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(54) A method of controlling the temperature of a parison during injection stretch-blow moulding

(57) A method of controlling the temperature of a parison (4a) during injection stretch-blow moulding is described. An injection moulded high temperature parison is first stretched and then the stretched parison (4a) is expanded, while holding the parison in a neck mould (1) in a hollow state, within a temperature control member (5) having an inner surface area greater than an outer surface area of the parison (4a) so that the outer surface of the parison (4a) and the inner surface of the temperature control member (5) are subjected to pressure and brought into contact with each other to cool the temperature of the parison (4a) to a stretch-blow moulding temperature. The parison may be initially stretched while in the member (5) as in Fig. 2, or else it may be stretched before being located in member (5), Figs. 5 to 7 (not shown).

FIG.2

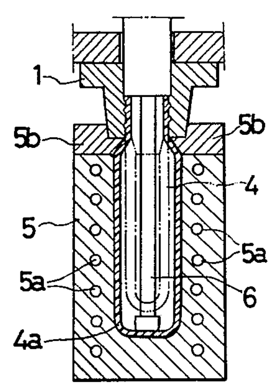

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FIG.1

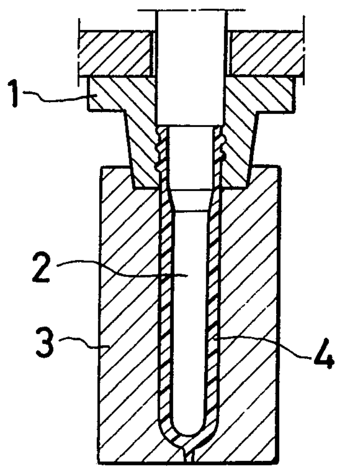


FIG.2

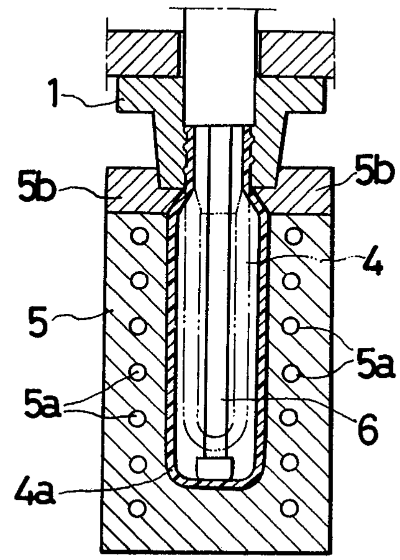


FIG.3

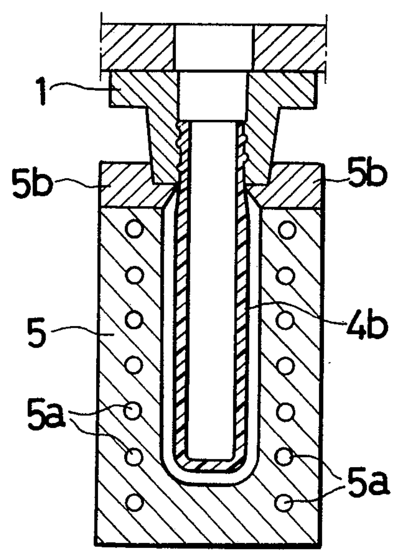
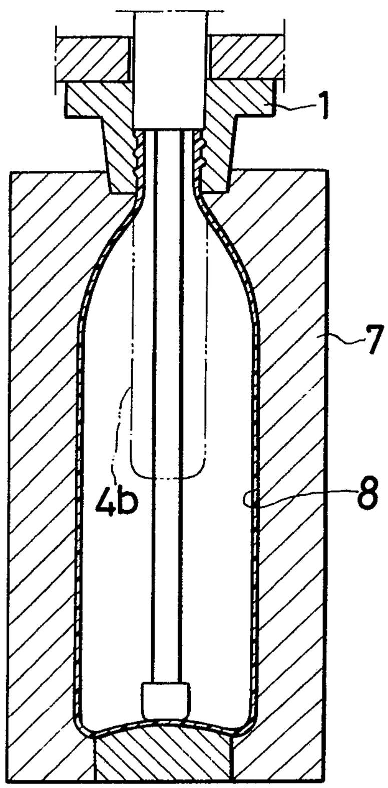


FIG.5

FIG.4



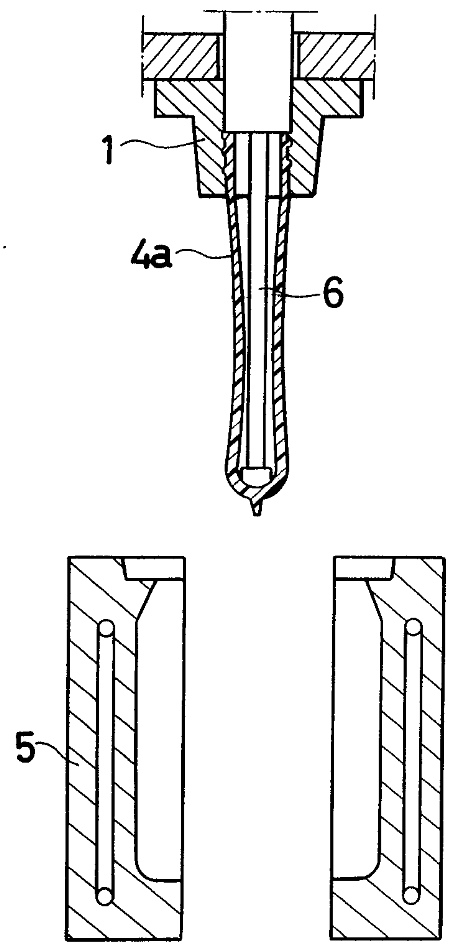


FIG.6

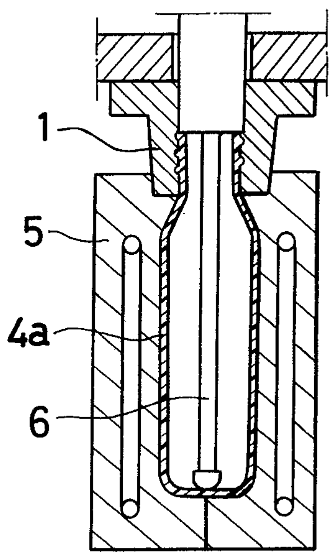
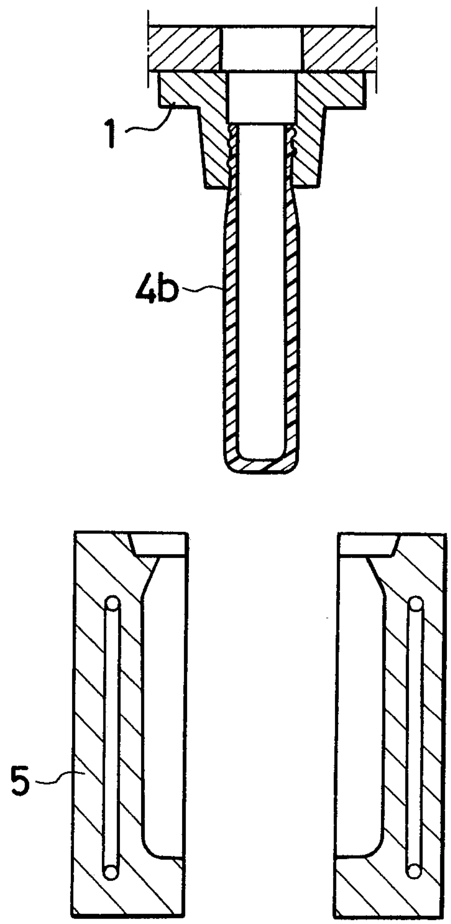


FIG.7



SPECIFICATION

A method of controlling the temperature of a parison during injection stretch-blow moulding

This invention relates to a method of controlling the temperature of a parison during injection stretch-blow moulding.

A method which comprises removing an injection moulded parison from an injection mould, immediately controlling the temperature thereof to a required temperature, and thereafter stretch-blow moulding the parison into a hollow moulded article, has an advantage in that the operation from the moulding of parison to the moulding of a hollow moulded article may be carried out continuously. However, since the temperature distribution of a parison just removed from an injection mould is uneven it is necessary to provide for temperature control.

The temperatures of various portions of the parison differ or become uneven principally for the following reasons:

(a) Unlike an extruding machine, an injection moulding apparatus carries out the injection of molten material intermittently and therefore the temperature of the material within a heating cylinder is not uniform.

(b) As the material passes through the nozzle, the hot runner and the mould gate of the injection moulding apparatus, turbulence occurs in the flow, resulting in an unevenness of temperature.

(c) The temperature will also depend on the order in which the molten material was poured into the cavity of the injection mould.

(d) If the wall thickness of the injection mould cavity is eccentric or one-sided, the wall thickness distribution of parison becomes uneven with the result that the thermal distribution in the parison also changes and is not uniform.

If the stretch-blow moulding is carried out when the temperature distribution of parison is uneven, a high temperature portion of the parison will be well stretched compared to a low temperature portion thereof, and due to the difference in stretching, the wall thickness distribution of the moulded article will not be uniform. Furthermore, the stretching of the high temperature portion sometimes becomes so great that it results in a rupture of the parison. Moulded articles having uneven wall thickness distribution are not good products because, even if the non-uniform wall thickness is not noticeable in the external appearance of the article, the physical strength of the hollow moulded article will be considerably decreased and the article may sometimes be rendered unusable.

Accordingly, temperature control of the continuous injection stretching blow moulding operation is carried out to control the parison temperature to be equal to the stretch-blow moulding temperature and at the same time to make the parison temperature uniform throughout the parison. The temperature control is generally carried out by heating. However, in such a case, the temperature of the parison is indirectly controlled by radiation heat. Therefore, the heat transfer efficiency is poor and it requires experience to change the temperature to make the parison temperature even.

U.S. Patent No. 4,145,392, for example, describes a method of controlling the parison temperature by cooling. Thus, pressure is applied to the parison interior when the parison, which will be at a high temperature, is removed from the injection mould to bring the outer surface of the parison into intimate contact with a temperature control member. Although temperature control by way of intimate contact provides a better heat transfer efficiency than the indirect temperature control system mentioned above and can control the parison temperature to be equal to the stretch-blow moulding temperature in a short period of time, the technique of applying a heat medium different in temperature to the temperature control member to change the temperature of part of the parison, as in the case where heating is carried out using an electric heater, is difficult and the temperature control of parison is therefore wholly carried out at the same temperature. Thus, even if the parison temperature is very high, irregularities in the temperature of the parison occur during the injection moulding and, the non-uniformity of the parison temperature is not overcome because the whole parison is cooled at the same temperature so that the temperature cannot be made uniform even by the temperature control. Thus, while the temperature control time is reduced in comparison with the indirect heating method, it is not possible to obtain a moulded article whose wall thickness distribution is even.

It is an object of the present invention to provide a method for controlling the temperature of an injection moulded parison which overcomes or at least mitigates the disadvantages of previous temperature control methods.

According to the present invention, there is provided a method of controlling the temperature of a parison in injection stretch-blow moulding, which method comprises stretching an injection moulded parison and expanding the stretched injection moulded high temperature parison within a temperature control member having an inner surface area greater than an outer surface area of the parison so that the outer surface of the parison is subjected to pressure and brought into contact with the inner surface of the temperature control member to bring the temperature of parison to a stretch-blow moulding temperature.

The Applicant has thus found, as the result of various studies, that to obtain the stretch-blow moulding temperature and the evenness of the temperature by a one-step temperature control, the parison has to be converted into a state wherein the temperature thereof tends to be even immediately before the temperature control of parison by cooling.

In a parison having an uneven temperature distribution, even if such unevenness results from a slight difference in temperature, a portion having a higher temperature tends to be stretched more than a portion having a lower temperature. This increased stretching causes the higher temperature portion to decrease in wall thickness and to increase in surface area relative to the lower temperature portion causing greater cooling of the higher temperature portion than the lower temperature portion and enables the parison temperature to be made more uniform before the parison is expanded in the temperature control member so that the parison temperature controlled to the stretch-blow temperature becomes more even.

The above mentioned effects could not be obtained within the pre-blowing mould disclosed in U.S. Patent No. 4,063,867 because during the axial stretching and radial expansion in the arrangement described in U.S. Patent No. 4,063,867, a preform stuck on a core or a pin at the time of injection moulding is separated from the core or the pin and remains in the range to open an orifice for cooling liquid. Moreover, the stretching and expansion hardly effect the entire preform.

In a preferred embodiment, the temperature controlling is carried out by cooling the parison. Accordingly, it is necessary that the parison temperature is higher than normal. A recently injection moulded parison is fed to a temperature control position in a manner similar to that of conventional methods and is positioned within a temperature control member preset to the required temperature.

The parison is axially stretched before air is blown into the parison radially expanding the parison and bringing the external surface of parison into intimate contact with the temperature control member.

The pressure inside the parison is maintained to hold it in contact with the inner surface of the temperature control member.

With previous temperature control members, there is not much difference between the internal surface area of the temperature control member and the external surface area of the parison. Thus, even if the parison is expanded due to the internal pressure, the stretching of the parison resulting from this expansion is negligible and, thus, the phenomena of thin wall-thickness and increase in surface area will not occur so that, even after the temperature has been controlled to a stretch-blow moulding temperature, the parison temperature remains uneven.

Accordingly, the internal surface area of the temperature control member is made larger than the external surface area of the parison in order to provide sufficient stretching and expansion. The difference between the surface areas should not be excessive, because otherwise the length and diameter of parison will be increased by the temperature controlling step, and the stretching magnification and expansion magnification at the time of stretch-blow moulding will be decreased so that insufficient biaxial orientation occurs.

Preferably, the pressure is released after a predetermined time, the parison moves out of contact with the temperature control member and the cooling is stopped. Thus, the duration of the temperature control is limited.

Generally, the outer surface area of the injection moulded parison is increased by from 1.5 to 3.0 times and the length of the injection moulded parison is increased by from 10 to 20% during the temperature controlling.

In a preferred arrangement, the stretching of the parison is performed by inserting a stretching rod into a parison held in a neck mould, and expansion is performed by blowing air into the parison. Only by this stretching and blowing does the external surface of parison come into intimate contact with the internal surface of temperature control member, so that heat exchange therebetween occurs during the time pressure is being applied. Further, the time required for cooling the parison is preferably such that the parison reaches the stretch-blow moulding temperature and the parison shrinks out of contact with the temperature control member when the air pressure is removed preventing any further cooling. This "self-shrinkage" causes the wall thickness of the parison to increase, the heat distribution is made even during shrinkage and the wall thickness is also evened, residual stress from the injection moulding being thereby removed.

The temperature of the temperature control member is determined by the wall thickness and temperature of the parison. The stretching of the parison may be performed either in the interior of the temperature control member or exterior to the temperature control member. Of course, if the parison is stretched outside the temperature control member, then some cooling due to the room temperature can be expected prior to cooling by the temperature control member.

For a better understanding of the present invention, and to show how the same may be put into effect, reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a sectional view showing a parison being injection moulded;

Figures 2 and 3 are sectional views showing one way in which the temperature of the parison is controlled, Figure 3 showing the final step ofsthe temperature control of parison;

Figure 4 is a sectional view showing the step of stretch-blow moulding a hollow moulded article from a temperature controlled parison; and

Figures 5 to 7 are sectional views showing, respectively, the step of stretching a parison outside a temperature control member, the step of cooling a perform within the temperature control member and the step of finishing the temperature control of the parison

Referring now to the drawings, and in particular Figure 1, a neck mould 1, an injection core 2 and an injection mould 3 are used to injection mould a parison 4 having a bottom. It should be noted that the material from which the parison is moulded is not limited to a specific resin. After the parison 4 has been cured for the required period of time, the injection core 2 is removed, and the hollow parison 4 held by the neck mould is removed from the injection mould 3 and passed to a temperature controlling position where it is positioned above a temperature control member 5.

The temperature control member 5 is cylindrical in shape and coolant passages 5a are formed within the walls of the temperature control member. The temperature control member has a closing member 5b at the top. However, the temperature control member can be formed in two halves, if desired, in which case, the closing member 5b need not be provided.

After the parison 4 has been inserted into the temperature control member, the closing member 5b is closed, the parison 4 is axially stretched by means of a stretching rod 6, as shown in Figure 2, and air is blown into the parison to expand the parison and thereby bring the external surface of the parison 4 into intimate contact with the internal surface of the temperature control member 5. At this stage, a high temperature portion of the parison 4 is stretched more than a low temperature portion thereof. Therefore, the wall thickness of the high temperature portion of the parison becomes smaller than that of the low temperature portion, so that the high temperature portion has an increased surface area in contact with the temperature control member 5.

The pressure inside the parison produced by the stretching rod and air blowing remains unchanged. Simultaneously with the intimate contact, heat exchanging between the parison 4 and the temperature control member 5 begins. The external surface of the cooled parison is likely to shrink but the parison is maintained in intimate contact because of the internal pressure, and the cooling progresses toward the interior of the parison thicker portions. The high temperature portion which has been made to have a smaller wall thickness and increased surface area is cooled more quickly than the low temperature portion because of the difference in wall thickness and the heat transfer surface area. As a result, the temperature of the parison becomes uniform by the time the stretching blow moulding temperature is obtained due to the difference in cooling rates.

When the parison temperature reaches the temperature for stretch-blow moulding, the stretching rod 6 is pulled out to discharge air and release the internal pressure in the parison so that, as shown in Figure 3, the stretched and expanded parison 4a is separated from the internal surface of the temperature control member 5 by self-shrinkage and the cooling automatically stops. The temperature control member 5 may be opened before releasing the internal pressure. At the time of self-shrinkage, the wall thickness of the entire parison increases by an amount equal to the shrinkage. Heat transfer also occurs as the wall thickness varies. Therefore, the parison temperature is further made uniform. Accordingly, cooling is preferably accomplished when the parison is likely to self-shrink.

The thus temperature-controlled parison 4b is immediately transferred to a blow mould 7 (Figure 4) and is stretched and blow moulded into a hollow moulded article 8 by conventional means.

Figures 5 to 7 illustrate an alternative method where a parison is stretched outside the temperature control member.

The parison which has been injection moulded similarly to the previous case, is immediately transferred to a position above the temperature control member (Figure 5), the stretching rod 6 is passed through the neck mould 1 and inserted into the parison 4 to stretch the parison 4 axially by a predetermined amount. The stretching causes the wall thickness of the parison 4 to decrease in proportion to the stretching rate, and a portion of the parison having a high temperature is stretched more than a portion having a low temperature and is liable to be reduced in wall thickness.

The outer surface of the parison 4a is increased, while the wall thickness is decreased, by the stretching and the parison is therefore liable to be cooled. In addition, a portion of the parison having a high temperature will be stretched more than a portion having a low temperature and will, therefore, be further decreased in thickness and increased in surface area so that the high temperature portion will be cooled more rapidly by the temperature control member 5 to produce a parison of uniform temperature.

Immediately upon completion of the stretching, the stretched parison 4a is inserted with the stretching rod 6 into a central portion of the aforesaid temperature control member 5 which, as shown in Figure 5, comprises a split mould. The insertion is accomplished by moving the temperature control member 5 in its open state upwardly to the neck mould 1 and closing the split mould (Figure 6). Immediately after the mould has been closed, air is blown through the root of the stretching rod 6, that is, a portion beneath the neck of the stretched parison 4a, to expand the stretched parison 4a to contact the walls of the temperature control member cavity, the inner surface area of which is larger than the outer surface area of parison.

This expansion causes the wall thickness of the stretched parison 4a to again decrease and the parison is pressed against and comes into intimate contact with the inner surface of the temperature control member 5, so that heat exchange occurs therebetween. At this time, the outer surface of the parison tends to be shrunk by cooling but is kept in intimate contact with the cavity wall by air pressure and cooling progresses towards the interior of the parison. During this cooling operation a portion having a higher temperature will be cooled more quickly than a lower temperature portion because of the decrease in wall thickness and increase in surface area of the higher temperature portion compared to the lower temperature portion. Thus, the parison temperature is made more uniform it reached the stretch-blow moulding temperature because of the differences in cooling speed.

When the parison temperature reaches the stretch-blow moulding temperature, the air is discharged from the parison to remove the internal pressure causing the stretched parison 4a to shrink in a radial direction and move away from the inner surface of the temperature control member 5 so that coooling stops automatically. After the mould has been opened and, the stretching rod 6 removed, axial self-shrinkage takes place. During this "self-shrinkage", the entire parison increases in wall thickness by an amount equal to the shrinkage. Thermal changes also occur as the wall thickness varies and therefore the parison temperature is made even more uniform and any residual stresses produced during injection moulding are also removed. Accordingly, cooling is preferably carried out when the parison tends to be self-shrunk.

After being subjected to temperature controlling as described above, the parison 4a is, as shown by Figure 4, transferred to the blow mould 7, where the parison is stretched and blow moulded into a hollow moulded article 8.

A number of examples of the methods detailed above will now be described. The stretching and blow moulding is carried out by, for example, the apparatus described in U.S. Patent No. 4,105,391.

Example 1

A vinyl chloride resin was injected into an injection mould to produce a parison of external diameter 38.5 mm, wall thickness 2.85 mm and length (except for the neck portion) 122 mm. The parison was cured for 20 seconds and after curing had a temperature of 130°C. The cured parison was then cooled and temperature controlled.

The temperature control member comprised a split mould of internal diameter 43 mm and interior height 138 mm having a temperature of 80°C determined by hot water in the coolant passages 5a.

The parison was axially stretched outside the temperature control member and immediately placed into the temperature control member and expanded by blowing air at a pressure of 4 kg/cm^2 therein. The outer surface of the parison was thus brought into intimate contact with the inner surface of the temperature control member by the expansion. After a lapse of 2 seconds for cooling, the air in the parison was discharged causing the parison to shrink radially and move away from the inner surface of the mould so that cooling was automatically stopped. When the stretching rod was removed after the temperature control member was opened, the parison shrank axially. As the result, the thus obtained parison had an external diameter of 40.5 mm, a wall thickness of 2.6 mm and a length of 127 mm.

The parison was then stretched and blow moulded within the blow mould by a conventional means to obtain a round bottle of external diameter 80 mm and length 240 mm.

The following table illustrates the characteristics of the parison, the temperature control member, the temperature controlled parison and the moulded article of three further examples. The method described in relation to Figures 1 to 4 was used in Example 2 while in Examples 3 and 4 the method described in relation to Figures 5 to 7 was used. The material used for Examples 1 and 2 was polyvinyl chloride (PVC) while the material used for Example 4 was polypropylene (PP).

Parison

	Length (mm)	*Outside diameter (mm)*	*Wall thickness (mm)*	*Temperature (°C)*
Example 2 (PVC)	107	29	2.6	130
Example 3 (PVC)	101	19	2.4	125
Example 4 (PP)	118	28	3.5	103

Temperature control member (cavity)

	Depth (mm)	*Inside diameter (mm)*	*Temperature (°C)*	*Air pressure (kg/cm^2)*	*Time sec.*
Example 2	124	39	100	4	3
Example 3	101	19	90	3	3
Example 4	122	40	100	8	1

Temperature controlled parison

	Length (mm)	*Outside diameter (mm)*	*Temperature (°C)*
Example 2	114	31	100
Example 3	107	22	98
Example 4	119	33	115

Moulded article (bottle)

	Length (mm)	*Outside diameter (mm)*	*Wall thickness (mm)*
Example 2 (1000 cc)	240	80	0.35
Example 3 (250 cc)	117	32	0.40
Example 4 (700 cc)	213	70	0.40

Examples 1 to 4 all produced articles having a uniform wall thickness and transparency of the articles was superior, except for Example 4, than that obtained by previous methods.

Claims

1. A method of controlling the temperature of a parison in injection stretch-blow moulding, which method comprises stretching an injection moulded parison and expanding the stretched injection moulded high temperature parison within a temperature control member having an inner surface area greater than an outer surface area of the parison so that the outer surface of the parison is subjected to pressure and brought into contact with the inner surface of the temperature control member to bring the temperature of parison to a stretch-blow moulding temperature.

2. A method according to Claim 1, further comprising releasing the pressure applied to the outer surface of the parison, allowing the parison to shrink and thereby move out of contact with the temperature control member.

3. A method according to Claim 1 or 2, wherein the injection moulded parison is axially stretched before being expanded in the temperature control member.

4. A method according to Claim 1, 2 or 3, wherein the stretched parison is radially expanded within the temperature control member to bring the outer surface of the parison into contact with the inner surface of the temperature control member.

5. A method according to any preceding claim, wherein the stretching of the parison is carried out outside the temperature control member.

6. A method according to any preceding claim, wherein the outer surface area of the injection moulded parison is increased by from 1.5 to 3.0 times and the length of the injection moulded parison is increased by from 10 to 20% during the temperature controlling.

7. A method of controlling the temperature of a parison in injection stretch-blow moulding substantially as hereinbefore described with reference to Figures 2 and 3 of the accompanying drawings.

8. A method of controlling the temperature of a parison in injection stretch-blow moulding substantially as hereinbefore described with reference to Figures 5 to 7 of the accompanying drawings.

9. A temperature controlled parison whenever produced by a method in accordance with any one of the preceding claims.

10. A method of injection stretch-blow moulding a parison comprising a method of controlling the temperature of the parison in accordance with any one of Claims 1 to 8.

11. A method of injection stretch-blow moulding a parison comprising a method of controlling the temperature of the parison, substantially as hereinbefore described with reference to Figures 1 to 4 of the accompanying drawings.

12. A method of injection stretch-blow moulding parison comprising a method of controlling the temperature of the parison, substantially as hereinbefore described with reference to Figures 1 and 4 to 7 of the accompanying drawings.

13. Any novel feature or combination of features described herein.

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