 90°C to 100°C at a normal temperature or a preform whose surface temperature at the time of orientation blow



molding is outside the temperature region of below 110°C or above 123°C, satisfactory results were not obtained as shown in Table 4 below.

TABLE 4

Preform wall thickness (mm)		Temperature 1 sec. after release	Temperature at orientation blow molding	Time of passage (sec.)	Molded state of molded articles. Wall thickness of body portion: 0.5 mm
Sample No.4 4.10	1	105.0	123.5	15.5	Bad, large one-sided wall thickness, burst
	2	95.5	120.5	14.5	Good
	3	93.0	156.8	13.5	Good
	4	92.5	156.5	12.5	Good
	5	91.6	112.5	14.0	Good
	6	91.0	113.0	14.0	Good
	7	90.5	111.3	14.0	Good
	8	89.0	110.0	15.0	Bad, large one-sided wall thickness, burst

It is apparent from FIGS. 3 to 5 showing the change by passage of time that in injection molding the preform 11, there is an allowable range of cooling time. It is also apparent that when the allowable time are compared between those different in wall thickness, there is cooling time adapted to each other.

FIG. 9 is a graph which selects two cooling time adapted to each other with respect to sample Nos. 1 and 2 from Table 1 to depict the change by passage of time of the surface temperatures in that case. A temperature difference Δt at the allowable time of orientation blow molding of a thick wall thickness portion D1 and a thin wall thickness portion D2 was 2.5°C to 3.0°C.

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Orientation blow molding was carried out for a narrow-mouth container from a preform with distribution of wall thickness intentionally changed.

Embodiment 3

A preform 11 shown in FIG. 1 whose wall thickness is made thin from an upper portion toward a bottom thereof so as to have a difference in wall thickness distribution of the whole body was injection molded from polyethylene terephthalate, and one-litre container 14 was orientation blow molded from the preform.

In injection molding, intentionally, the wall thickness, 3.05 mm, of the D1 portion of the preform 11 is differentiated from the wall thickness, 2.80 mm, of the D2 portion. Furthermore, cooling time adapted to the wall thicknesses for both was selected from sample Nos. 1 and 2 in Table 1 so that the surface temperature of the preform immediately after release is in the range of 60°C to 70°C.

Injection molding conditions:

Weight of material	33 gr
Injection temperature	275°C
Mold temperature (cooling water)	13°C
Draft	1.5°
Injection and filling time	5.3 sec
Example 1:	
Cooling time (1)	4.1 sec
Surface temperature (D1)	
Immediately after release	63.8°C
At blow molding	85.7°C

Surface temperature (D2)

Immediately after release	68.0°C
At blow molding	86.0°C

Example 2:
Cooling time (2) 4.5 sec.

Surface temperature (D1)	..
Immediately after release	62.4°C
At blow molding	82.5°C

Surface temperature (D2)

Immediately after release	67.0°C
At blow molding	82.6°C
Time of passage (after release)	7.5 sec.
Blow air pressure	14 kg/cm ²

In the Examples 1 and 2, the molded state of the orientation blow molded container 14 was good. The transparency of the container is excellent, one-sided wall thickness thereof was hardly recognized, and the wall thickness (0.3 mm) of the body portion was uniform.

It is understood from the foregoing that the most preferable molding method for the 3-station system is to adjust wall thicknesses of various portions of oriented portions of a preform according to an orienting state and control an orienting state of an oriented portion from a difference of heat amount different according to the wall thickness, in other words, to carry out orientation blow molding in the state where the temperature of the preform is uneven as a whole. Adjustment of a wall thickness can be easily made by grinding a core mold or applying a padding through plating or the like, and a delicate difference of wall thickness can be also provided.





WHAT IS CLAIMED IS:

1. An injection orientation blow molding method characterized in that in injecting and filling molten resin into an injection mold to form it into a preform as required, holding a mouth portion of said preform by a lip mold to transfer it from the injection mold to a blow mold, and orientation blow molding the preform into a thin-wall hollow molded article as required, releasing of said preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and the orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

2. An injection orientation blow molding method characterized in that releasing of a preform made of polyethylene terephthalate from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 60°C but below 70°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 80°C but below 95°C.





3. An injection orientation blow molding method characterized in that releasing of a preform made of polypropylene from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 90°C but below 100°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 100°C but below 122°C.
4. An injection orientation blow molding method according to claim 1, wherein resins used to form a preform comprise crystalline resins such as polyethylene, polycarbonate, etc.
5. An injection orientation blow molding method according to claims 1, 2 and 3, wherein internal heat of various portions of an oriented portion of a preform is controlled by a temperature of a mold maintained at a predetermined temperature and an intentionally adjusted wall-thickness distribution of the preform, and an orienting condition of an oriented portion is controlled by a difference of heat quantity which differs with the wall thickness.
6. An injection orientation blow molding method according to claims 1, 2, 3 and 5, wherein cooling time when a preform is formed is limited within a specific time to render orientation blow molding after release possible at any wall

thickness portion of the preform.



7. An injection orientation blow molding method according to claims 1, 2, 3, 5 and 6, wherein intentional adjustment of a wall thickness of a preform when the preform is injection molded is made according to the orienting condition of various portions thereof.



ABSTRACT

A molding method for continuously carrying out the steps from injection molding of a synthetic resin preform to orientation blow molding thereof into a thin-wall hollow molded article, characterized in that releasing of the preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

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FIG.1

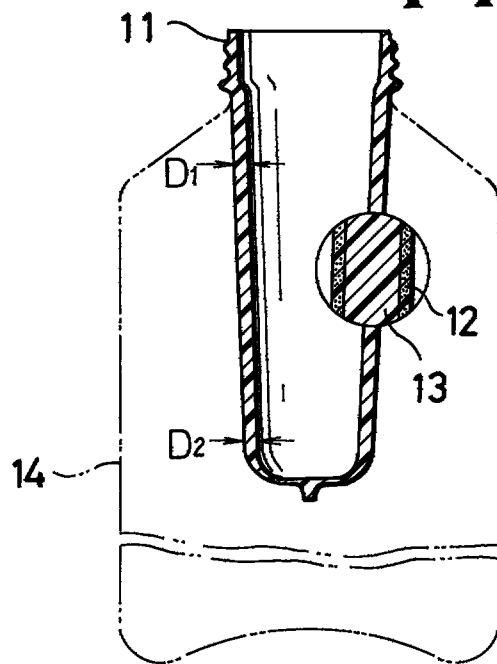
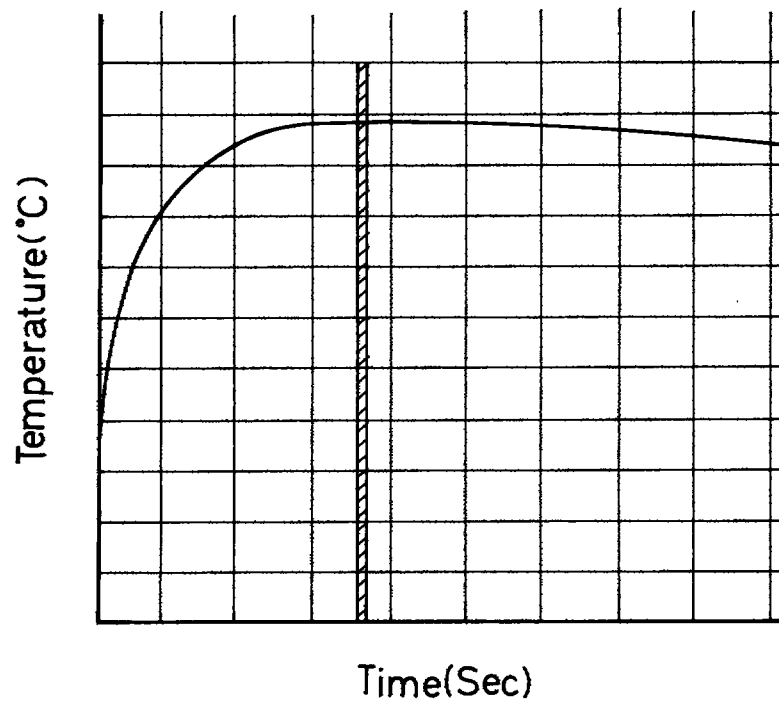


FIG.2

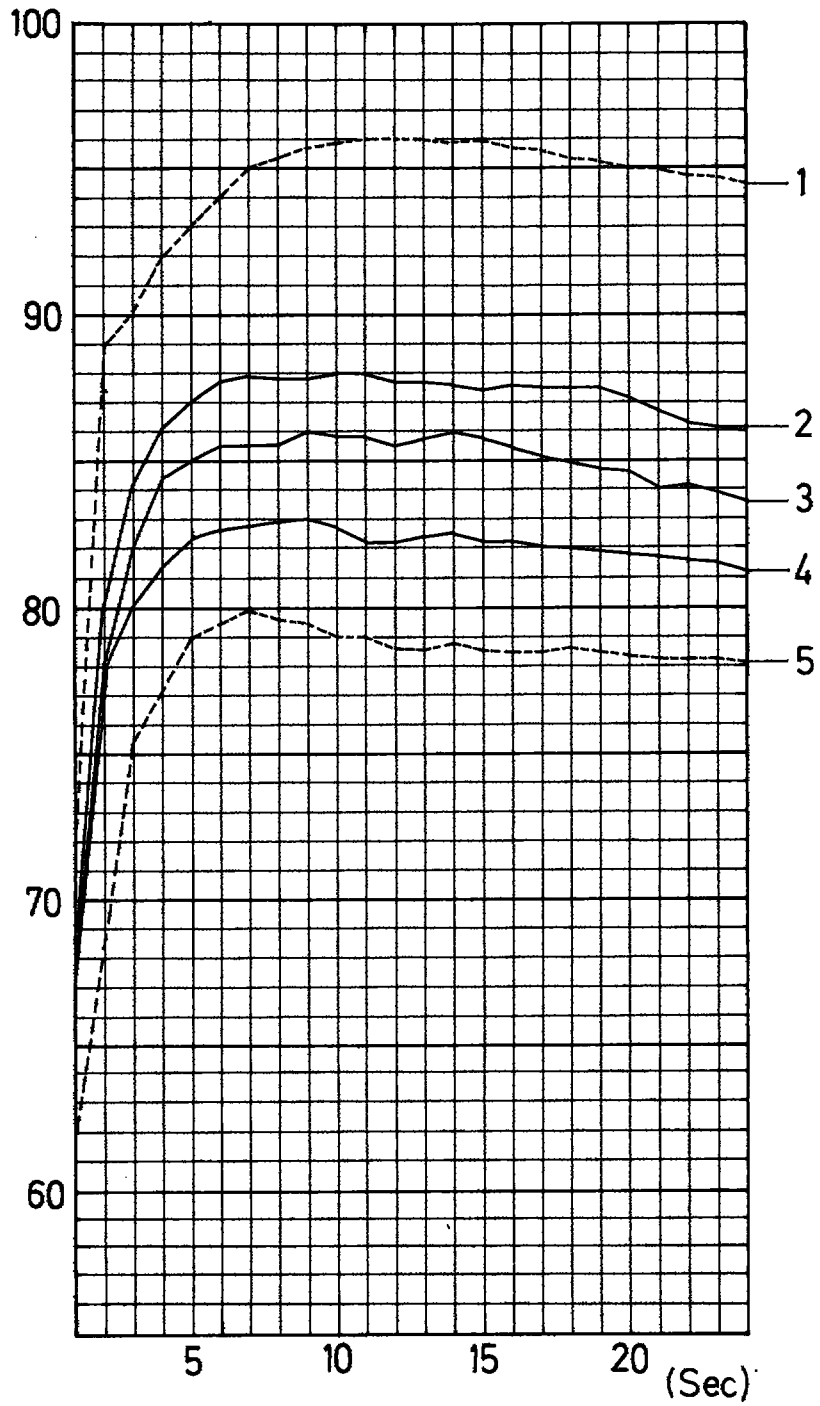


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FIG.3

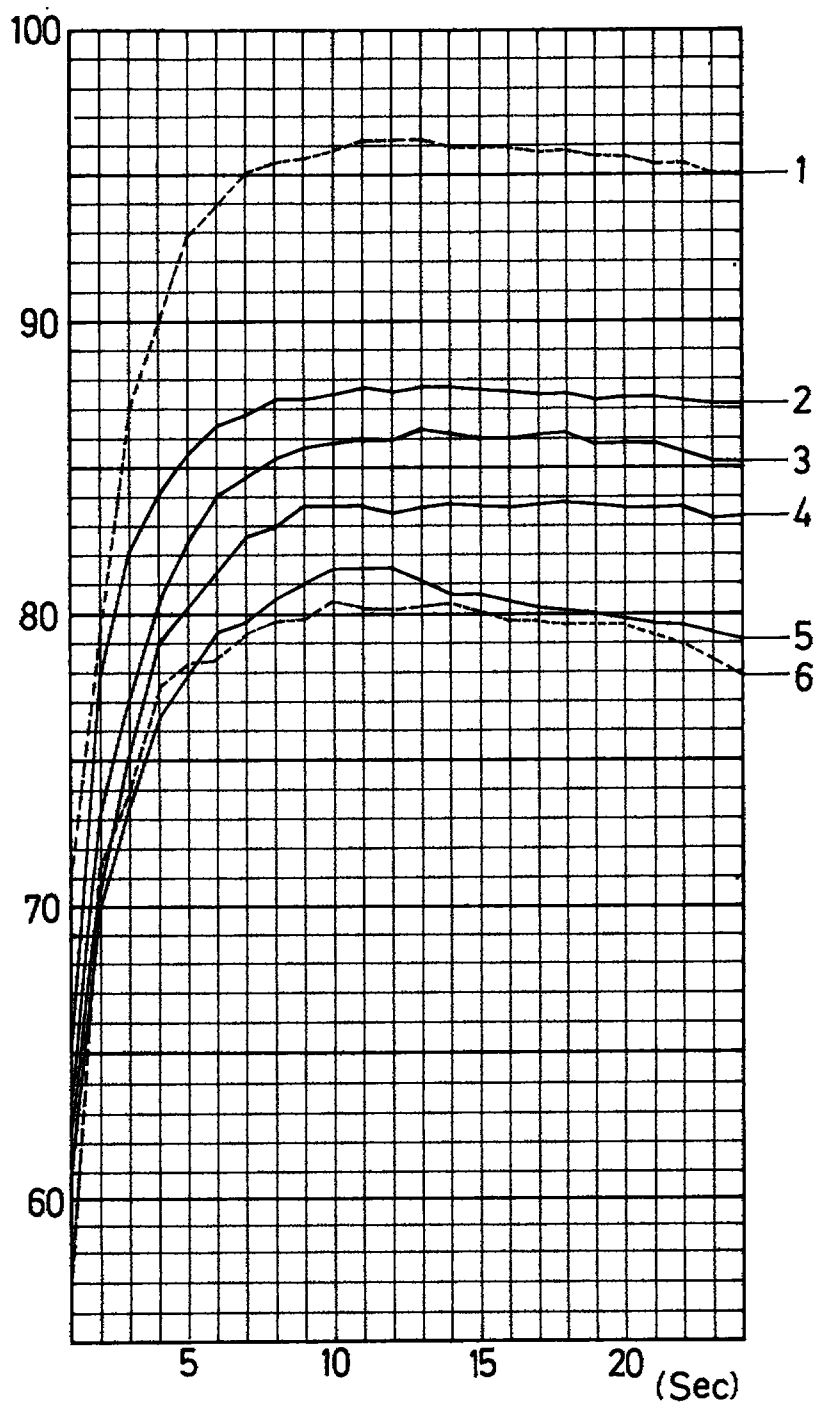


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FIG.4

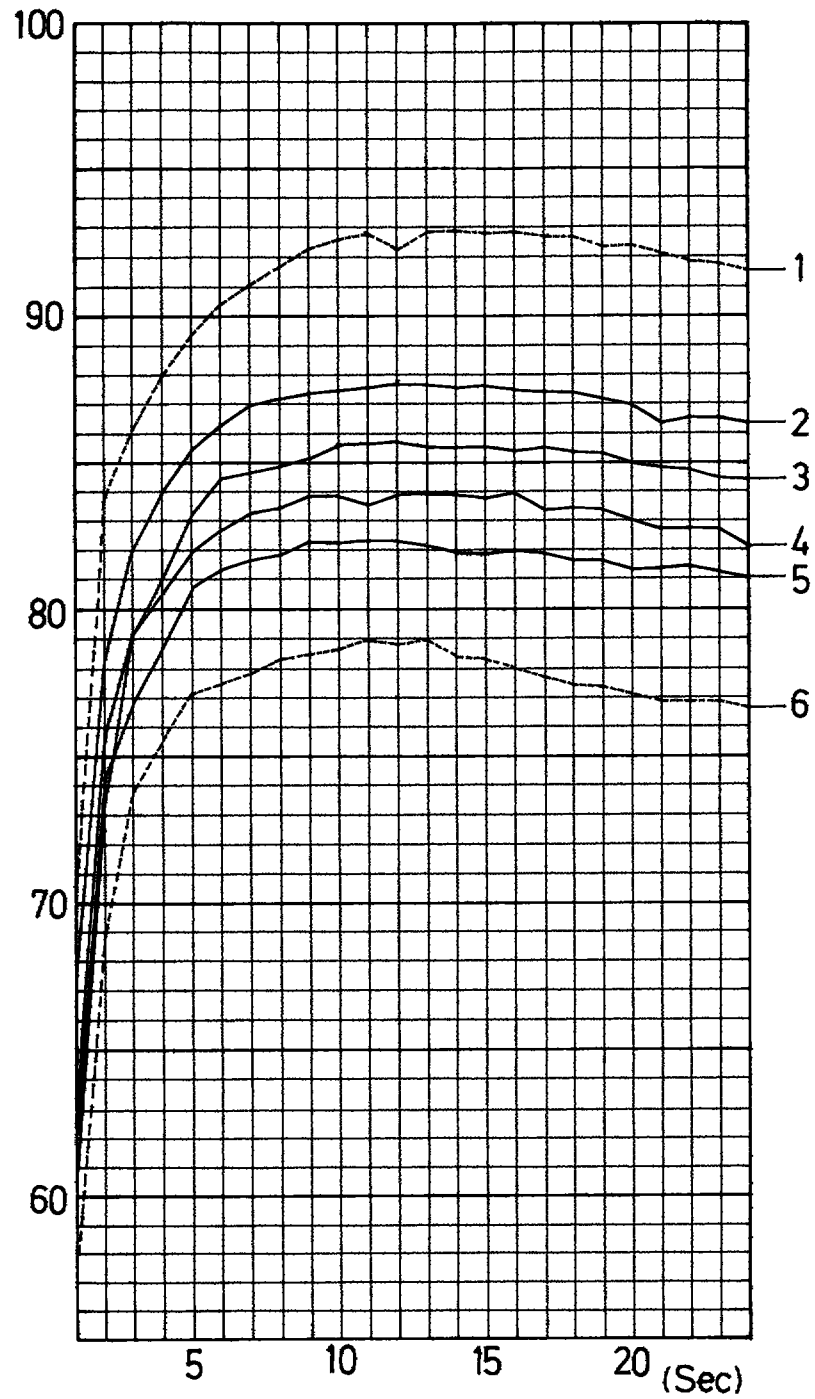


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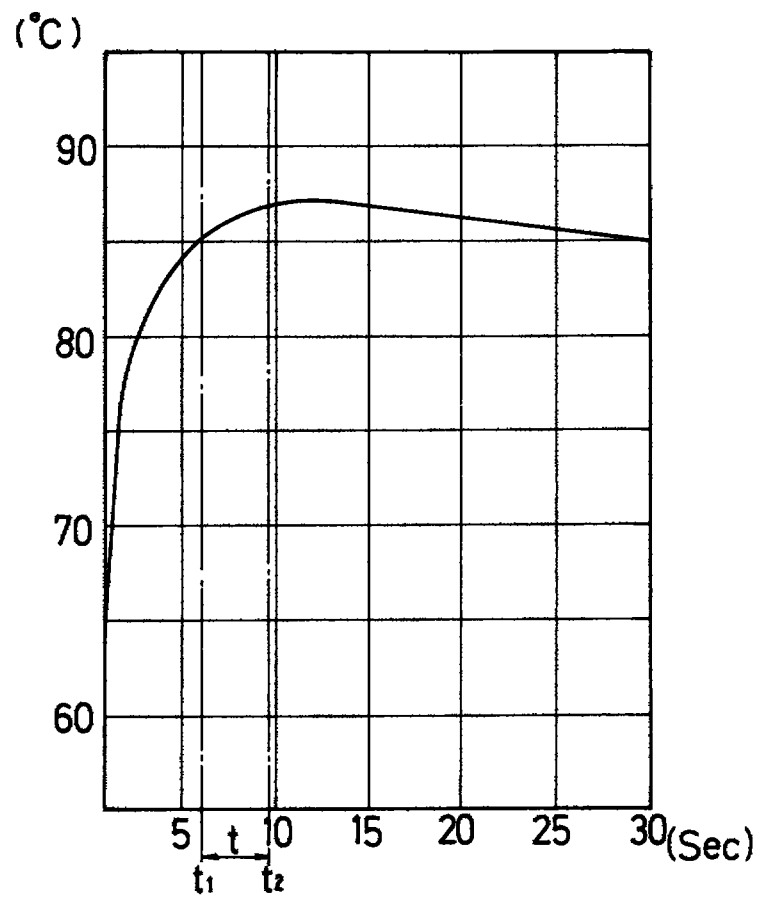
FIG.5



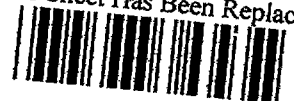
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FIG.6

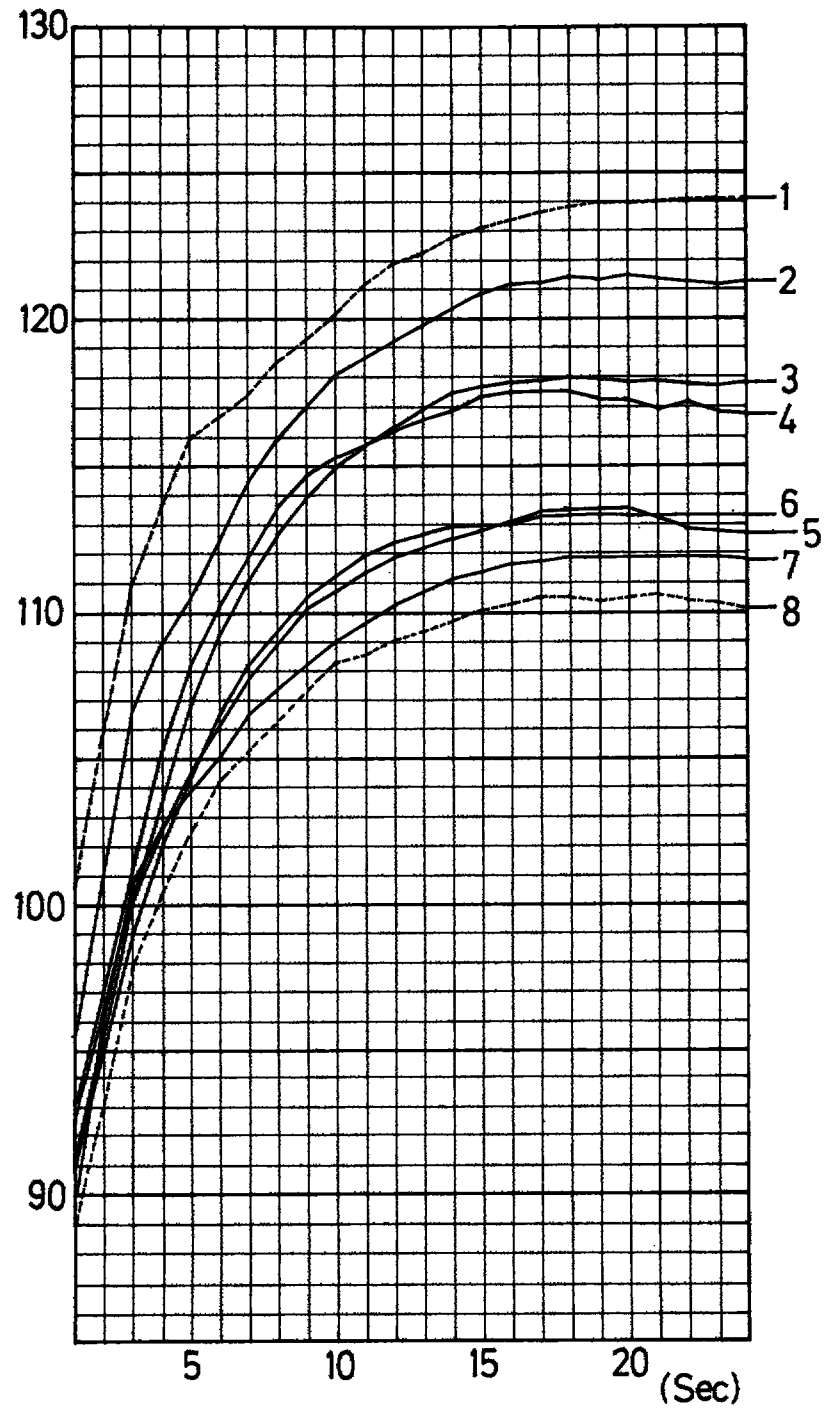


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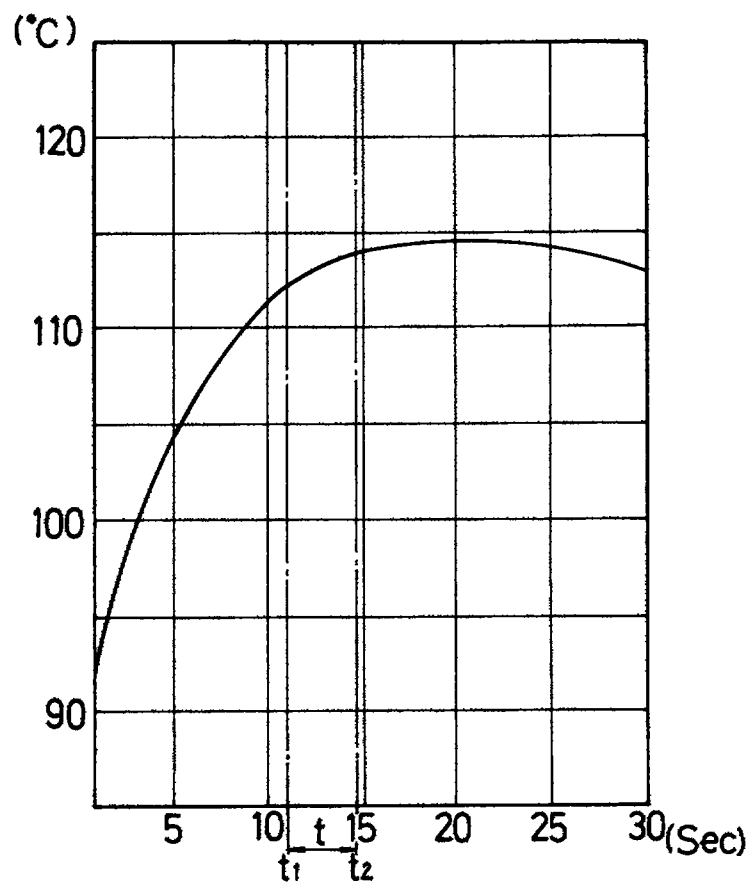
FIG.7



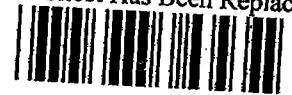
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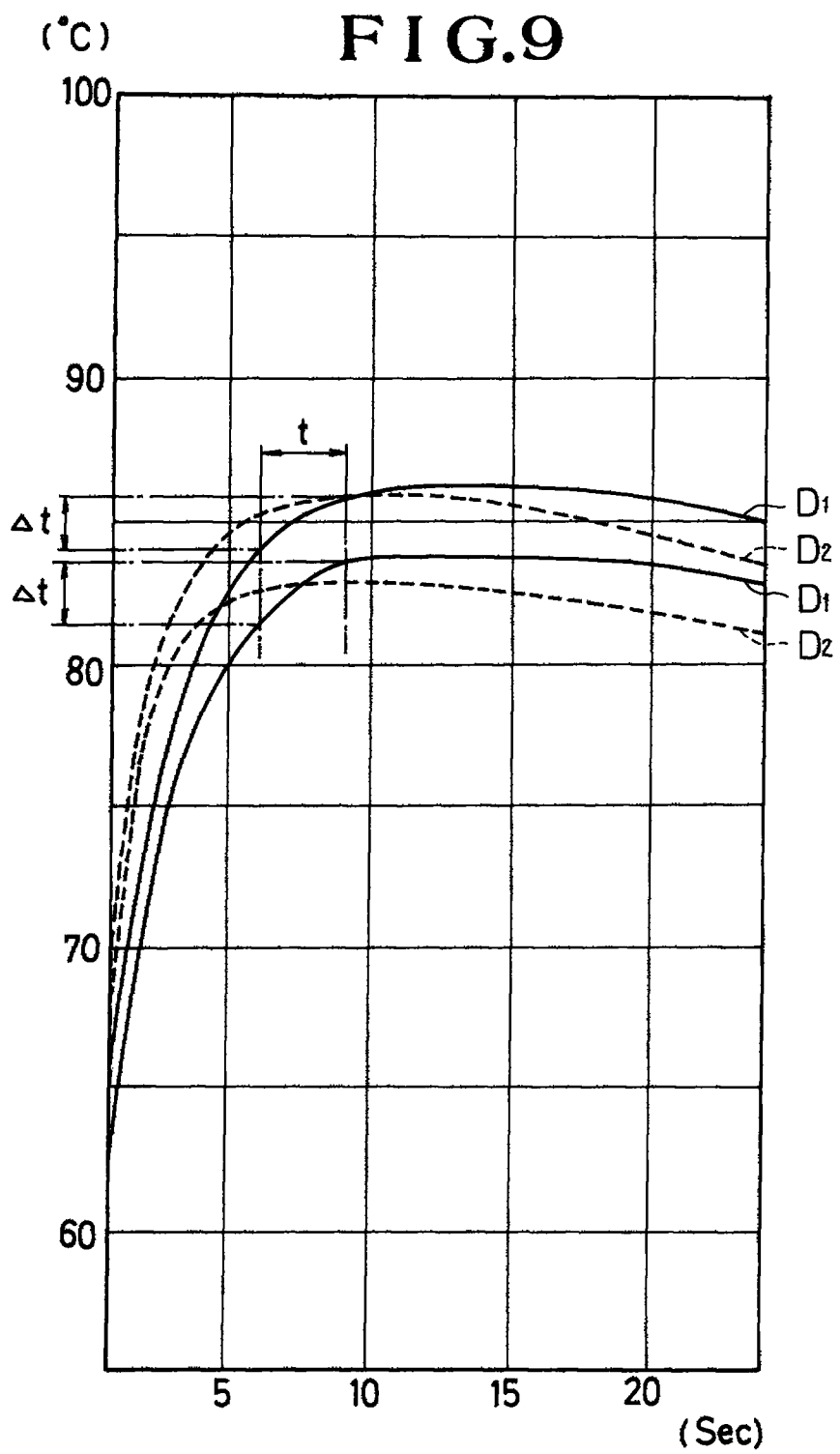


FIG.8



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☒	Claim(s)	: paged ...10... to paged ...11...
☐	Drawing(s)	: paged to paged
☐	Abstract	: paged to paged

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REPLACEMENT SHEETS		SG
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☒	Drawing(s)	: paged ...1... to paged ...8...
☒	Abstract	: paged ...12... to paged ...12...
DATE OF RECEIPT		8/1/97

Injection orientation blow molding method

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a molding method for continuously performing orientation blow molding from injection molding of a preform made of synthetic resin to a thin-wall hollow molded article.

Prior Art

As one of molding methods generally called injection orientation blow molding, there is a 3-station molding method in which a mouth portion of an injection molded preform is held by a lip mold and the preform is immediately transferred to a blow mold for orientation blow molding.

In a molding method of a 3-station system disclosed in Japanese Patent Application Laid-Open No. 63-296921, orientation blow molding is carried out after inner and outer temperatures of a preform released at a high temperature are made uniform by internal heat of the preform itself to eliminate a temperature difference therebetween.

A technical idea for releasing a preform at a high temperature is already disclosed in a molding method of 4-station system.

This molding method comprises releasing a preform made of injection molded polyethylene terephthalate in a range of temperature at which shape is maintained at a high temperature, making uniform a temperature difference between inner and outer surfaces and an internal center portion in the same plane section of the preform, and thereafter adjusting the temperature of the preform to a high temperature in excess of 95°C by external energy to effect blow molding.

In the 3-station system of which molding steps comprise three steps, "injection molding of a preform - orientation blow molding - removal of a molded article", a step of adjusting a temperature to be carried out immediately before orientation blow molding which is unavoidable in the 4-station system requiring four steps, "injection molding of a preform - temperature adjustment - orientation blow molding - removal of a molded article" is not required.

Therefore, a temperature adjusting device for a preform and other accessorial devices used in the 4-station system can be omitted, and in addition, there is a merit in construction that the number of neck molds also serving as a transfer member for a preform is reduced by one. Moreover, there is economically advantageous in that molding cycle time is also shortened and cost of machines is reduced.

However, molded articles molded by use of the 3-station system tends to be limited to wide-mouth containers. This is because of the fact that an aperture of a preform is so large that there involves no technical difficulty in designing a draft or taper from an injection mold, a core and the like, and releasing at high temperature is easily carried out.

In molding of narrow-mouth containers such as bottles which are extremely small in aperture of a preform and long in oriented portion and require a large orientation magnification, the 4-station system capable of controlling temperature immediately before blow molding has been used in terms of difficulty of temperature control of a preform and limitation of draft.

The difficulty of temperature control of a preform in the 3-station system is that there is no means for correctly detecting a state that a surface layer is heated by internal heat, and the temperature of the preform becomes uniform.

Therefore, orientation blow timing is determined making rough estimation from a lapse of time after release, and repeating a trial at that time. It requires experiences and time to effect the trial. In the case where resin as a material is polypropylene, it is often that the molding condition somewhat differs according to the manufacture lot. Therefore, the condition has to be set as needed, thus inevitably increasing a loss of products.

A method having only some of the features included in the preamble of claim 1 is disclosed in US-A - 2,331,702. According to said method an injection molded thin-walled preform may be heated externally before blow molding it in order to improve its ability to be blow molded. The external heating results in an even temperature distribution of the preform and requires a particular heating means rendering the method more expensive.

JP-A-63 296 921 discloses to even the temperature distribution across the wall thickness of a preform by using heat transfer of the heat retained internally of the wall of the preform to the surface thereof, the preform being left as it is and allowing the temperature distribution to become even.

SUMMARY OF THE INVENTION

This invention has been contemplated in order to solve the task of the high temperature release in molding involved in the 3-station. An object of this invention is to provide a new injection orientation blow molding which can mold narrow-mouth synthetic resin containers such as bottles, similarly to the case of wide-mouth containers, without being subjected to limitations of the shape, a draft, a wall-thickness distribution and the like of a preform, despite the fact that a preform made of a crystalline resin is released at a high temperature.

It is a further object of this invention to provide a new injection orientation blow molding which can mold, by three stations, bottle-like containers which are less in stress and strain which are liable to occur when a low temperature preform is orientation blow molded, which are hard to expose to shrinkage deformation at the time of filling at a high temperature caused by the stress and strain, and which are transparent and orderly in distribution of wall-thickness.

It is another object of this invention to provide a new injection orientation blow molding which can carry out the temperature adjustment of various parts of a preform at the time of injection molding whereby the orientation blow molding can be materially shortened as compared with prior art to increase a production quantity per hour.

According to a first feature of this invention for achieving the aforesaid objects, in injecting and filling molten resin into an injection mold to form it into a preform as required, holding a mouth portion of said preform by a lip mold to transfer it from the injection mold to a blow mold, and orientation blow molding the preform into a thin-wall hollow molded article as required, releasing of said preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and the orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

According to a second feature of this invention, releasing of a preform made of polyethylene terephthalate from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 60°C but below 70°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 80°C but below 95°C.

According to a third feature of this invention, releasing of a preform made of polypropylene from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 90°C but below 100°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 100°C but below 122°C. A preform made of thermoplastic synthetic resin such as polyethylene, polycarbonate, etc. other than the aforementioned resins as a crystalline resin can be orientation molded by similar means.

According to a fourth feature of this invention, internal heat of various portions of an oriented portion of a preform is controlled by a temperature of a mold maintained at a predetermined temperature and an intentionally adjusted wall-thickness distribution of the preform, and an orienting condition of an oriented portion is controlled by a difference of heat quantity which differs with the wall thickness to thereby make it unnecessary to adjust the temperature after release.

A bottle-like container obtained by orientation blow molding according to this invention has less stress and strain which are liable to occur when a low temperature preform is orientation blow molded. Accordingly, shrinkage and deformation during high-temperature filling to be caused by the stress and strain are hard to occur. Containers made of polyethylene terephthalate have an increased heat resistance.

Since a preform is oriented when the interior thereof is in a half molten state, there is hardly affected by unevenness of temperature. Since molding is finished before the interior of a preform is crystallized, a thin-wall container which is transparent and without one-sided wall thickness may be obtained.

Furthermore, since a skin layer is formed by quick cooling, releasing can be made even if the interior of a preform is soft. Even a bottle-like narrow-mouth container which has been difficult to be released at an adequate temperature and which has been required to adjust a temperature in terms of draft of a preform can be molded easily even in a 3-station similarly to the case of a wide-mouth container.

Moreover, time required for orientation blow molding is materially short as compared with prior art, thus quickening a molding cycle and increasing a production amount per hour.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a high-temperature preform.

FIG. 2 is a graph showing a change by passage of time of a high-temperature preform obtained by injection molding a crystalline resin.

FIG. 3 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 1 obtained by injection molding a polyethylene terephthalate.

FIG. 4 is a graph showing a change by passage of time of the surface temperature of a high-temperature of sample No. 2 obtained by injection molding a polyethylene terephthalate.

FIG. 5 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 3 obtained by injection molding a polyethylene terephthalate.

FIG. 6 is a graph showing a change by passage of time of the surface temperature when a preform made of polyethylene terephthalate is orientation blow molded.

FIG. 7 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 4 obtained by injection molding a polypropylene.

FIG. 8 is a graph showing a change by passage of time of the surface temperature when a preform made of polypropylene is orientation blow molded.

FIG. 9 is a graph showing a change by passage of time of the surface temperature when two preforms which are different in wall thickness are orientation blow molded.

DETAILED DESCRIPTION OF THE INVENTION

Molten resin is injected and filled into a mold to injection mold a preform 11 having a sectional construction shown in FIG. 1, and the preform is released while maintaining a temperature as high as possible from an injection mold. When the preform is left as it is at a room temperature, the surface temperature of the preform changes as shown in FIG. 2.

The change by passage of time of the surface temperature has a difference to some extent in time till it reaches a peak temperature but most thermoplastic resins used to mold containers indicate similar progress. A rise of initial surface temperature is caused by the fact that in a preform released at a high temperature, the surface of cavity of a mold or the surface of a preform in contact with a core is solidified by cooling the mold to form a skin layer but internal cooling is not yet finished and temperature is high which is in a half-molten state, and cooling is cut off by releasing after which the skin layer is heated from inside.

Of course, in such a state, the temperature of the preform is not uniform except a mouth portion completely cooled and solidified at the time of release. When orientation blow molding takes place in a state where a temperature difference between inner and outer portions of a preform is present, white turbidity due to crystallization or crazing occurs. Therefore, in the aforementioned conventional method, the temperature of the preform is made uniform before orientation blowing.

According to the researches by the present inventor, the white turbidity of a molded article in the orientation blow molding often results from the temperature of orientation blow molding rather than a temperature difference between inner and outer portions.

According to experiments so far conducted, in case of polyethylene terephthalate, when the surface temperature of a preform is less than 80°C, the white turbidity tends to occur. It was also found that when the surface temperature of a preform immediately after release is 80°C or more and orientation blow molding takes place after passage of very short time, crazing rarely occurs.

It has been also found however that even such a case, when cooling time is long and the temperature immediately after release is less than 80°C, the white turbidity tends to occur in an article injection blow molded even if the orientation blow molding temperature is 80°C or more.

In case of polyethylene terephthalate, when cooling time is set shortly and the surface temperature immediately after release is set to be 70°C or more, the peak temperature is often 95°C or more. In molding under such a set condition as described, one-sided wall thickness tends to occur, and rigidity is lost.

Accordingly, cooling time of a preform in an injection mold is limited within a certain predetermined time. However, cooling is different according to wall thicknesses even in case of the same resin and further different according to temperatures of cooling water to be used therefor. An allowable range with the same wall thickness is more or less one second in case of polyethylene terephthalate. It is possible to obtain a surface temperature immediately after release capable of molding a narrow-mouth container which is transparent and well ordered in shape within the aforesaid allowable range.

Similarly, with respect to a preform made of polypropylene, the surface temperature rapidly rises from a temperature at the time of release at a room temperature and reaches a peak, after which the peak temperature is maintained for a long period of time and gradually lowers.

Time at which temperature of the whole preform is made uniform due to the internal temperature is obscure from the change by passage of time of the surface temperature. However, in conventional orientation blow molding of a high-temperature wide-mouth preform, orientation blow molding is carried out about 17 seconds after release. Therefore, orientation blow molding was tried around the diagonal line with such a time as described used as a standard. For a preform for a wide-mouth container, it was possible to mold a thin-wall wide-mouth container of which body portion is transparent in about 17 seconds.

However, in case of a preform for a narrow-mouth container which is large in orientation magnification than the case of a wide-mouth container, even those which are so large in draft as to be easily released, one-sided wall thicknesses and defective molding of a bottom often occur, failing to provide a molded article.

However, even in the case of polypropylene, when the surface temperature immediately after release is 90°C or more and the temperature of orientation blow molding is 110°C or more, a narrow-mouth container can be molded. The allowable range of cooling time with the same wall thickness was more or less 1 seconds.

It is apparent from an attempt of orientation blow molding that when orientation blow molding is carried out after passage of a given time for the purpose of making a temperature of a preform uniform after release, the preform is subjected to gradual cooling, and therefore, whiteness caused by crystallization tends to occur. Naturally, it becomes difficult to mold a narrow-mouth container.

Accordingly, hardness or ease of orientation blow molding of a preform released at a high temperature is not only affected by unevenness of temperature but greatly affected by a composition of a high-temperature preform which changes by passage of time, orientation blow timing, etc.

The high-temperature preform 11 after release is low in surface temperature as can be seen in FIG. 1 immediately after it is released from the injection mold, and therefore, the surface thereof forms a skin layer 12 having a hardness. However, the forming condition of the skin layer 12 is different according to the cooling speed.

In the high-temperature release, a central portion is not cooled, and the internal resin 13 has a fluidity to some extent at a high temperature. A draw-down is prevented by the skin layer 12 of the surface, and even after release, the form of the preform 11 is maintained.

The internal temperature is released outside as time passes and at the same time the skin layer 12 forming the surface is heated from inside. Therefore, the surface temperature abruptly rises, and the skin layer 12 becomes softened whereas the internal temperature lowers. Therefore, the flowing portion is reduced toward the center portion.

The skin layer 12 whose surface temperature reaches a peak is thin to a degree that forms a skin, and the interior thereof is in a half hardened state.

After the peak, the surface temperature slowly lowers as time passes. As for the whole preform, the temperature becomes uniform and at the same time, crystallization progresses.

In the high-temperature preform till the surface temperature reaches a peak, even if the surface is solidified to form the skin layer 12, the skin layer 12 is softened in the vicinity of the peak temperature, which is in the state where orientation can be made.

A thick-wall portion which is high in internal heat of the skin layer 12 is first softened by heat received from inside. There is a temperature difference between a thick wall portion and a thin wall portion till some time passes after the surface temperature reaches the peak, and the aforesaid difference is evident particularly before peak.

When orientation blow molding takes place in such a state as described, the skin layer on the side of the thick wall portion where much heat is present, that is, on the side in which surface temperature is high is first oriented in the state where, internal resin in a softened state is embraced.

Naturally, the surface area increases due to the orientation, and as the result, the radiant surface becomes large and the temperature lowers to eliminate a temperature difference from the thin wall side. Furthermore, the temperature on the thin wall side relatively rises, and subsequently, orientation of the thin wall portion precedes. Such a mutual orientation is repeatedly carried out for an extremely short period of time, and the internal temperature with much heat amount during that period lowers to a temperature suitable for orientation. And, the internal resin 13 so far oriented while being accompanied by the skin layer 12 is thinly oriented similarly to the skin layer 12 halfway, whereby a molded article having a uniform distribution of wall thickness is formed.

Accordingly, in the injection molding of the preform 11, first, orientation amount of various portions of the preform 11 is taken into consideration in advance from the shape of a container 14 to be a molded article whereby the wall-thickness distribution of the various portions is intentionally adjusted whereas the temperature of the injection mold is maintained constant, and preferably, cooling of the preform 11 molded by being injected and filled in the cavity is uniformly carried out at any portion.

For the high-temperature preform 11 formed with the skin layer 12 by quick cooling, the best result was obtained by molding at the time before the surface temperature reaches the peak. At the time seemed to have reached the peak, one-sided wall thickness tends to occur, failing to obtain a good result.

The surface temperature when orientation blow molding takes place was 80°C or more and 110°C or more for polyethylene terephthalate and polypropylene, respectively, and time after release was more or less 3 seconds and more or less 14 seconds for the former and the latter, respectively.

However, it is apparent from the foregoing attempts that the better result cannot be obtained unless the skin layer 12 is formed by quick cooling. This seems to have resulted from a difference of a crystalline state produced in the skin layer 12 by cooling. A crystal due to quick cooling forms a fine crystal. In case of gradual cooling, a crystal greatly grows, and joining of crystals with each other is weaker than the fine crystal.

More preferably, orientation blow molding is carried out in the range of temperature capable of adapted to wall thicknesses of any portion of the preform 11.

According to the attempt by the present inventor, most conveniently, if a difference of wall thickness is 0.25 mm or so, there is no much difference in the peak temperature and the time till the peak is reached even if a difference of surface temperature immediately after release is present. Moreover, there involves no much technical difficulty to timely grasp the temperature range to make orientation blow molding for both possible.

In the case where heat amount of various portions is controlled in the injection mold with a difference of wall thickness intentionally provided as a means for controlling an orientation degree of various portions of the preform from the shape of a molded article, the difference of wall thickness is very minute and is mostly within the allowable time including the difference of wall thickness in case of a flat container which is materially different in orientation degree between lateral and longitudinal portions thereof.

Accordingly, there involves not much technical difficulty in that the internal heat of various portions of the oriented portion of the preform is controlled by the temperature of the mold maintained at constant temperature and the intentionally adjusted wall thickness distribution of the preform, and the orienting condition of the oriented portion is controlled by the difference of heat amount different according to the wall thickness.

Embodiment 1

Molten resin of polyethylene terephthalate was injected and filled into an injection mold to form a narrow-mouth preform 11 as shown in FIG. 1 by quick cooling.

Three examples of preforms different in wall thickness were injection molded changing cooling time sample by sample, and the change by passage of time of the surface temperature was measured.

The preform is prepared for one-litre container whose overall length is 124 mm. Temperatures of the preform were measured at three points, 30 mm, 60 mm, and 100 mm upwardly from the bottom, and temperatures to be measured were an average value.

As a temperature measuring unit, a digital radiation thermometer IR-AHOT (made by K.K. Chino) was used.

The injection molding conditions are as follows:

Weight of material	33 gr
Injection temperature	275°C
Mold temperature	13°C
Draft	1.5°
Injection and filling time	5.3 sec.
Note: The mold temperature means a cooling water temperature of a cavity mold and a core mold.	

FIGS. 3 to 5 show the change by passage of time (average value) of the surface temperatures of the following samples at a room temperature (22°C), main points of which are as given in Table 1 below.

TABLE 1

Preform Wall thickness (mm)		Cooling Time (sec)	Preform Temperature (°C)		Peak Time (sec)
			1 sec after release	Peak	
Sample No.1 2.80	1	3.0	72.0	96.0	11
	2	3.5	68.7	88.0	10
	3	4.0	68.0	86.0	9
	4	4.5	66.9	83.0	9
	5	5.0	62.3	79.8	7
Sample No.2 3.05	1	3.6	71.3	96.2	12
	2	3.9	65.1	87.9	11
	3	4.2	63.8	86.3	13
	4	4.5	62.5	83.8	9
	5	4.8	60.3	81.5	10
	6	5.5	57.0	80.2	10
Sample No.3 3.30	1	3.5	70.5	92.8	11
	2	4.9	67.4	87.9	12
	3	5.2	63.2	85.7	10
	4	5.5	62.6	83.9	9
	5	5.8	60.5	82.2	9
	6	6.5	58.0	79.0	11

Cooling time is time after passage of injection and filling time.

For the above-described samples, orientation blow molding was carried out under blow air pressure of 14 kg/cm² to form a bottle-like container 14 as indicated by the broken line in FIG. 1. It has been found that the best result was obtained when orientation blow molding was carried out within the time shown in FIG. 6, that is, within time t between time t_1 before the surface temperature reaches the peak and time t_2 seemed to have reached the peak. However, in case of a preform whose surface temperature immediately after release is outside the range of 60°C to 70°C at a normal temperature or a preform whose surface temperature at the time of orientation blowing molding is outside the temperature region of 80°C to 95°C, satisfactory molded articles were not obtained as shown in Table 2 below.

TABLE 2

Preform wall thickness (mm)	Temperature 1 sec. after release	Temperature at orientation blow molding	Time of passage (sec.)	Molded state of molded articles. Wall thickness of body portion: 0.3 mm
Sample No. 1 2.80	71.0	95.5	9.0	Bad, short of rigidity, one-sided wall thickness
	68.7	87.9	7.0	Good
	68.0	85.5	8.0	Good
	66.9	82.0	7.5	Good
	62.3	79.5	6.0	Bad, short of rigidity, one-sided wall thickness
Sample No. 2 3.05	71.3	95.0	8.0	Bad, short of rigidity, one-sided wall thickness
	65.1	86.8	7.0	Good
	63.8	85.0	7.5	Good
	62.5	82.8	8.0	Good
	60.3	81.4	8.0	Good
	57.0	79.0	7.5	Bad, white turbidity, large one-sided wall thickness
Sample No. 3 3.20	70.5	92.0	8.0	Bad, short of rigidity, one-sided wall thickness
	67.4	88.0	8.5	Good
	63.2	85.7	9.5	Good
	62.6	83.0	6.5	Good
	60.5	82.4	6.5	Good
	58.0	78.5	8.5	Bad, white turbidity, large one-sided wall thickness

In Table 2, the time of passage is time from release of a preform to start of orientation blow molding. The results obtained by molding a few samples in the range of more or less one second on the time of passage were shown in the molded state.

Embodiment 2

Molten resin of polypropylene was injected and filled into an injection mold to form a narrow-mouth preform 11 as shown in FIG. 1 similar to the case of Embodiment 1 by quick cooling.

Eight preforms having the same wall thickness were injection molded changing cooling time, and the change by passage of time of the surface temperatures thereof at room temperature were measured.

The injection molding conditions are as follows:

Weight of material	40 gr
Injection temperature	240°C
Mold temperature (cooling water)	13°C
Draft	3.0°
Injection and filling time	6.0 sec.

FIG. 7 shows the change by passage of time (average value) of the surface temperatures of the following samples at a room temperature (22°C), main points of which are as given in Table 3 below.

TABLE 3

Preform wall thickness (mm)		Cooling Time (sec)	Preform Temperature (°C)		Peak Time (sec)
			1 sec after release	Peak	
Sample No.4 4.10	1	1.5	105.0	124.0	19
	2	2.0	95.5	121.4	18
	3	2.5	93.0	118.0	18
	4	3.0	92.5	117.6	16
	5	3.5	91.5	113.5	18
	6	4.5	91.0	113.3	17
	7	6.0	90.5	111.8	18
	8	5.5	89.0	110.5	17

For the above-described sample No. 4, orientation blow molding was carried out under blow air pressure of 12 kg/cm² within the time shown in FIG. 6 similar to the case of polyethylene terephthalate to form a bottle-like container 14 as indicated by the broken line in FIG. 1. It has been found that the best result was obtained when orientation blow molding was carried out within the time shown in FIG. 8, that is, within time t between time t_1 before the surface temperature reaches the peak and time t_2 seemed to have reached the peak.

However, in case of a preform whose surface temperature immediately after release is outside the range of 90°C to 100°C at a normal temperature or a preform whose surface temperature at the time of orientation blow molding is outside the temperature region of below 110°C or above 123°C, satisfactory results were not obtained as shown in Table 4 below.

TABLE 4

Preform wall thickness (mm)		Temperature 1 sec. after release	Temperature at orientation blow molding	Time of passage (sec.)	Molded state of molded articles. Wall thickness of body portion: 0.5 mm
Sample No. 4 4.10	1	105.0	123.5	15.5	Bad, large one-sided wall thickness, burst
	2	95.5	120.5	14.5	Good
	3	93.0	117.3	13.5	Good
	4	92.5	116.8	12.5	Good
	5	91.6	112.5	14.0	Good
	6	91.0	113.0	14.0	Good
	7	90.5	111.3	14.0	Good
	8	89.0	110.0	15.0	Bad, large one-sided wall thickness, burst

It is apparent from FIGS. 3 to 5 showing the change by passage of time that in injection molding the preform 11, there is an allowable range of cooling time. It is also apparent that when the allowable time are compared between those different in wall thickness, there is cooling time adapted to each other.

FIG. 9 is a graph which selects two cooling time adapted to each other with respects to sample Nos. 1 and 2 from Table 1 to depict the change by passage of time of the surface temperatures in that case. A temperature difference Δt at the allowable time of orientation blow molding of a thick wall thickness portion D1 and a thin wall thickness portion D2 was 2.5°C to 3.0°C.

Orientation blow molding was carried out for a narrow-mouth container from a preform with distribution of wall thickness intentionally changed.

Embodiment 3

A preform 11 shown in FIG. 1 whose wall thickness is made thin from an upper portion toward a bottom thereof so as to have a difference in wall thickness distribution of the whole body was injection molded from polyethylene terephthalate, and one-litre container 14 was orientation blow molded from the preform.

In injection molding, intentionally, the wall thickness, 3.05 mm, of the D1 portion of the preform 11 is differentiated from the wall thickness, 2.80 mm, of the D2 portion. Furthermore, cooling time adapted to the wall thicknesses for both was selected from sample Nos. 1 and 2 in Table 1 so that the surface temperature of the preform immediately after release is in the range of 60°C to 70°C.

Injection molding conditions:

Weight of material	33 gr
Injection temperature	275°C
Mold temperature (cooling water)	13°C
Draft	1.5°
Injection and filling time	5.3 sec



Example 1:

Cooling time (1)	4.1 sec
Surface temperature (D1)	
Immediately after release	53.8°C
At blow molding	85.7°C
Surface temperature (D2)	
Immediately after release	68.0°C
At blow molding	86.0°C

Example 2:

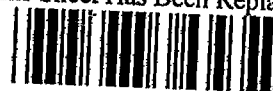
Cooling time (2)	4.5 sec.
Surface temperature (D1)	
Immediately after release	82.4°C
At blow molding	82.5°C
Surface temperature (D2)	
Immediately after release	67.0°C
At blow molding	82.6°C
Time of passage (after release)	7.5 sec.
Blow air pressure	14 kg/cm ²

In the Examples 1 and 2, the molded state of the orientation blow molded container 14 was good. The transparency of the container is excellent, one-sided wall thickness thereof was hardly recognized, and the wall thickness (0.3 mm) of the body portion was uniform.

It is understood from the foregoing that the most preferable molding method for the 3-station system is to adjust wall thicknesses of various portions of oriented portions of a preform according to an orienting state and control an orienting state of an oriented portion from a difference of heat amount different according to the wall thickness, in other words, to carry out orientation blow molding in the state where the temperature of the preform is uneven as a whole. Adjustment of a wall thickness can be easily made by grinding a core mold or applying a padding through plating or the like, and a delicate difference of wall thickness can be also provided.

Claims

1. An injection orientation blow molding method comprising the steps of injecting and filling molten resin into an injection mold to form it into a preform (11), said injection mold comprising a lip mold holding a mouth portion of said preform (11),
quick cooling the preform (11) in the injection mold to a state in which the shape of the preform (11) can be maintained by a skin layer (12) produced on the surface of the preform (11) by said cooling and in which the temperature in the resin (13) internally of the skin is still high,
releasing the preform (11) from the injection mold during said state while the preform (11) is held in said lip mold, transferring the preform (11) from said injection mold to a blow mold while held in said lip mold,



and blow molding in said blow mold a thin-wall hollow article (14) from said-preform (11), characterised in that said hollow article (14) is orientation blow molded within a time after release of the preform (11) from the injection mold until the surface temperature of the preform (11), which rises responsive to heat transfer from the resin (13) internal of the skin (12) to the surface of the preform (11), reaches a peak temperature.

2. A method as claimed in claim 1 for molding a hollow article of polyethylene terephthalate, characterised in that the preform (11) is cooled to such an extent that immediately after release of the preform (11) from the injection mold to air at normal temperature the surface temperature of the preform (11) is above 60°C but below 70°C and that the orientation blow molding is carried out within a time until the surface temperature of the preform (11) reaches a peak temperature above 80°C but below 95°C.
3. A method as claimed in claim 1 for molding a hollow article of polypropylene, characterised in that the preform (11) is cooled to such an extent that immediately after release of the preform (11) from the injection mold to air at normal temperature the surface temperature of the preform (11) is above 90°C but below 100°C, and that the orientation blow molding is carried out within a time until the surface temperature of the preform (11) reaches a peak temperature above 100°C but below 122°C.
4. A method as claimed in claim 1, wherein the resins used to form the preform (11) comprise crystalline resins such as polyethylene and polycarbonate.
5. A method as claimed in any of claims 1 to 3 wherein the orientation degree of an oriented portion of the hollow article (14) is controlled by controlling the quantity of heat included in the corresponding portion of the preform (11) and that said quantity of heat is controlled by intentionally adjusting the wall thickness of the corresponding portion of the preform (11) while the temperature of the injection mold is maintained at a predetermined value.
6. A method as claimed in any of claims 1 to 3 and 5 wherein the cooling time is so selected that for any wall thicknesses present in the preform (11) the surface temperature after release of the preform (11) allows orientation blow molding of the hollow article (14) as defined in claim 1.
7. A method as claimed in any of claims 1 to 3 and 5 and 6 wherein the degree of orientation of various portions of the hollow article (14) is adjusted by intentionally adjusting the wall thickness in respectively corresponding portions of the injection molded preform (11).

INJECTION ORIENTATION BLOW MOLDING METHOD

ABSTRACT

A molding method for continuously carrying out the steps from injection molding of a synthetic resin preform to orientation blow molding thereof into a thin-wall hollow molded article, characterized in that releasing of the preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

FIGURE 2.

FIG.1

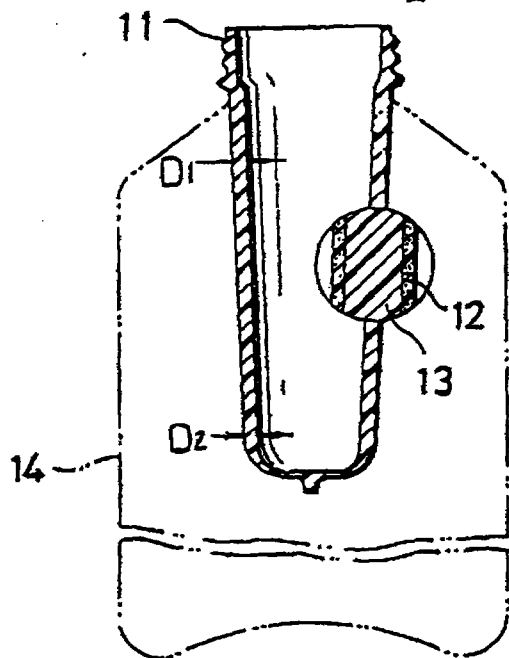
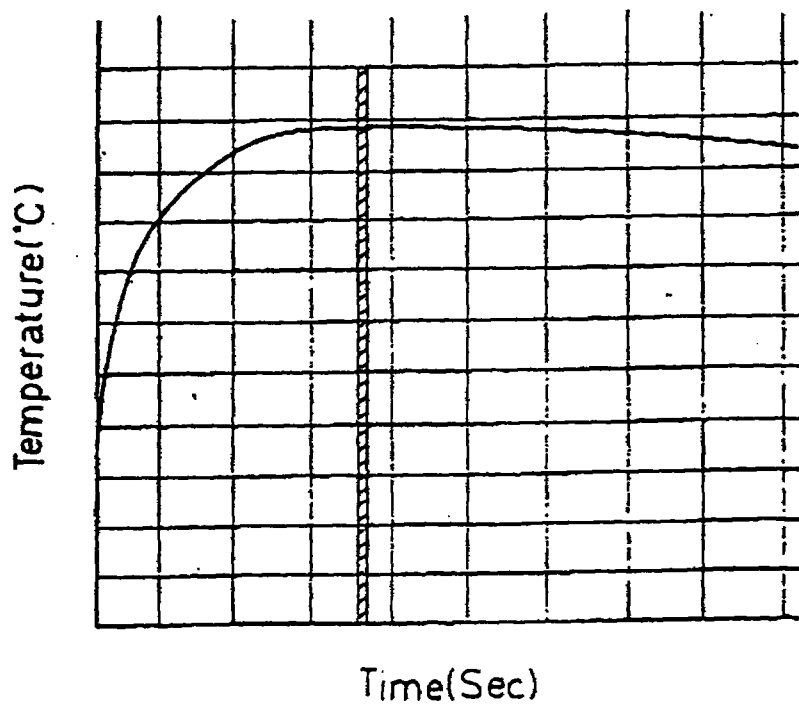
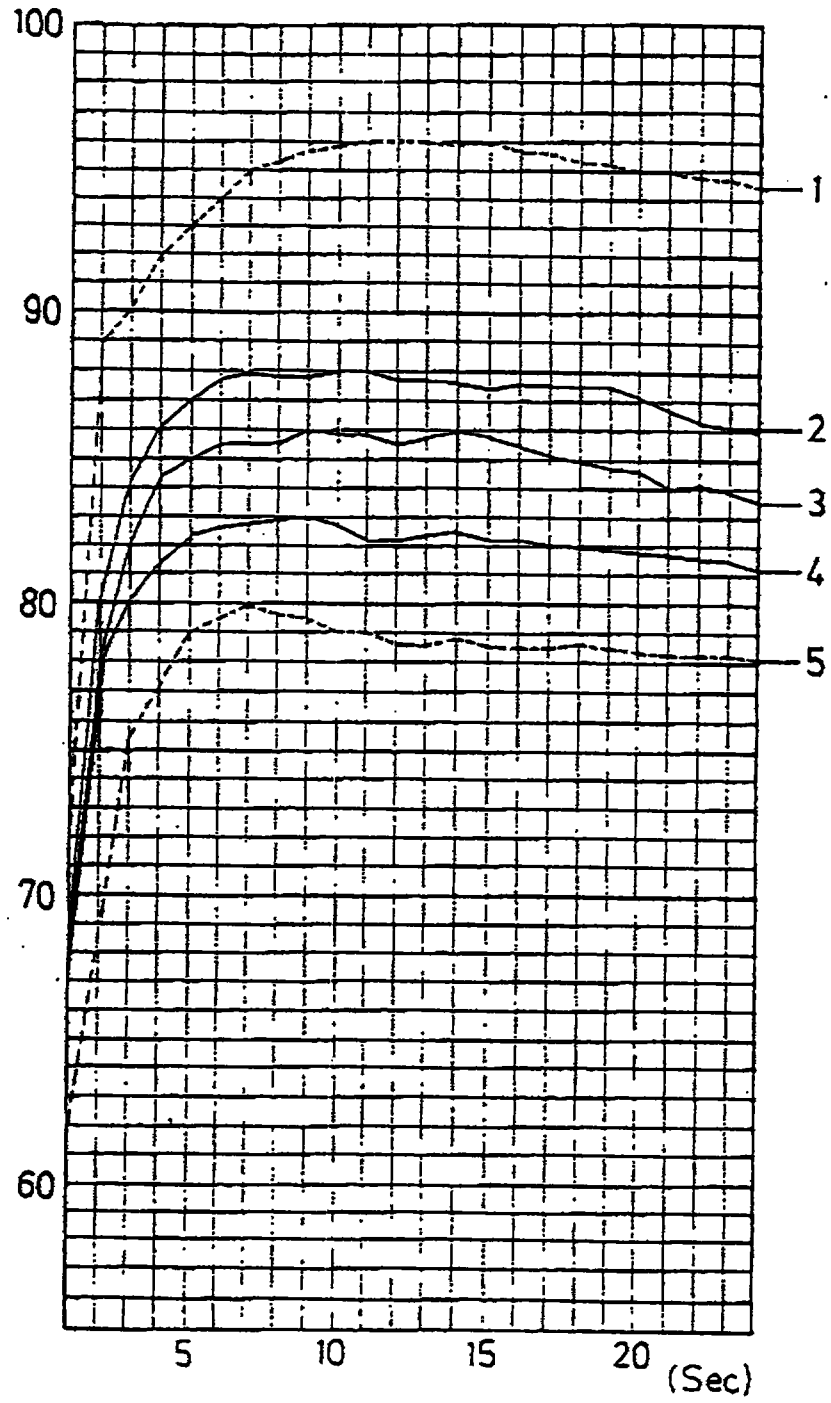


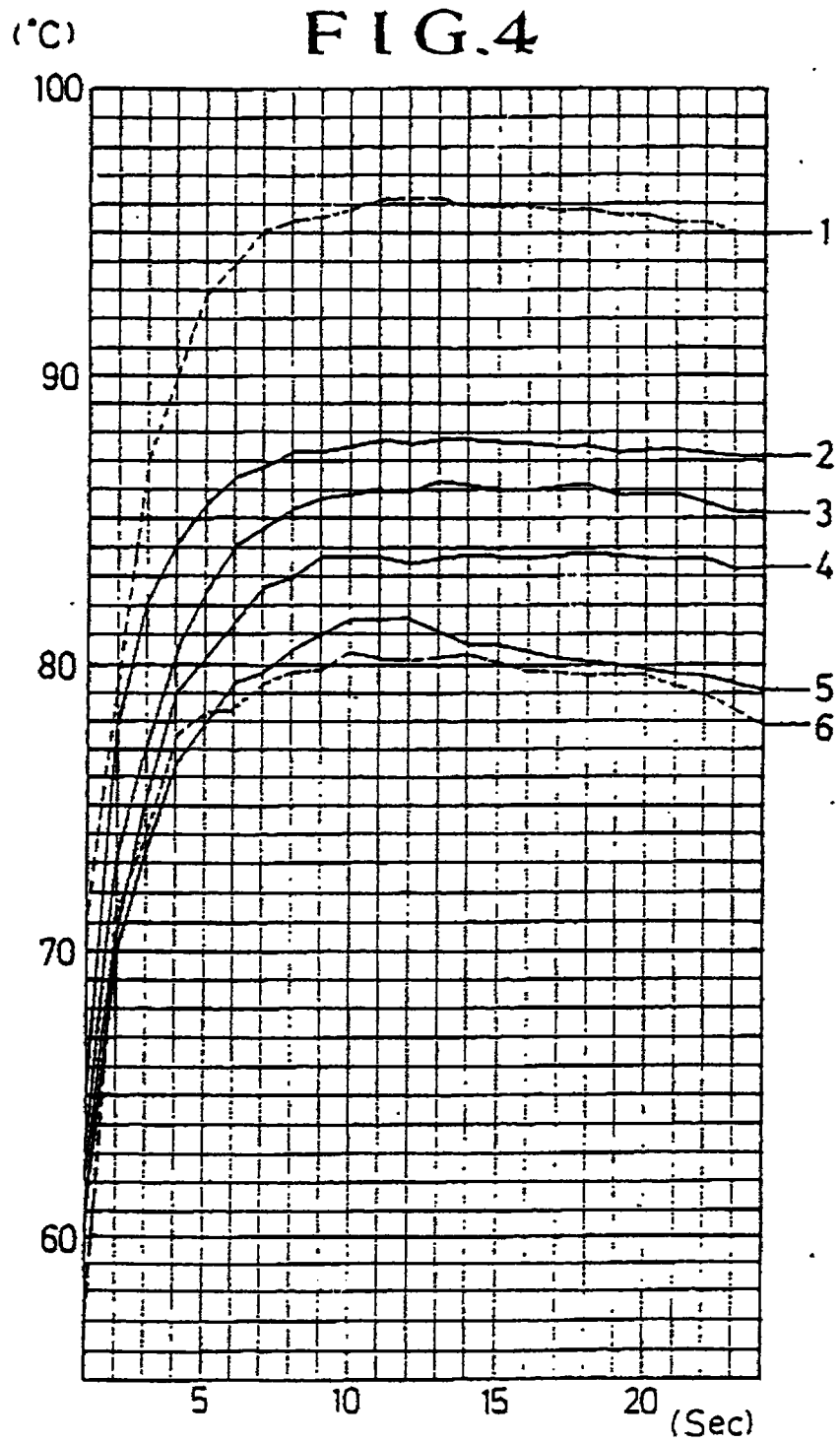
FIG.2



(°C)

FIG.3





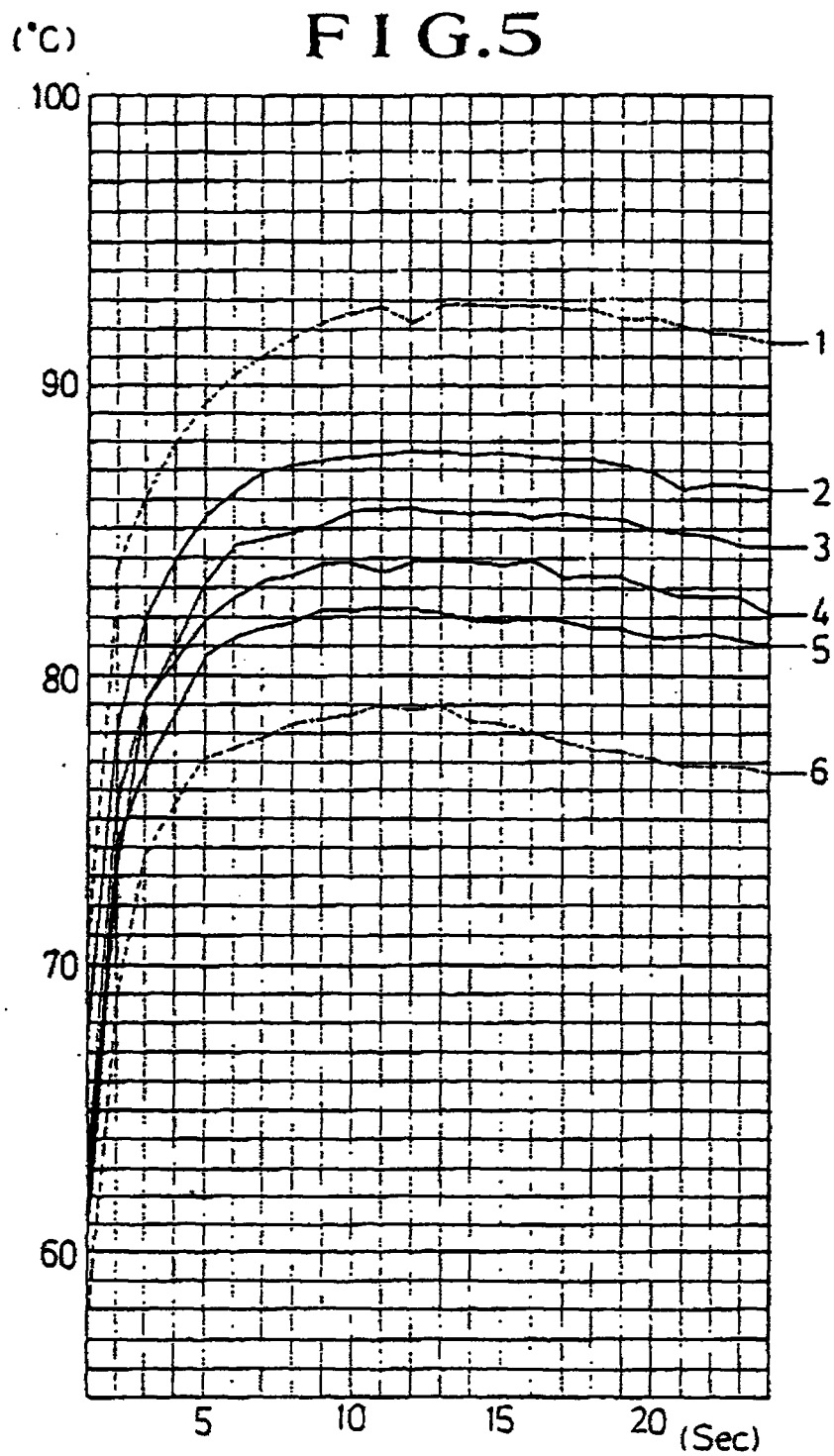
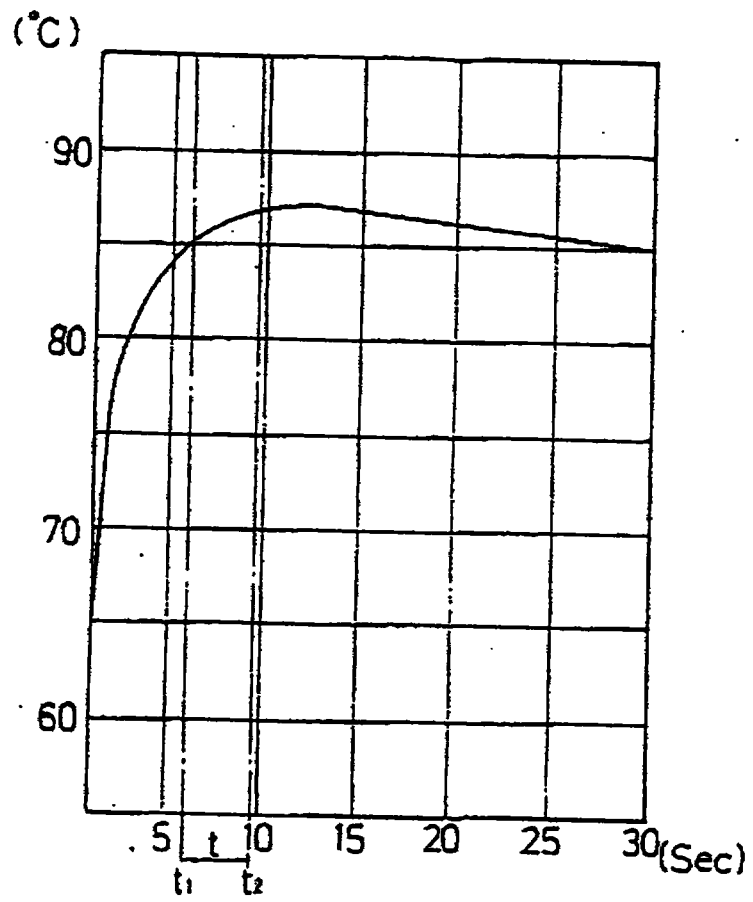


FIG.6



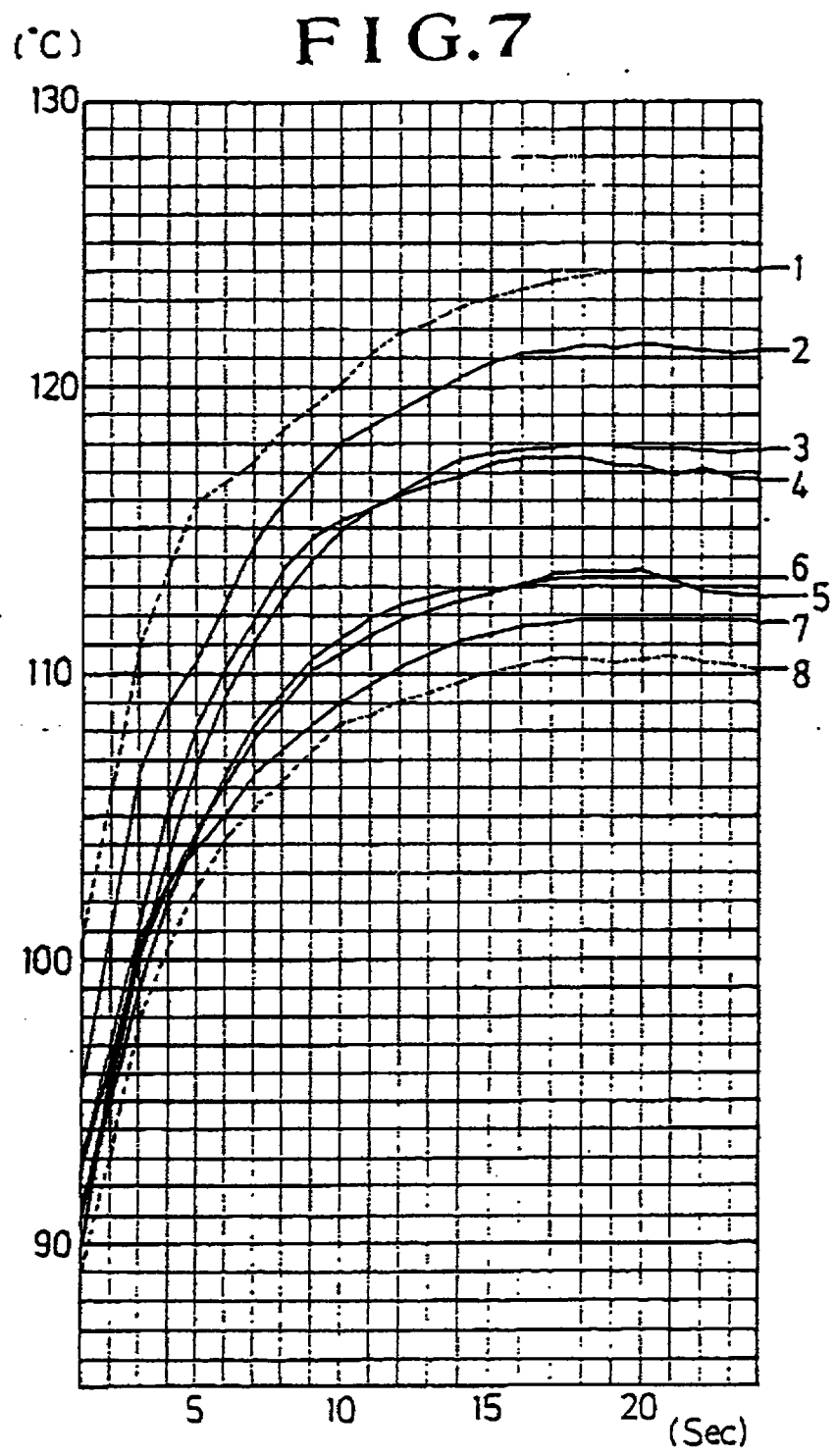
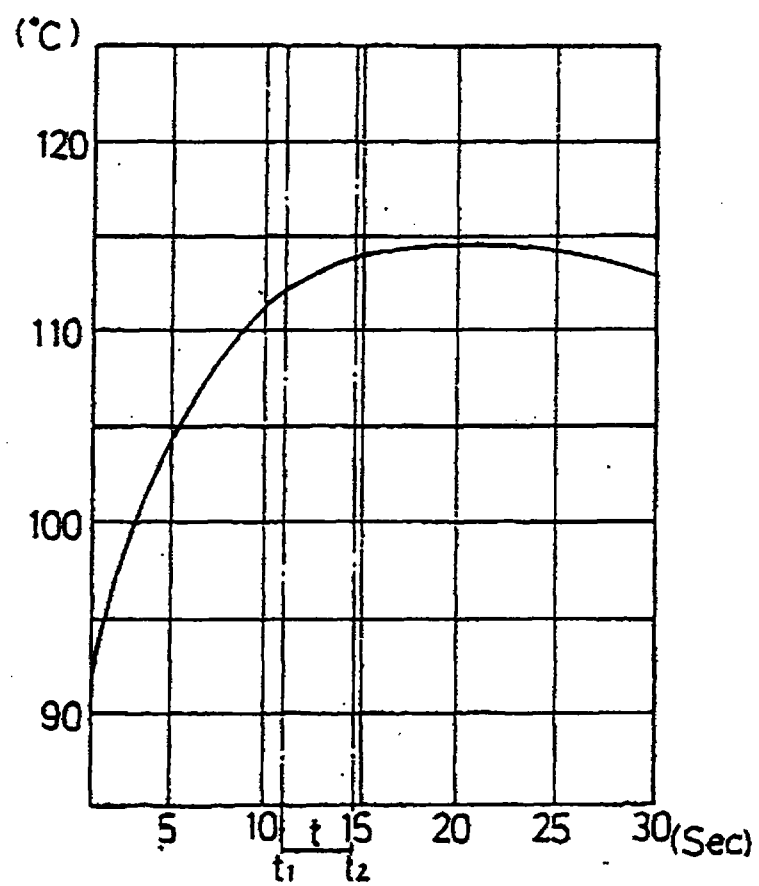
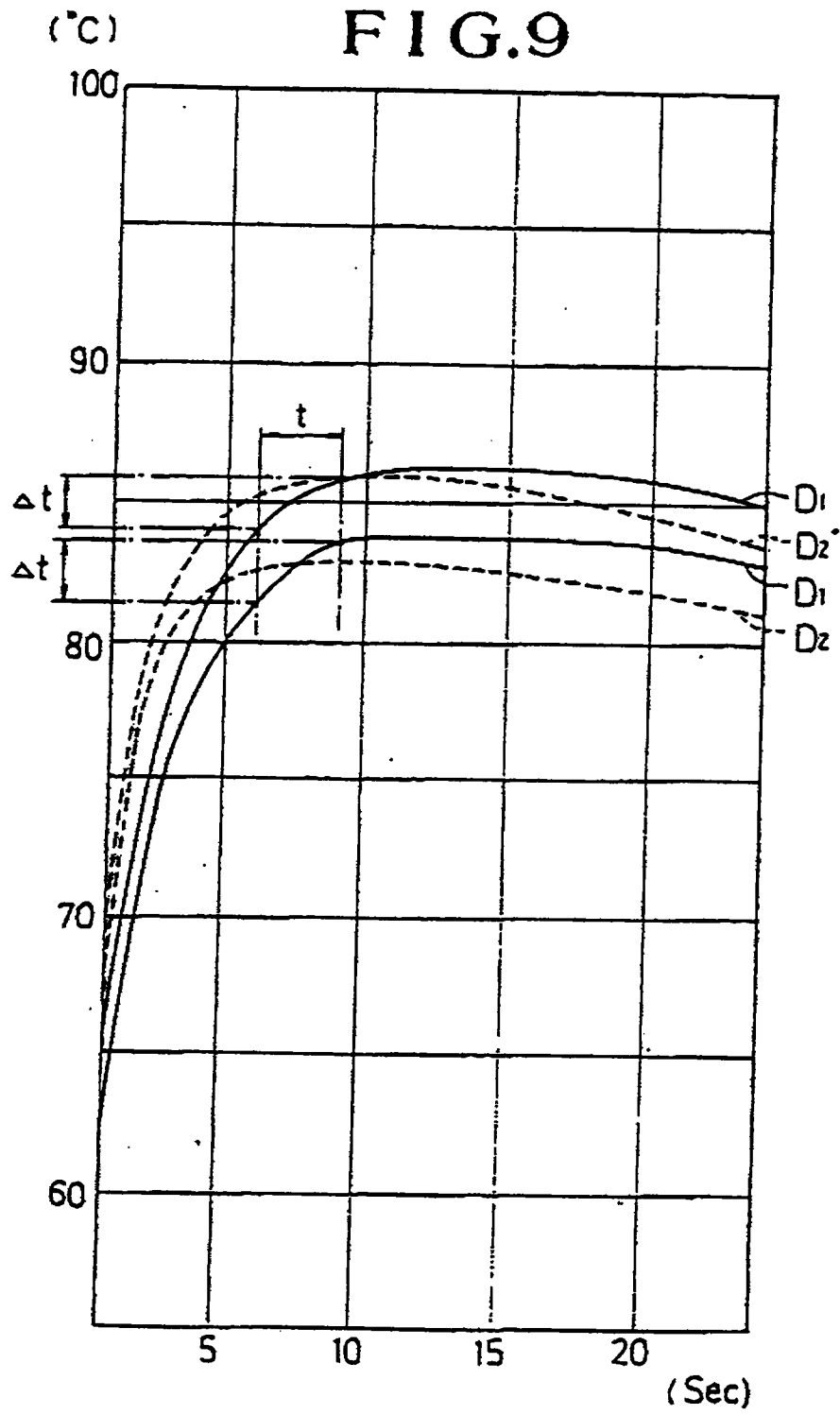


FIG.8





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Example 1:

REPLACEMENT SHEETS SG	
☒ Description :	paged .10 to paged .10
☒ Claim(s) :	paged .11 to paged .11
☐ Drawing(s) :	paged . to paged .
☐ Abstract :	paged . to paged .
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Cooling time (1)	4.1 sec
Surface temperature (D1)	
Immediately after release	63.8°C
At blow molding	85.7°C
Surface temperature (D2)	
Immediately after release	68.0°C
At blow molding	86.0°C

Example 2:

Cooling time (2)	4.5 sec.
Surface temperature (D1)	
Immediately after release	62.4°C
At blow molding	82.5°C
Surface temperature (D2)	
Immediately after release	67.0°C
At blow molding	82.6°C
Time of passage (after release)	7.5 sec.
Blow air pressure	14 kg/cm ²

In the Examples 1 and 2, the molded state of the orientation blow molded container 14 was good. The transparency of the container is excellent, one-sided wall thickness thereof was hardly recognized, and the wall thickness (0.3 mm) of the body portion was uniform.

It is understood from the foregoing that the most preferable molding method for the 3-station system is to adjust wall thicknesses of various portions of oriented portions of a preform according to an orienting state and control an orienting state of an oriented portion from a difference of heat amount different according to the wall thickness, in other words, to carry out orientation blow molding in the state where the temperature of the preform is uneven as a whole. Adjustment of a wall thickness can be easily made by grinding a core mold or applying a padding through plating or the like, and a delicate difference of wall thickness can be also provided.



Claims

1. An injection orientation blow molding method comprising the steps of injecting and filling molten resin into an injection mold to form it into a preform (11), said injection mold comprising a lip mold holding a mouth portion of said preform (11),
quick cooling the preform (11) in the injection mold to a state in which the shape of the preform (11) can be maintained by a skin layer (12) produced on the surface of the preform (11) by said cooling and in which the temperature in the resin (13) internally of the skin is still high,
releasing the preform (11) from the injection mold during said state while the preform (11) is held in said lip mold, transferring the preform (11) from said injection mold to a blow mold while held in said lip mold,
and blow molding in said blow mold a thin-wall hollow article (14) from said preform (11),
characterised in that said hollow article (14) is orientation blow molded within a time after release of the preform (11) from the injection mold until the surface temperature of the preform (11), which rises responsive to heat transfer from the resin (13) internal of the skin (12) to the surface of the preform (11), reaches a peak temperature.
2. A method as claimed in claim 1 for molding a hollow article of polyethylene terephthalate, characterised in that the preform (11) is cooled to such an extent that immediately after release of the preform (11) from the injection mold to air at normal temperature the surface temperature of the preform (11) is above 60°C but below 70°C and that the orientation blow molding is carried out within a time until the surface temperature of the preform (11) reaches a peak temperature above 90°C but below 95°C.
3. A method as claimed in claim 1 for molding a hollow article of polypropylene, characterised in that the preform (11) is cooled to such an extent that immediately after release of the preform (11) from the injection mold to air at normal temperature the surface temperature of the preform (11) is above 90°C but below 100°C, and that the orientation blow molding is carried out within a time until the surface temperature of the preform (11) reaches a peak temperature above 100°C but below 122°C.
4. A method as claimed in claim 1, wherein the resins used to form the preform (11) comprise crystalline resins such as polyethylene and polycarbonate.
5. A method as claimed in any of claims 1 to 3 wherein the orientation degree of an oriented portion of the hollow article (14) is controlled by controlling the quantity of heat included in the corresponding portion of the preform (11) and that said quantity of heat is controlled by intentionally adjusting the wall thickness of the corresponding portion of the preform (11) while the temperature of the injection mold is maintained at a predetermined value.
6. A method as claimed in any of claims 1 to 3 and 5 wherein the cooling time is so selected that for any wall thicknesses present in the preform (11) the surface temperature after release of the preform (11) allows orientation blow molding of the hollow article (14) as defined in claim 1.
7. A method as claimed in any of claims 1 to 3 and 5 and 6 wherein the degree of orientation of various portions of the hollow article (14) is adjusted by intentionally adjusting the wall thickness in respectively corresponding portions of the injection molded preform (11).

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☒ Claim(s) : paged26 to paged28	
☒ Drawing(s) : paged1 to paged8	
☒ Abstract : paged ...29 to paged ...29	

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REPLACEMENT SHEETS	SG
☒ Description : paged ...1. to paged ...25	
☒ Claim(s) : paged ...26 to paged ...28	
☒ Drawing(s) : paged ...1 to paged ...8	
☒ Abstract : paged ...29 to paged ...29	
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TITLE OF THE INVENTION

INJECTION ORIENTATION BLOW MOLDING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a molding method for continuously performing orientation blow molding from injection molding of a preform made of synthetic resin to a thin-wall hollow molded article.

Prior Art

As one of molding methods generally called injection orientation blow molding, there is a 3-station molding method in which a mouth portion of an injection molded preform is held by a lip mold and the preform is immediately transferred to a blow mold for orientation blow molding.

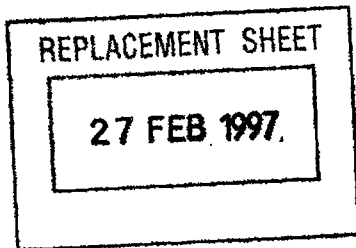
In a molding method of a 3-station system disclosed in Japanese Patent Application Laid-Open No. 63-296921, orientation blow molding is carried out after inner and outer temperatures of a preform released at a high temperature are made uniform by internal heat of the preform itself to eliminate a temperature difference therebetween.

A technical idea for releasing a preform at a high temperature is already disclosed in a molding method of 4-station system.

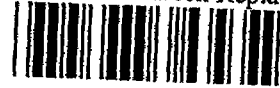
This molding method comprises releasing a preform

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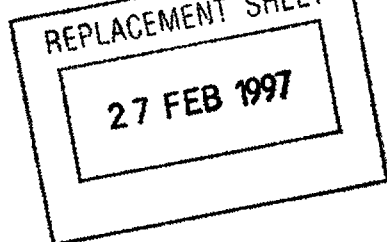
- 2 -

made of injection molded polyethylene terephthalate in a range of temperature at which shape is maintained at a high temperature, making uniform a temperature difference between inner and outer surfaces and an internal center portion in the same plane section of the preform, and thereafter adjusting the temperature of the preform to a high temperature in excess of 95°C by external energy to effect blow molding.

In the 3-station system of which molding steps comprise three steps, "injection molding of a preform - orientation blow molding - removal of a molded article", a step of adjusting a temperature to be carried out immediately before orientation blow molding which is unavoidable in the 4-station system requiring four steps, "injection molding of a preform - temperature adjustment - orientation blow molding - removal of a molded article" is not required.

Therefore, a temperature adjusting device for a preform and other accessorial devices used in the 4-station system can be omitted, and in addition, there is a merit in construction that the number of neck molds also serving as a transfer member for a preform is reduced by one. Moreover, there is economically advantageous in that molding cycle time is also shortened and cost of machines is reduced.

However, molded articles molded by use of the 3-station system tends to be limited to wide-mouth containers. This is because of the fact that an aperture of a preform



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is so large that there involves no technical difficulty in designing a draft or taper from an injection mold, a core and the like, and releasing at high temperature is easily carried out.

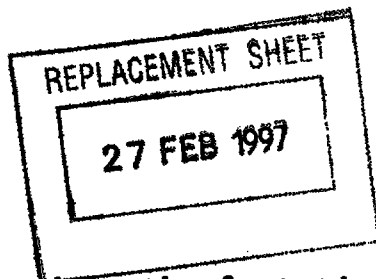
In molding of narrow-mouth containers such as bottles which are extremely small in aperture of a preform and long in oriented portion and require a large orientation magnification, the 4-station system capable of controlling temperature immediately before blow molding has been used in terms of difficulty of temperature control of a preform and limitation of draft.

The difficulty of temperature control of a preform in the 3-station system is that there is no means for correctly detecting a state that a surface layer is heated by internal heat, and the temperature of the preform becomes uniform.

Therefore, orientation blow timing is determined making rough estimation from a lapse of time after release, and repeating a trial at that time. It requires experiences and time to effect the trial. In the case where resin as a material is polypropylene, it is often that the molding condition somewhat differs according to the manufacture lot. Therefore, the condition has to be set as needed, thus inevitably increasing a loss of products.

SUMMARY OF THE INVENTION

This invention has been contemplated in order to solve the task of the high temperature release in molding



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involved in the 3-station. An object of this invention is to provide a new injection orientation blow molding which can mold narrow-mouth synthetic resin containers such as bottles, similarly to the case of wide-mouth containers, without being subjected to limitations of the shape, a draft, a wall-thickness distribution and the like of a preform, despite the fact that a preform made of a crystalline resin is released at a high temperature.

It is a further object of this invention to provide a new injection orientation blow molding which can mold, by three stations, bottle-like containers which are less in stress and strain which are liable to occur when a low temperature preform is orientation blow molded, which are hard to expose to shrinkage deformation at the time of filling at a high temperature caused by the stress and strain, and which are transparent and orderly in distribution of wall-thickness.

It is another object of this invention to provide a new injection orientation blow molding which can carry out the temperature adjustment of various parts of a preform at the time of injection molding whereby the orientation blow molding can be materially shortened as compared with prior art to increase a production quantity per hour.

According to a first feature of this invention for achieving the aforesaid objects, in injecting and filling molten resin into an injection mold to form it into a preform as required, holding a mouth portion of said preform by

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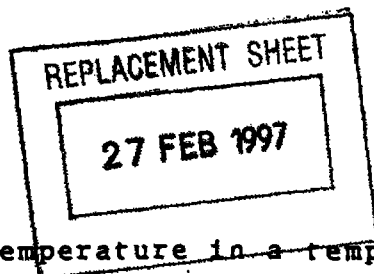


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a lip mold to transfer it from the injection mold to a blow mold, and orientation blow molding the preform into a thin-wall hollow molded article as required, releasing of said preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and the orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

According to a second feature of this invention, releasing of a preform made of polyethylene terephthalate from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 60°C but below 70°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 80°C but below 95°C.

According to a third feature of this invention, releasing of a preform made of polypropylene from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 90°C but below 100°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a



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peak temperature in a temperature region above 100°C but below 122°C. A preform made of thermoplastic synthetic resin such as polyethylene, polycarbonate, etc. other than the aforementioned resins as a crystalline resin can be orientation molded by similar means.

According to a fourth feature of this invention, internal heat of various portions of an oriented portion of a preform is controlled by a temperature of a mold maintained at a predetermined temperature and an intentionally adjusted wall-thickness distribution of the preform, and an orienting condition of an oriented portion is controlled by a difference of heat quantity which differs with the wall thickness to thereby make it unnecessary to adjust the temperature after release.

A bottle-like container obtained by orientation blow molding according to this invention has less stress and strain which are liable to occur when a low temperature preform is orientation blow molded. Accordingly, shrinkage and deformation during high-temperature filling to be caused by the stress and strain are hard to occur. Containers made of polyethylene terephthalate have an increased heat resistance.

Since a preform is oriented when the interior thereof is in a half molten state, there is hardly affected by unevenness of temperature. Since molding is finished before the interior of a preform is crystallized, a thin-wall container which is transparent and without one-sided wall

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thickness may be obtained.

Furthermore, since a skin layer is formed by quick cooling, releasing can be made even if the interior of a preform is soft. Even a bottle-like narrow-mouth container which has been difficult to be released at an adequate temperature and which has been required to adjust a temperature in terms of draft of a preform can be molded easily even in a 3-station similarly to the case of a wide-mouth container.

Moreover, time required for orientation blow molding is materially short as compared with prior art, thus quickening a molding cycle and increasing a production amount per hour.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a high-temperature preform.

FIG. 2 is a graph showing a change by passage of time of a high-temperature preform obtained by injection molding a crystalline resin.

FIG. 3 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 1 obtained by injection molding a polyethylene terephthalate.

FIG. 4 is a graph showing a change by passage of time of the surface temperature of a high-temperature of sample No. 2 obtained by injection molding a polyethylene terephthalate.

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FIG. 5 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 3 obtained by injection molding a polyethylene terephthalate.

FIG. 6 is a graph showing a change by passage of time of the surface temperature when a preform made of polyethylene terephthalate is orientation blow molded.

FIG. 7 is a graph showing a change by passage of time of the surface temperature of a high-temperature preform of sample No. 4 obtained by injection molding a polypropylene.

FIG. 8 is a graph showing a change by passage of time of the surface temperature when a preform made of polypropylene is orientation blow molded.

FIG. 9 is a graph showing a change by passage of time of the surface temperature when two preforms which are different in wall thickness are orientation blow molded.

DETAILED DESCRIPTION OF THE INVENTION

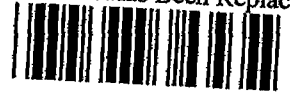
Molten resin is injected and filled into a mold to injection mold a preform 11 having a sectional construction shown in FIG. 1, and the preform is released while maintaining a temperature as high as possible from an injection mold. When the preform is left as it is at a room temperature, the surface temperature of the preform changes as shown in FIG. 2.

The change by passage of time of the surface temperature has a difference to some extent in time till

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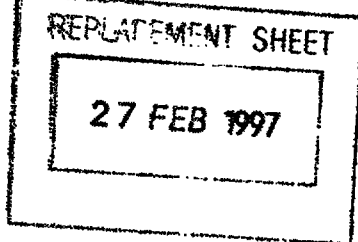
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it reaches a peak temperature but most thermoplastic resins used to mold containers indicate similar progress. A rise of initial surface temperature is caused by the fact that in a preform released at a high temperature, the surface of cavity of a mold or the surface of a preform in contact with a core is solidified by cooling the mold to form a skin layer but internal cooling is not yet finished and temperature is high which is in a half-molten state, and cooling is cut off by releasing after which the skin layer is heated from inside.

Of course, in such a state, the temperature of the preform is not uniform except a mouth portion completely cooled and solidified at the time of release. When orientation blow molding takes place in a state where a temperature difference between inner and outer portions of a preform is present, white turbidity due to crystallization or crazing occurs. Therefore, in the aforementioned conventional method, the temperature of the preform is made uniform before orientation blowing.

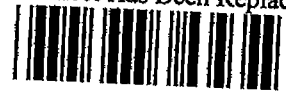
According to the researches by the present inventor, the white turbidity of a molded article in the orientation blow molding often results from the temperature of orientation blow molding rather than a temperature difference between inner and outer portions.

According to experiments so far conducted, in case of polyethylene terephthalate, when the surface temperature of a preform is less than 80°C, the white turbidity tends



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to occur. It was also found that when the surface temperature of a preform immediately after release is 80°C or more and orientation blow molding takes place after passage of very short time, crazing rarely occurs.

It has been also found however that even such a case, when cooling time is long and the temperature immediately after release is less than 60°C, the white turbidity tends to occur in an article injection blow molded even if the orientation blow molding temperature is 80°C or more.

In case of polyethylene terephthalate, when cooling time is set shortly and the surface temperature immediately after release is set to be 70°C or more, the peak temperature is often 95°C or more. In molding under such a set condition as described, one-sided wall thickness tends to occur, and rigidity is lost.

Accordingly, cooling time of a preform in an injection mold is limited within a certain predetermined time. However, cooling is different according to wall thicknesses even in case of the same resin and further different according to temperatures of cooling water to be used therefor. An allowable range with the same wall thickness is more or less one second in case of polyethylene terephthalate. It is possible to obtain a surface temperature immediately after release capable of molding a narrow-mouth container which is transparent and well ordered in shape within the aforesaid allowable range.

Similarly, with respect to a preform made of

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polypropylene, the surface temperature rapidly rises from a temperature at the time of release at a room temperature and reaches a peak, after which the peak temperature is maintained for a long period of time and gradually lowers.

Time at which temperature of the whole preform is made uniform due to the internal temperature is obscure from the change by passage of time of the surface temperature. However, in conventional orientation blow molding of a high-temperature wide-mouth preform, orientation blow molding is carried out about 17 seconds after release. Therefore, orientation blow molding was tried around the diagonal line with such a time as described used as a standard. For a preform, for a wide-mouth container, it was possible to mold a thin-wall wide-mouth container of which body portion is transparent in about 17 seconds.

However, in case of a preform for a narrow-mouth container which is large in orientation magnification than the case of a wide-mouth container, even those which are so large in draft as to be easily released, one-sided wall thicknesses and defective molding of a bottom often occur, failing to provide a molded article.

However, even in the case of polypropylene, when the surface temperature immediately after release is 90°C or more and the temperature of orientation blow molding is 110°C or more, a narrow-mouth container can be molded. The allowable range of cooling time with the same wall thickness was more or less 3 seconds.

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It is apparent from an attempt of orientation blow molding that when orientation blow molding is carried out after passage of a given time for the purpose of making a temperature of a preform uniform after release, the preform is subjected to gradual cooling, and therefore, whiteness caused by crystallization tends to occur. Naturally, it becomes difficult to mold a narrow-mouth container.

Accordingly, hardness or ease of orientation blow molding of a preform released at a high temperature is not only affected by unevenness of temperature but greatly affected by a composition of a high-temperature preform which changes by passage of time, orientation blow timing, etc.

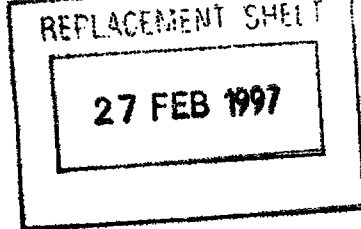
The high-temperature preform 11 after release is low in surface temperature as can be seen in FIG. 1 immediately after it is released from the injection mold, and therefore, the surface thereof forms a skin layer 12 having a hardness. However, the forming condition of the skin layer 12 is different according to the cooling speed.

In the high-temperature release, a central portion is not cooled, and the internal resin 13 has a fluidity to some extent at a high temperature. A draw-down is prevented by the skin layer 12 of the surface, and even after release, the form of the preform 11 is maintained.

The internal temperature is released outside as time passes and at the same time the skin layer 12 forming the surface is heated from inside. Therefore, the surface

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temperature abruptly rises, and the skin layer 12 becomes softened whereas the internal temperature lowers. Therefore, the flowing portion is reduced toward the center portion.

The skin layer 12 whose surface temperature reaches a peak is thin to a degree that forms a skin, and the interior thereof is in a half hardened state.

After the peak, the surface temperature slowly lowers as time passes. As for the whole preform, the temperature becomes uniform and at the same time, crystallization progresses.

In the high-temperature preform till the surface temperature reaches a peak, even if the surface is solidified to form the skin layer 12, the skin layer 12 is softened in the vicinity of the peak temperature, which is in the state where orientation can be made.

A thick-wall portion which is high in internal heat of the skin layer 12 is first softened by heat received from inside. There is a temperature difference between a thick wall portion and a thin wall portion till some time passes after the surface temperature reaches the peak, and the aforesaid difference is evident particularly before peak.

When orientation blow molding takes place in such a state as described, the skin layer on the side of the thick wall portion where much heat is present, that is, on the side in which surface temperature is high is first oriented in the state where internal resin is in a softened

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state is embraced.

Naturally, the surface area increases due to the orientation, and as the result, the radiant surface becomes large and the temperature lowers to eliminate a temperature difference from the thin wall side. Furthermore, the temperature on the thin wall side relatively rises, and subsequently, orientation of the thin wall portion precedes. Such a mutual orientation is repeatedly carried out for an extremely short period of time, and the internal temperature with much heat amount during that period lowers to a temperature suitable for orientation. And, the internal resin 13 so far oriented while being accompanied by the skin layer 12 is thinly oriented similarly to the skin layer 12 halfway, whereby a molded article having a uniform distribution of wall thickness is formed.

Accordingly, in the injection molding of the preform 11, first, orientation amount of various portions of the preform 11 is taken into consideration in advance from the shape of a container 14 to be a molded article whereby the wall-thickness distribution of the various portions is intentionally adjusted whereas the temperature of the injection mold is maintained constant, and preferably, cooling of the preform 11 molded by being injected and filled in the cavity is uniformly carried out at any portion.

For the high-temperature preform 11 formed with the skin layer 12 by quick cooling, the best result was obtained by molding at the time before the surface

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temperature reaches the peak. At the time seemed to have reached the peak, one-sided wall thickness tends to occur, failing to obtain a good result.

The surface temperature when orientation blow molding takes place was 80°C or more and 110°C or more for polyethylene terephthalate and polypropylene, respectively, and time after release was more or less 8 seconds and more or less 14 seconds for the former and the latter, respectively.

However, it is apparent from the foregoing attempts that the better result cannot be obtained unless the skin layer 12 is formed by quick cooling. This seems to have resulted from a difference of a crystalline state produced in the skin layer 12 by cooling. A crystal due to quick cooling forms a fine crystal. In case of gradual cooling, a crystal greatly grows, and joining of crystals with each other is weaker than the fine crystal.

More preferably, orientation blow molding is carried out in the range of temperature capable of adapted to wall thicknesses of any portion of the preform 11.

According to the attempt by the present inventor, most conveniently, if a difference of wall thickness is 0.25 mm or so, there is no much difference in the peak temperature and the time till the peak is reached even if a difference of surface temperature immediately after release is present. Moreover, there involves no much technical difficulty to timely grasp the temperature range to make orientation blow molding for both possible.

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In the case where heat amount of various portions is controlled in the injection mold with a difference of wall thickness intentionally provided as a means for controlling an orientation degree of various portions of the preform from the shape of a molded article, the difference of wall thickness is very minute and is mostly within the allowable time including the difference of wall thickness in case of a flat container which is materially different in orientation degree between lateral and longitudinal portions thereof.

Accordingly, there involves not much technical difficulty in that the internal heat of various portions of the oriented portion of the preform is controlled by the temperature of the mold maintained at constant temperature and the intentionally adjusted wall thickness distribution of the preform, and the orienting condition of the oriented portion is controlled by the difference of heat amount different according to the wall thickness.

Embodiment 1

Molten resin of polyethylene terephthalate was injected and filled into an injection mold to form a narrow-mouth preform 11 as shown in FIG. 1 by quick cooling.

Three examples of preforms different in wall thickness were injection molded changing cooling time sample by sample, and the change by passage of time of the surface temperature was measured.

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The preform is prepared for one-litre container whose overall length is 124 mm. Temperatures of the preform were measured at three points, 30 mm, 60 mm, and 100 mm upwardly from the bottom, and temperatures to be measured were an average value.

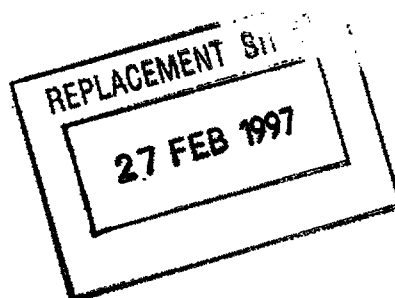
As a temperature measuring unit, a digital radiation thermometer IR-AHOT (made by K.K. Chino) was used.

The injection molding conditions are as follows:

Weight of material	33 gr
Injection temperature	275°C
Mold temperature	13°C
Draft	1.5°
Injection and filling time	5.3 sec.

Note: The mold temperature means a cooling water temperature of a cavity mold and a core mold.

FIGS. 3 to 5 show the change by passage of time (average value) of the surface temperatures of the following samples at a room temperature (22°C), main points of which are as given in Table 1 below.



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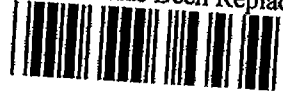


TABLE 1

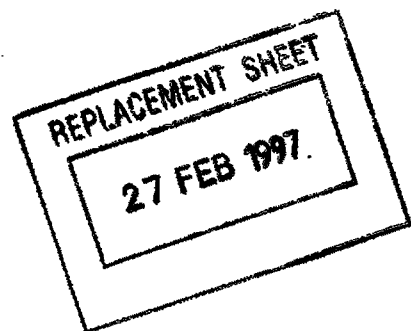
Preform Wall thickness (mm)		Cooling Time (sec)	Preform Temperature (°C) 1 sec after release Peak		Peak Time (sec)
Sample No.1 2.80	1	3.0	72.0	96.0	11
	2	3.5	68.7	88.0	10
	3	4.0	68.0	86.0	9
	4	4.5	66.9	83.0	9
	5	5.0	62.3	79.8	7
Sample No.2 3.05	1	3.6	71.3	96.2	12
	2	3.9	65.1	87.9	11
	3	4.2	63.8	86.3	13
	4	4.5	62.5	83.8	9
	5	4.8	60.3	81.5	10
	6	5.5	57.0	80.2	10
Sample No.3 3.30	1	3.5	70.5	92.8	11
	2	4.9	67.4	87.9	12
	3	5.2	63.2	85.7	10
	4	5.5	62.6	83.9	9
	5	5.8	60.5	82.2	9
	6	6.5	58.0	79.0	11

Cooling time is time after passage of injection and filling time.

For the above-described samples, orientation blow molding was carried out under blow air pressure of 14 kg/cm^2 to form a bottle-like container 14 as indicated by the

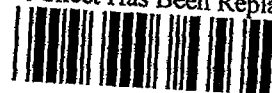


broken line in FIG. 1. It has been found that the best result was obtained when orientation blow molding was carried out within the time shown in FIG. 6, that is, within time t between time t_1 before the surface temperature reaches the peak and time t_2 seemed to have reached the peak. However, in case of a preform whose surface temperature immediately after release is outside the range of 60°C to 70°C at a normal temperature or a preform whose surface temperature at the time of orientation blowing molding is outside the temperature region of 80°C to 95°C, satisfactory molded articles were not obtained as shown in Table 2 below.



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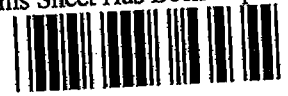
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TABLE 2

Preform wall thickness (mm)	Temperature 1 sec. after release	Temperature at orientation blow molding	Time of passage (sec.)	Molded state of molded articles. Wall thickness of body portion: 0.3 mm
Sample No.1 2.80	72.0	95.5	9.0	Bad, short of rigidity, one-sided wall thickness
	68.7	87.9	7.0	Good
	68.0	85.5	8.0	Good
	66.9	82.8	7.5	Good
	62.3	79.5	6.0	Bad, short of rigidity, one-sided wall thickness
Sample No.2 3.05	71.3	95.0	8.0	Bad, short of rigidity one-sided wall thickness
	65.1	86.8	7.0	Good
	63.8	85.0	7.5	Good
	62.5	82.8	8.0	Good
	60.3	81.4	8.0	Good
	57.0	79.0	7.5	Bad, white turbidity, large one-sided wall thickness
Sample No.3 3.30	70.5	92.0	8.0	Bad, short of rigidity, one-sided wall thickness
	67.4	88.8	8.5	Good
	63.2	85.7	9.5	Good
	62.6	83.0	6.5	Good
	60.5	82.4	6.5	Good
	58.0	78.5	8.5	Bad, white turbidity, large one-sided wall thickness



In Table 2, the time of passage is time from release of a preform to start of orientation blow molding. The results obtained by molding a few samples in the range of more or less one second on the time of passage were shown in the molded state.

Embodiment 2

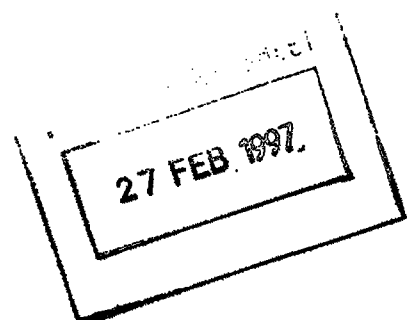
Molten resin of polypropylene was injected and filled into an injection mold to form a narrow-mouth preform 11 as shown in FIG. 1 similar to the case of Embodiment 1 by quick cooling.

Eight preforms having the same wall thickness were injection molded changing cooling time, and the change by passage of time of the surface temperatures thereof at room temperature were measured.

The injection molding conditions are as follows:

Weight of material	40 gr
Injection temperature	240°C
Mold temperature (cooling water)	13°C
Draft	3.0°
Injection and filling time	6.0 sec.

FIG. 7 shows the change by passage of time (average value) of the surface temperatures of the following samples at a room temperature (22°C), main points of which are as given in Table 3 below.



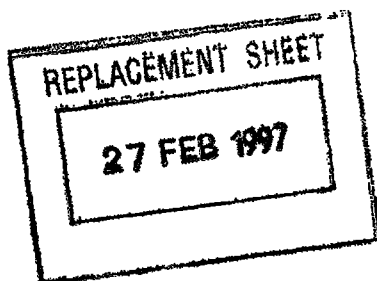
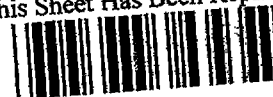


TABLE 3

Preform wall thickness (mm)		Cooling Time (sec)	Preform Temperature (°C)		Peak Time (sec)
			1 sec after release	Peak	
Sample No. 4 4.10	1	1.5	105.0	124.0	19
	2	2.0	95.5	121.4	18
	3	2.5	93.0	118.0	18
	4	3.0	92.5	117.6	16
	5	3.5	91.6	113.5	18
	6	4.5	91.0	113.3	17
	7	6.0	90.5	111.8	18
	8	5.5	89.0	110.5	17

For the above-described sample No. 4, orientation blow molding was carried out under blow air pressure of 12 kg/cm^2 within the time shown in FIG. 6 similar to the case of polyethylene terephthalate to form a bottle-like container 14 as indicated by the broken line in FIG. 1. It has been found that the best result was obtained when orientation blow molding was carried out within the time shown in FIG. 8, that is, within time t between time t_1 before the surface temperature reaches the peak and time t_2 seemed to have reached the peak.

However, in case of a preform whose surface temperature immediately after release is outside the range of 90°C to 100°C at a normal temperature or a preform whose surface temperature at the time of orientation blow



molding is outside the temperature region of below 110°C or above 123°C , satisfactory results were not obtained as shown in Table 4 below.

TABLE 4

Preform wall thickness (mm)		Temperature 1 sec. after release	Temperature at orientation blow molding	Time of passage (sec.)	Molded state of molded articles. Wall thickness of body portion: 0.5 mm
Sample No. 4	1	105.0	123.5	15.5	Bad, large one-sided wall thickness, burst
4.10	2	95.5	120.5	14.5	Good
	3	93.0	117.3	13.5	Good
	4	92.5	116.8	12.5	Good
	5	91.6	112.5	14.0	Good
	6	91.0	113.0	14.0	Good
	7	90.5	111.3	14.0	Good
	8	89.0	110.0	15.0	Bad, large one-sided wall thickness, burst

It is apparent from FIGS. 3 to 5 showing the change by passage of time that in injection molding the preform 11, there is an allowable range of cooling time. It is also apparent that when the allowable time are compared between those different in wall thickness, there is cooling time adapted to each other.

FIG. 9 is a graph which selects two cooling time adapted to each other with respect to sample Nos. 1 and 2 from Table 1 to depict the change by passage of time of the surface temperatures in that case. A temperature difference Δt at the allowable time of orientation blow molding of a thick wall thickness portion D1 and a thin wall thickness portion D2 was 2.5°C to 3.0°C .

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Orientation blow molding was carried out for a narrow-mouth container from a preform with distribution of wall thickness intentionally changed.

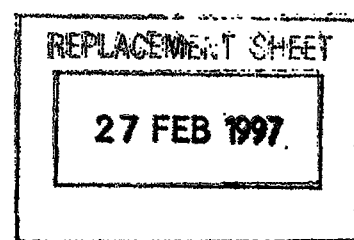
Embodiment 3

A preform 11 shown in FIG. 1 whose wall thickness is made thin from an upper portion toward a bottom thereof so as to have a difference in wall thickness distribution of the whole body was injection molded from polyethylene terephthalate, and one-litre container 14 was orientation blow molded from the preform.

In injection molding, intentionally, the wall thickness, 3.05 mm, of the D1 portion of the preform 11 is differentiated from the wall thickness, 2.80 mm, of the D2 portion. Furthermore, cooling time adapted to the wall thicknesses for both was selected from sample Nos. 1 and 2 in Table 1 so that the surface temperature of the preform immediately after release is in the range of 60°C to 70°C.

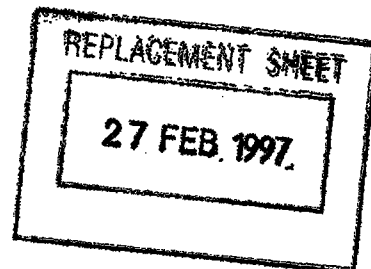
Injection molding conditions:

Weight of material	33 gr
Injection temperature	275°C
Mold temperature (cooling water)	13°C
Draft	1.5°
Injection and filling time	5.3 sec
Example 1: Cooling time (1)	4.1 sec
Surface temperature (D1)	
Immediately after release	63.8°C
At blow molding	85.7°C



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Surface temperature (D2)

Immediately after release 68.0°C

At blow molding 86.0°C

Example 2:

Cooling time (2) 4.5 sec.

Surface temperature (D1)

Immediately after release 62.4°C

At blow molding 82.5°C

Surface temperature (D2)

Immediately after release 67.0°C

At blow molding 82.6°C

Time of passage (after release) 7.5 sec.

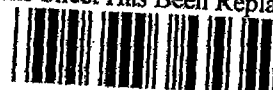
Blow air pressure 14 kg/cm²

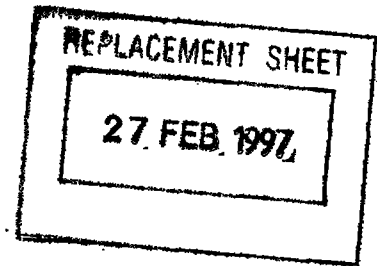
In the Examples 1 and 2,

the molded state of the orientation blow molded container 14 was good. The transparency of the container is excellent, one-sided wall thickness thereof was hardly recognized, and the wall thickness (0.3 mm) of the body portion was uniform.

It is understood from the foregoing that the most preferable molding method for the 3-station system is to adjust wall thicknesses of various portions of oriented portions of a preform according to an orienting state and control an orienting state of an oriented portion from a difference of heat amount different according to the wall thickness, in other words, to carry out orientation blow molding in the state where the temperature of the preform is uneven as a whole. Adjustment of a wall thickness can be easily made by grinding a core mold or applying a padding through plating or the like, and a delicate difference of wall thickness can be also provided.

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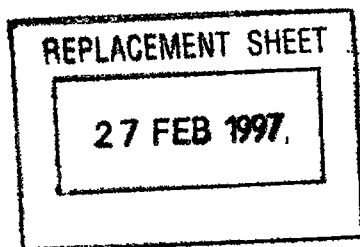
WHAT IS CLAIMED IS:

1. An injection orientation blow molding method characterized in that in injecting and filling molten resin into an injection mold to form it into a preform as required, holding a mouth portion of said preform by a lip mold to transfer it from the injection mold to a blow mold, and orientation blow molding the preform into a thin-wall hollow molded article as required, releasing of said preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and the orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

2. An injection orientation blow molding method characterized in that releasing of a preform made of polyethylene terephthalate from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 60°C but below 70°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 80°C but below 95°C.

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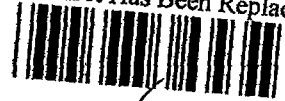
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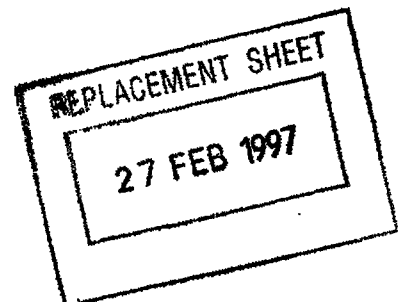
3. An injection orientation blow molding method characterized in that releasing of a preform made of polypropylene from an injection mold is carried out in the range of temperature at which the surface temperature immediately after release is above 90°C but below 100°C at a normal temperature, and orientation blow molding is carried out within a time till the surface temperature of the preform reaches a peak temperature in a temperature region above 100°C but below 122°C.
4. An injection orientation blow molding method according to claim 1, wherein resins used to form a preform comprise crystalline resins such as polyethylene, polycarbonate, etc.
5. An injection orientation blow molding method according to claims 1, 2 and 3, wherein internal heat of various portions of an oriented portion of a preform is controlled by a temperature of a mold maintained at a predetermined temperature and an intentionally adjusted wall-thickness distribution of the preform, and an orienting condition of an oriented portion is controlled by a difference of heat quantity which differs with the wall thickness.
6. An injection orientation blow molding method according to claims 1, 2, 3 and 5, wherein cooling time when a preform is formed is limited within a specific time to render orientation blow molding after release possible at any wall

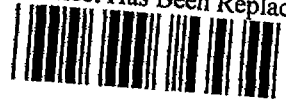
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thickness portion of the preform.

7. An injection orientation blow molding method according to claims 1, 2, 3, 5 and 6, wherein intentional adjustment of a wall thickness of a preform when the preform is injection molded is made according to the orienting condition of various portions thereof.



INJECTION ORIENTATION BLOW MOLDING METHODABSTRACT

A molding method for continuously carrying out the steps from injection molding of a synthetic resin preform to orientation blow molding thereof into a thin-wall hollow molded article, characterized in that releasing of the preform from the injection mold is carried out during the state where the shape thereof can be maintained by a skin layer produced in the surface by quick cooling and the state where internal cooling is not yet finished and the temperature is high, and orientation blow molding of the preform is carried out within a time till a surface temperature of the preform which rises by its own internal temperature reaches a peak temperature.

FIGURE 2.

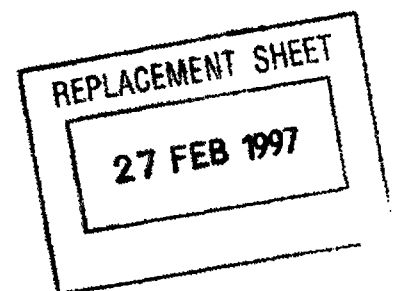




FIG.1

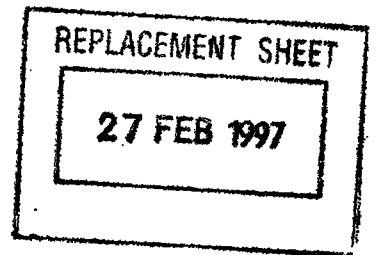
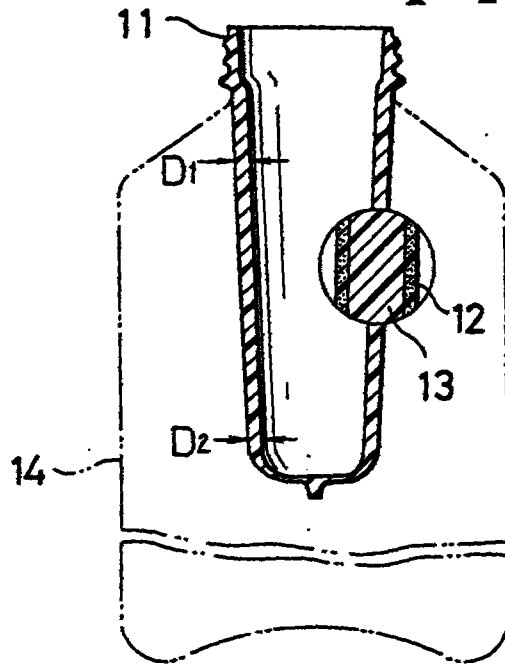
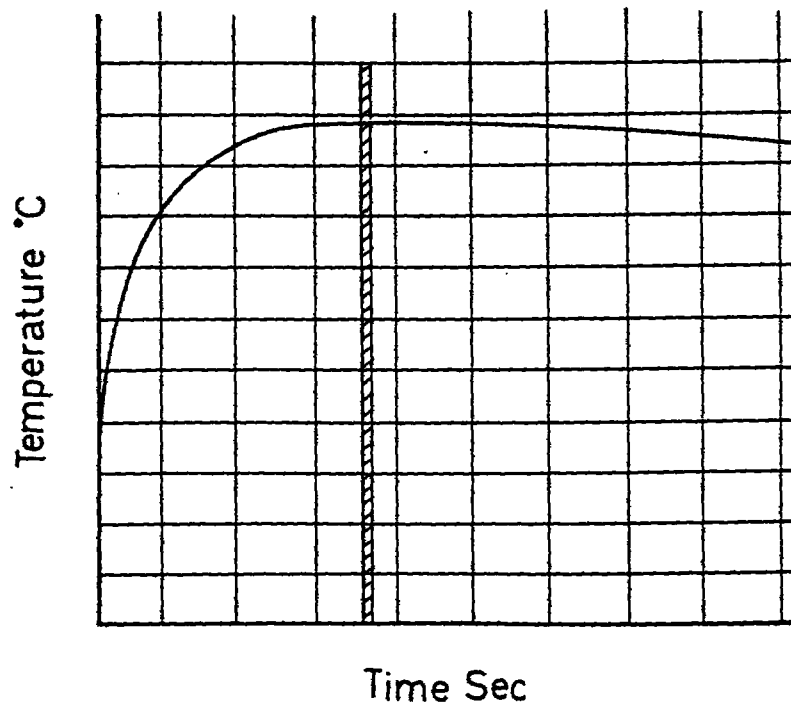
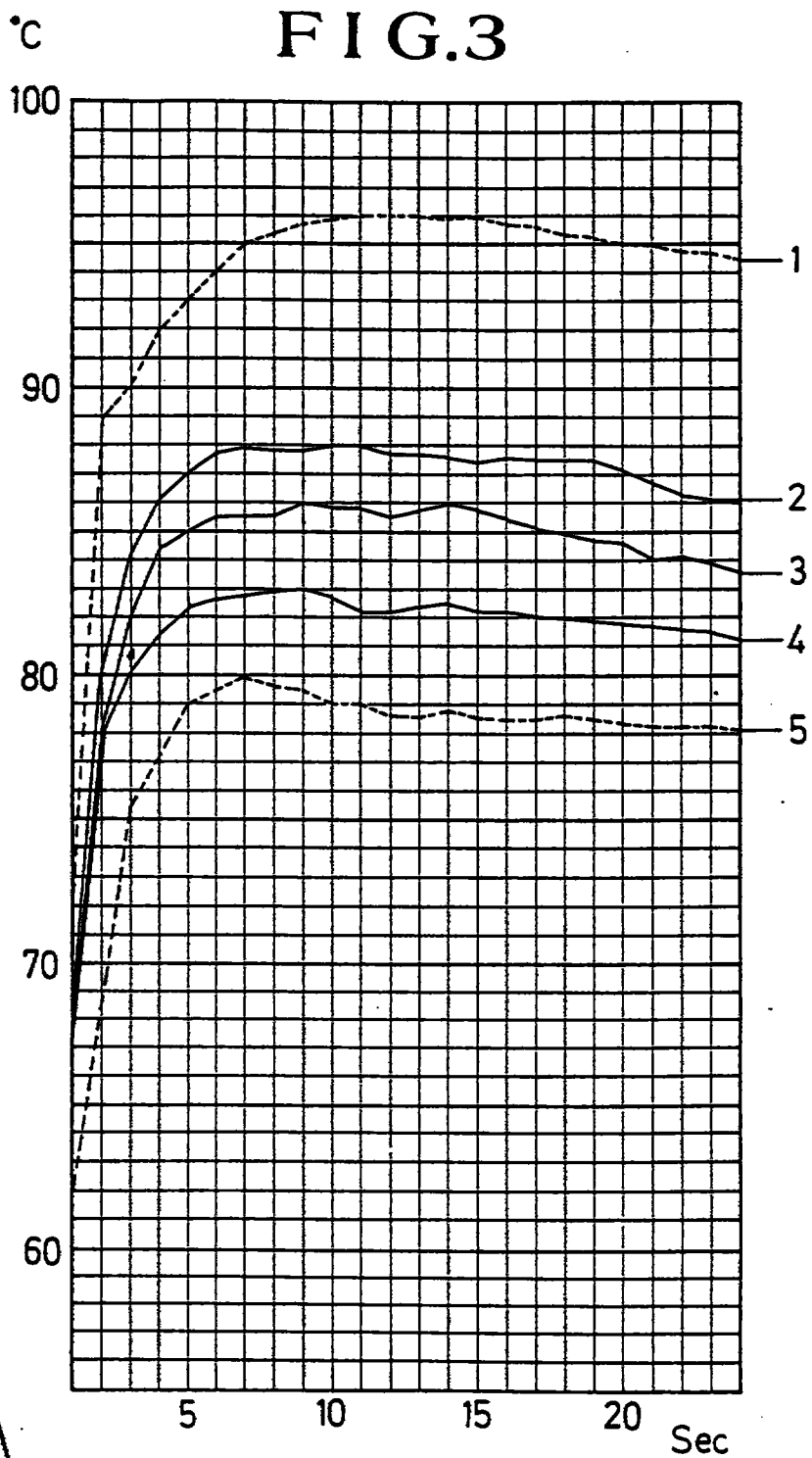
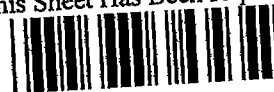


FIG.2



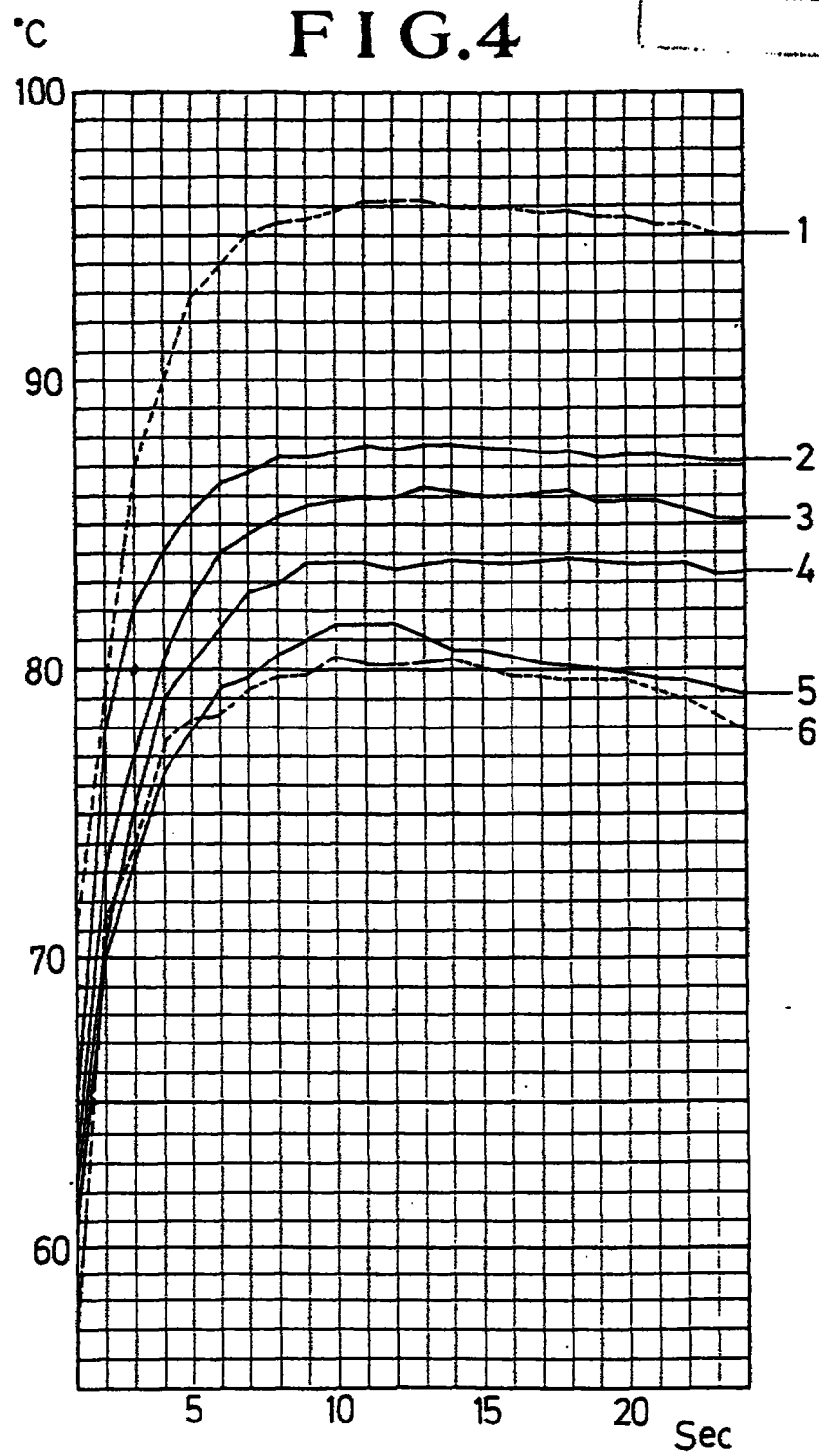
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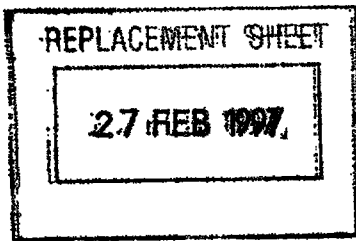


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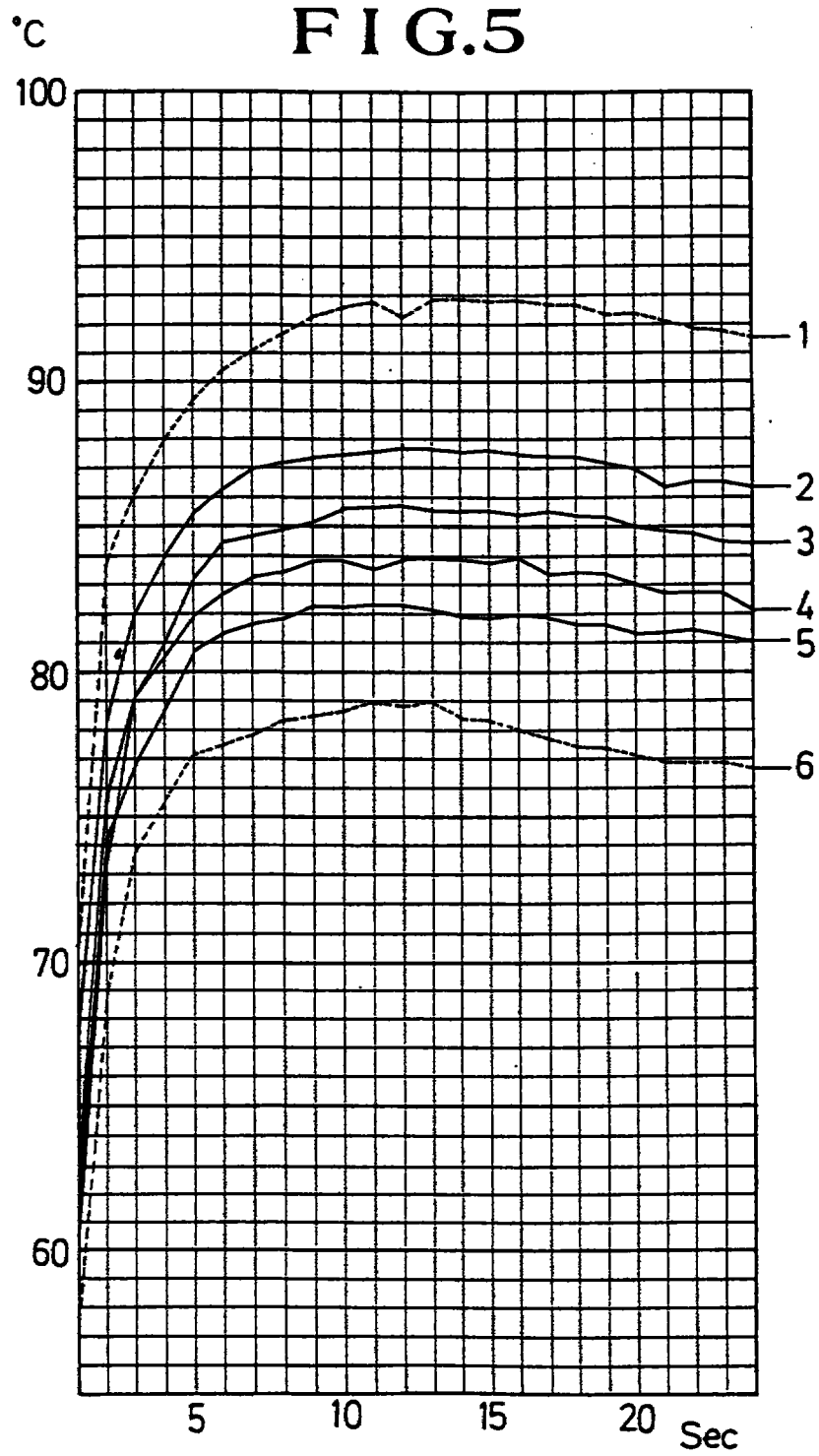
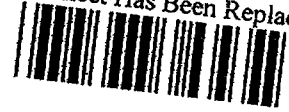
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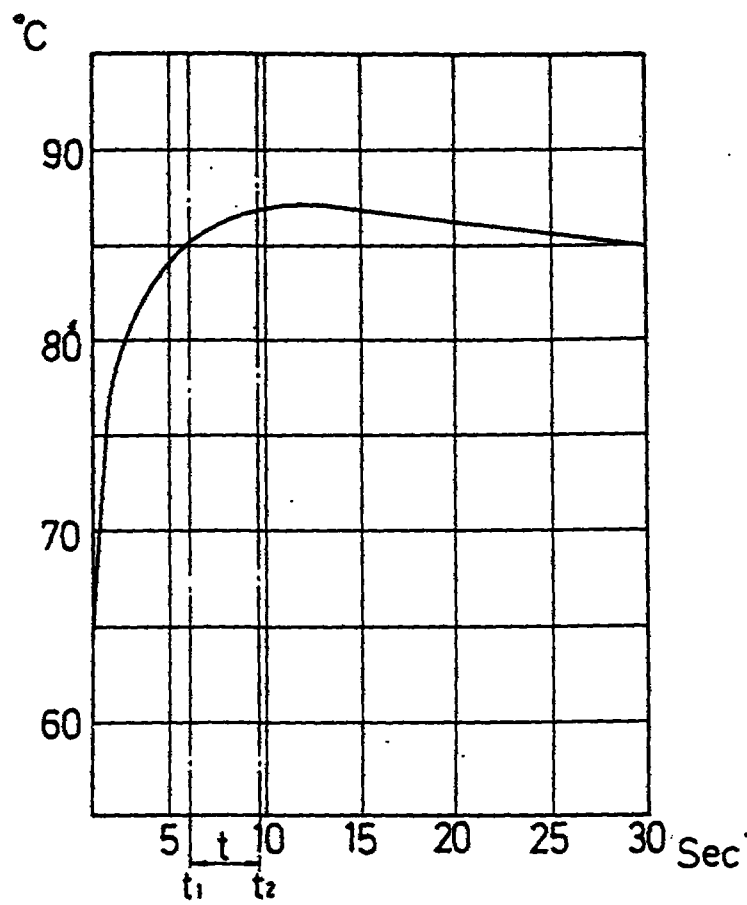
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FIG.6

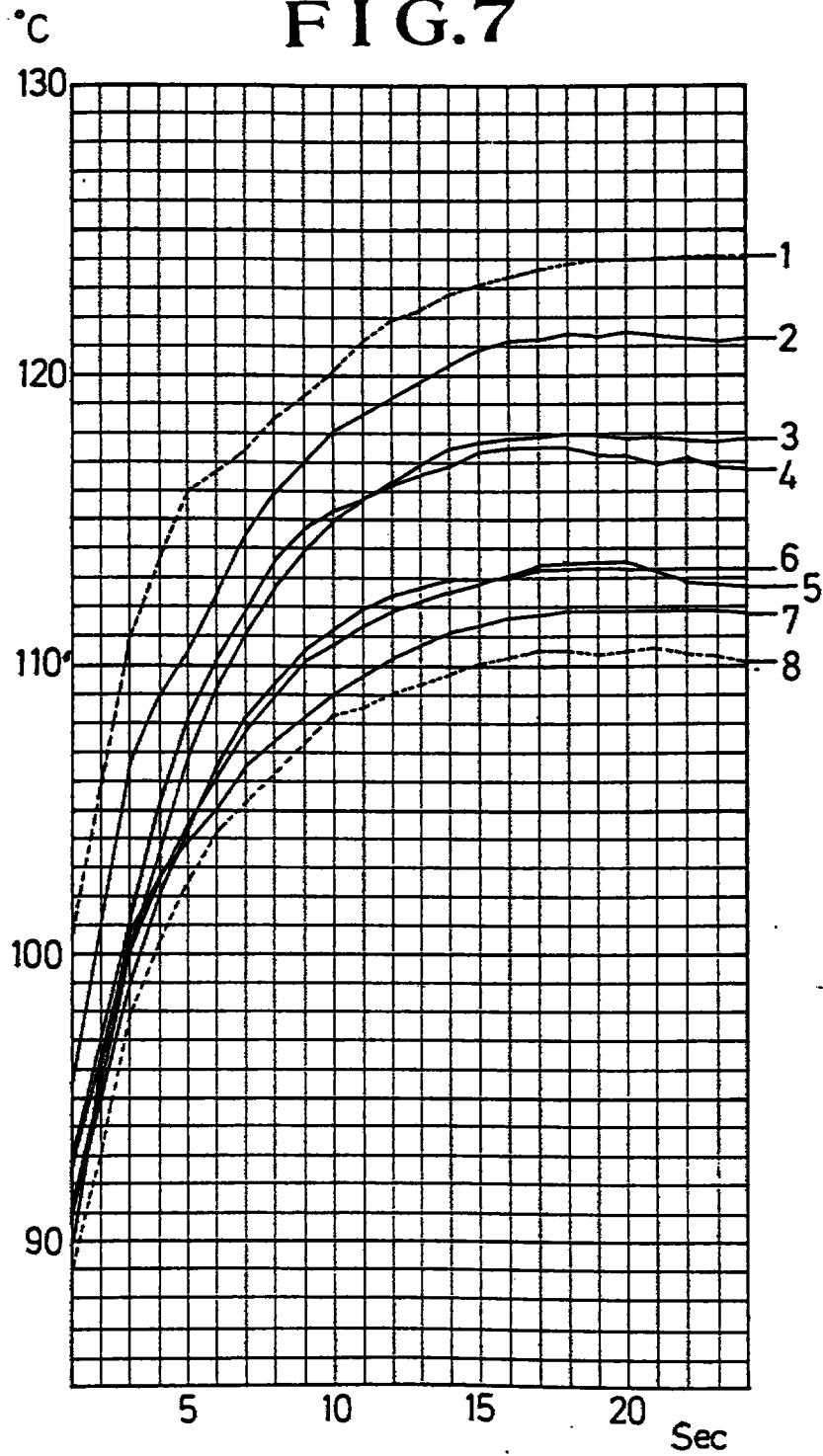


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FIG.7



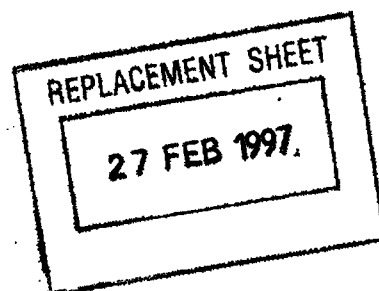
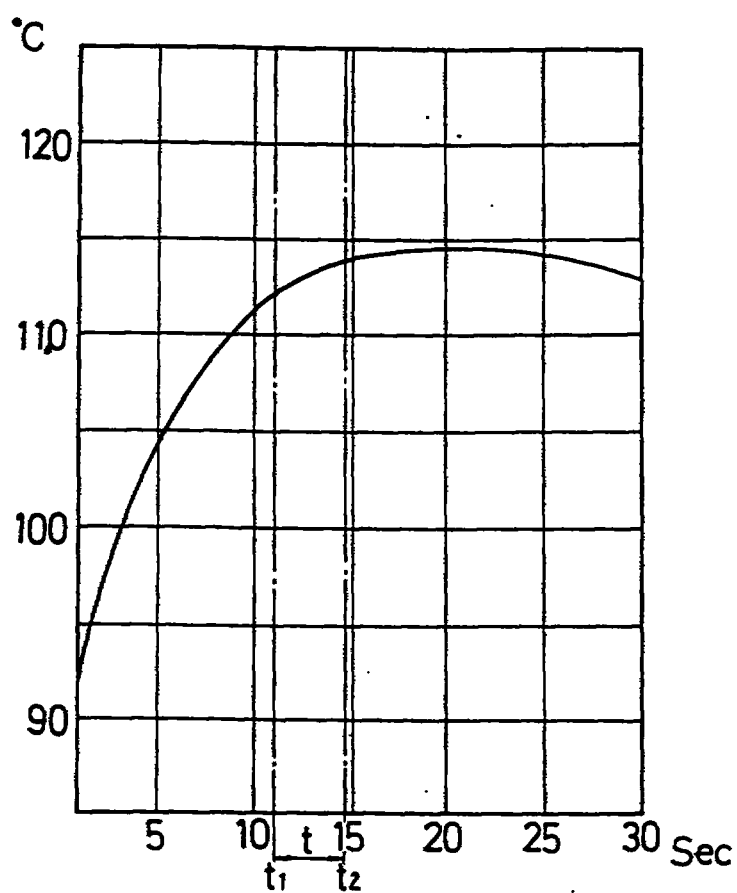
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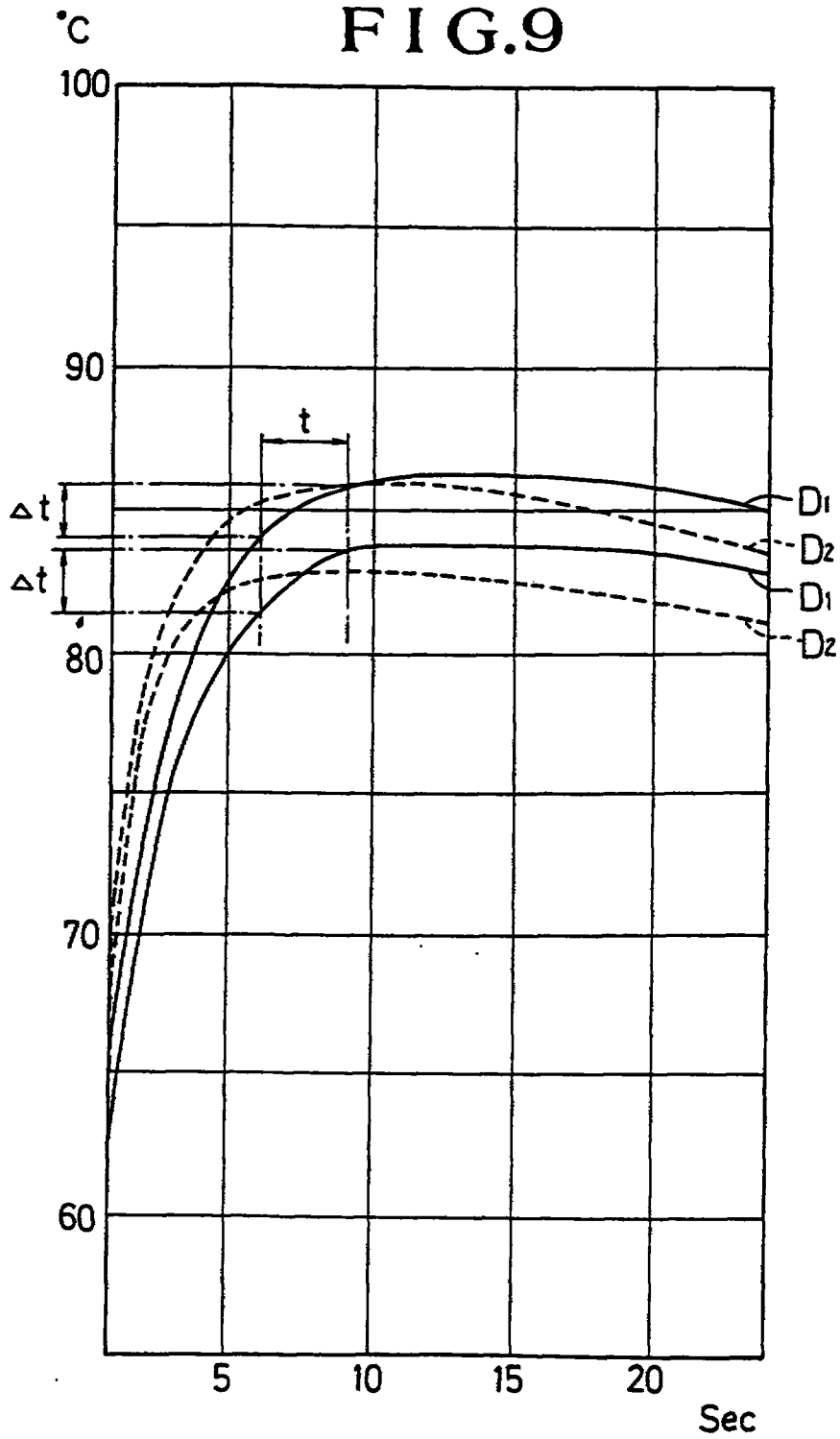
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FIG.8



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