

SPECIFICATION

A tubular pre-moulding of thermoplastic material

5 The present invention relates to a tubular pre-moulding of thermoplastic material, for example, for subsequent reshaping to produce containers and the like.

10 In a production process used for the manufacture of containers from thermoplastic material, blanks for containers are produced from severed parts of extruded long tubes of an amorphous thermoplastic material, these blanks normally being called pre-mouldings. At one end, the severed pieces are
15 shaped in such a way that they form the mouth part of the container, whilst they are closed at the other end.

20 A pre-moulding of the present invention may be made from a thermoplastic of the polyester or polyamide type. Examples of such materials are polyethylene terephthalate, polyhexamethylene-adipamide, polycaprolactam, polyhexamethylene-sebacamide, polyethylene 2,6- and 1,5-naphthalate, polytetramethylene 1,2-dihydroxybenzoate and
25 copolymers of ethylene terephthalate, ethylene isophthalate and similar polymers. The description of the invention below relates mainly to polyethylene terephthalate called PET in the further text, for the invention is not restricted only to the use
30 of either this material or one of the other materials already mentioned; instead it is also applicable to other thermoplastic materials.

For a better understanding of the invention, several characteristic properties of the polyester polyethylene terephthalate are described below. From the literature, for example "Properties of Polymers", by D.W. van Krevelen, Elsevier Scientific Publishing Company, 2nd compl. revised edition 1976, it is known that the properties of the material
40 change when amorphous polyethylene terephthalate is oriented. Some of these changes are shown in the diagrams, Figures 14.3 and 14.4 on pages 317 and 319 in the book "Properties of Polymers". The symbols used in the discussion below correspond to
45 the symbols in that book.

PET, like many other thermoplastic materials, can be oriented by stretching the material. Normally this stretching takes place at a temperature above the glass transition temperature T_g of the material. The
50 strength properties of the material are improved by orienting. The literature shows that, in the case of the thermoplastic PET, an increase in the stretching ratio Λ , that is to say the quotient of the length of the stretched material and the length of the unstretched
55 material, also leads to an increase in the improvement of the material properties. When the stretching ratio Λ is increased from about 2 to a little more than 3, particularly large changes in the material properties are obtained. The strength in the direction of
60 orientation is here markedly improved, whilst at the same time the density ρ and likewise the crystallinity x_c rises and the glass transition temperature T_g is raised. It can be seen from the stress-strain diagram on page 317 that, after stretching, with Λ assuming
65 the value of 3.1, a stress of 10 CN/tex applied to the

material produces a very small elongation, whilst after stretching with Λ assuming the value of 2.8 the elongation at the same stress is substantially larger. In the text, the term "step" is sometimes used to
70 designate orienting which is obtained by stretching, or a reduction in thickness by about 3 times, and which leads to the marked improvements of the material properties, indicated above.

The diagrams quoted above show changes which
75 are obtained on mono-axial orientation of the material. In biaxial orientation, similar effects are obtained in both directions of orientation. Orientation is carried out as a rule by successive stretchings.

Improved material properties corresponding to
80 those which are obtained by the "step" defined above, are also obtained if an amorphous material is stretched until it flows and, before flowing, the material is at a temperature which is below the glass transition temperature T_g . In a rod being drawn, a
85 reduction of the diameter of about 3 times results in the flow zone. On drawing, the flow zone is continuously displaced into the amorphous material, whilst at the same time the material, which has already undergone the state of flowing, absorbs the
90 tensile forces of the test rod without an additional permanent stretching.

For bottles, defined external diameters of the mouth with the associated thread are standardised and, in the technology known at present when using
95 the moulding process described as an introduction, this determines the greatest diameter which is permissible in the blow-moulding container body. The reasons for this are explained in more detail in the following text. In order to obtain an amorphous
100 starting material for the pieces of tube, which are to be shaped into pre-mouldings, the material must be cooled rapidly to below the glass transition temperature T_g after extruding - in the case of extruded tubes from which the pieces of tube are severed. In the
105 case of excessive wall thickness, the material does not possess adequate heat conductivity to enable the central sections of the wall to be cooled as rapidly as required, so that the material located in the centre becomes crystalline and opaque. For this
110 reason, viewed theoretically, the largest possible wall thickness of the extruded tubes is less than about 9 mm. In practice, however, wall thicknesses of less than 4 mm are used. In fact, in blow-moulding of a pre-moulding having wall material of excessive
115 thickness, problems arise due to the cooling of the material during the actual blow-moulding step and before the material reaches the wall of the mould. The blow-moulded container is no longer clear as glass and, instead, contains opaque white sections.
120 In blow-moulding, in order to obtain containers having the requisite resistance against stresses and penetration of the container wall, the wall thickness of the finished container must not fall below a defined value. Moreover, a reduction of the external
125 diameter of the tube during the shaping of the mouth part of the pre-moulding is not possible in accordance with known technology. The result is that the desired mouth diameter of the blow-moulded container is decisive for the diameter of the
130 pre-moulding and thus for the maximum diameter of

the blow-moulded container body. If bottles of large capacity are required, these bottles are extended, according to known technology, in the axial direction after they have reached the maximum possible diameter. In addition to the disadvantage of a certain instability, the extension represents an unsatisfactory utilisation of the quantity of material in the container body since the requisite quantity of material per unit volume of storage capacity is greater than would be necessary if both the diameter and the length of the container body were adapted to the actual volume required. Moreover, the unnecessarily large surface of the container leads to a corresponding increase in the overall penetration of carbon dioxide during the storage of beverages containing carbonic acid.

To utilise the material properties of the material in the best way, it is desirable that the diameter of those parts of the pre-moulding which, after the blow-moulding step, represent the actual container body, is given a value which has the result that the material in the blow-moulded container body assumes the desired orientation. In containers of PET it is desirable that the material, in conjunction with blow-moulding, is biaxially stretched in such a way that the product of the stretchings is about 9.

The above shows that, according to known technology, the quantity of material in the mouth part is not determined by the calculated stresses but by the maximum diameter of the container body. As a rule, this leads to a considerable excess of material in the mouth part.

For example, in a PET bottle of 1 litre capacity, the mouth part can, according to known technology, contain up to 25-30% of the total quantity of material. Disregarding the unpleasant appearance of the oversizing of the mouth part, this fact also results in a waste of material, which is of importance in the mass production of articles.

In the technology used at present, the mouth part and adjacent neck parts consist of unoriented material, that is to say amorphous material. This means that the material in the mouth part including the adjacent neck parts has properties which differ from those of the container body. In containers of, for example, PET, the material in the mouth part has a glass transition temperature T_g of 71°C, whilst the glass transition temperature of the material in the container body is about 81°C. It follows from this that the material in the mouth part softens at a lower temperature than the material in the container body.

It is already known, by cold-forming of the mouth part of the blank, to displace material downwards from the mouth part into the sections of the blank, which later represent the wall sections of the container body. In this way, a certain matching of the quantity of material in the mouth part to the future stresses is achieved but, between the actual container body and the mouth part, neck sections are formed in which the material is stretched by a factor of less than 3. These neck sections in the moulded container thus consist of inadequately oriented material, whilst at the same time the wall thickness is undesirably large. This method is described in

British Patent No. 2016360B.

U.S. Patent No. 4108937 describes a method wherein a tubular blank, which is closed at one end and which is provided at the other end with beading for fixing the blank in a downstream blowing element, is injection-moulded and wherein the tubular blank is blow-moulded after a certain reshaping to give a container. Material in the tubular part of the blank is expanded in the radial direction at a temperature above the glass transition temperature T_g in order thus to form the mouth part of the container. A container formed in the manner described possesses a mouth part and a neck section in which the material has been exposed to only very slight stretching and hence orienting, so that the disadvantages, already indicated, with respect to the mouth part of the known containers are also present in this container.

The invention described in the U.S. Patent also has the disadvantage that only a part of the material content of the injection-moulded tubular blank is utilised when reshaping the blank to give the finished container. It is obvious that the losses of material, which occur in this process, represent an economic disadvantage in the mass production of articles.

From Federal German Offenlegungsschrift DOS 2,540,930, a process is known wherein a tubular blank of PET is reshaped to give a container and wherein the container wall consists of a material which is stretched by a factor of, for example, more than 1.5. The bottom part of the container consists of an amorphous unoriented material, whilst the neck sections of the container consists of material which has been oriented only to a slight extent. As a result of heating and crystallisation, caused thereby, the strength of the material is improved in the unoriented zones which at the same time become opaque. Furthermore, a combination of the methods indicated above results in an undesired oversizing of the neck sections of the containers, whilst the latter at the same time have poorer properties than the material in the actual container body.

According to the present invention there is provided a tubular pre-moulding of thermoplastic material comprising a tubular section having a mouth part and an adjacent neck section at one end, the other end of the tubular section being closed, the tubular section and the closed end being formed substantially of amorphous unoriented material having a crystallinity of less than 5%, wherein the material of the mouth part and the adjacent neck section has been oriented substantially in the axial direction of the pre-moulding by reducing the thickness of the material, and wherein the crystallinity of the material in the mouth part and the adjacent neck section is at most 50%.

A blank or pre-moulding of the invention can be used to form a container in which the mouth part, the neck section and the container body are all of a material which is adapted to the stresses occurring and in which the material in the said parts is oriented to a satisfactory extent. Preferably, the material is stretched, at least in the axial direction, by a factor of more than 3.

This results in the advantage of a raised glass

transition temperature T_g in all the said parts of the container. This means that all the said parts will have the same heat resistance, and this is a great advantage compared with containers which are

5 formed according to the known technology and which, at least as far as containers with mainly clear and transparent materials are concerned, have neck sections and mouth parts which are more sensitive to heat stresses than the actual container body.

10 Moreover, the invention enables a container of smaller mouth diameter to be manufactured, the length and diameter of the container body being matched to the storage capacity of the container in such a way that the smallest possible quantity of

15 material per unit volume of storage space results.

In addition, the invention enables a container with a neck part of any desired shape to be formed from the blank, the material in the mouth part and in the neck part also being oriented and having a crystallinity of more than 10%. This is achieved by stretching the material to the requisite extent, for example in the case of containers of PET by stretching in the axial direction by a factor of more than 3. According to known technology it was hitherto not possible to

20 obtain such a degree of orienting, unless the mouth part and neck sections of the containers were to consist of mainly unoriented material, in which case the neck sections merge in the shortest possible distance with oriented sections of the container

25 body, where the wall thickness has been reduced by a factor of at least 3. This shaping represented an attempt to reduce the size of that zone in the neck part, which has mainly amorphous material and low orientation and hence a low glass transition temperature T_g .

In an embodiment of the tubular pre-moulding, the material of the mouth part and the neck section has been oriented by reducing the thickness of the material by a factor of at least 3.

40 Preferably, the material of the mouth part is also oriented in the circumferential direction of the pre-moulding, and the crystallinity of the material in the mouth part and the adjacent neck section is between 10% and 35%. The material in the neck

45 section may be oriented in the circumferential direction of the pre-moulding by means of a blow-moulding process whilst the material is at a temperature below the glass transition temperature.

In one embodiment, the material of the mouth part of the pre-moulding has a crystallinity deriving from the orientation which is at most 20%, preferably between 10% and 17%. Furthermore, the material of the neck section has a crystallinity deriving from the orientation which is at most 34%, preferably between

50 12% and 30%.

A tubular pre-moulding may be manufactured by clamping a tube of thermoplastic material between two mutually separate clamping devices. The material in the zone between the two clamping devices is

60 stretched in the axial direction of the tube by moving the clamping devices away from one another. The length of displacement of the clamping devices relative to the length of the part to be stretched is selected such that the material reaches a crystallinity

65 of at least 10% on axial orientation. When PET is

used, stretching by a factor of at least 3 takes place.

The material in the tube may be stretched while the material is at a temperature above the glass transition temperature T_g , or it may be stretched in the cold state, which means that the material is at a temperature below the glass transition temperature T_g at the beginning of the stretching step. On stretching "in the cold state", the material is drawn until flow sets in.

75 After stretching, at least the central sections of the drawn material are blow-moulded against a mould at a temperature above the glass transition temperature T_g in order to form, for example, threads and, in some cases parts of the adjacent neck sections,

80 while two future mouth parts are in adjacent positions.

Subsequently, the tube is severed at the transition between the two future mouth parts. Each of the two severed blank parts thus produced form a tubular

85 pre-moulding, after closing at one end, and if appropriate, reworking at the other end in order to obtain the required closure surfaces.

Alternatively, the material may be heated before the axial stretching to a temperature above the glass transition temperature T_g , or the stretching step may be preceded by a blow-moulding step in which the heated material is subjected to a certain expansion in order to increase the diameter of the zone.

Alternatively, the mouth parts of the pre-mouldings can be shaped by simultaneous axial stretching, and blow-moulding for the purpose of a radial expansion of the heated material.

The heated material zone may have a temperature profile such that one or several annular sections are at a temperature which exceeds the temperature of the adjacent material by 3° to 20°C, preferably 10° to 15°C. The actual drawing or stretching step starts in the sections of higher temperature.

Where the material in the tube is, at the start of axial stretching of the material, at a temperature which is less than the glass transition temperature T_g , the drawing or stretching step may be initiated with the aid of pressure forces. This is achieved, for example, by means of a ring which surrounds the tube, the inner surface of the ring being brought into contact with the outer surface of the tube by reducing the internal diameter of the ring.

On axial stretching of the material, the external diameter of the tube is reduced. It is thus possible to produce a pre-moulding, the mouth part of which has an external diameter which is less than the external diameter of the tube.

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

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Figure 1 shows a perspective view of a stretching and blow-moulding apparatus having two sets of clamping devices, with the two sets of clamping devices positioned to receive a piece of tube,

125 *Figure 2* shows a perspective view of the apparatus of *Figure 1* with the clamping devices positioned for fixing a piece of tube,

Figure 3 shows a longitudinal section of the stretching and blow-moulding apparatus during the heating of a central part of a piece of tube,

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Figure 4 shows a longitudinal section of the stretching and blow-moulding apparatus with the piece of tube fixed and drawn,

Figure 5 shows a longitudinal section of the stretching and blow-moulding apparatus with the internal volume of the piece of tube subjected to pressure to form mouth sections and adjacent neck sections,

Figure 6 shows a device for severing the piece of tube into two separate blank parts,

Figure 7 shows diagrammatically apparatus for the stepwise production of blank parts for pre-mouldings,

Figure 8 shows a longitudinal section of a stretching and blow-moulding apparatus having a device for heating an annular section in the piece of tube,

Figure 9 shows a longitudinal section of a stretching and blow-moulding apparatus during a cold-drawing step of the piece of tube,

Figure 10 shows a longitudinal section of a stretching and blow-moulding apparatus after the cold-drawing step of the piece of tube has been carried out,

Figure 11 shows a longitudinal section of part of a stretching and blow-moulding apparatus with the length of the axially drawn zone increased,

Figure 12 shows a partial longitudinal section of the stretching and blow-moulding apparatus of Figure 11, in which the internal volume of the piece of tube has been subjected to pressure to form neck sections adjacent to a mouth part,

Figure 13 shows a longitudinal section of a completed tubular pre-moulding which has been produced as illustrated in Figure 5, and

Figure 14 shows a longitudinal section of a completed tubular pre-moulding which has been produced as illustrated in Figure 12.

Figures 1 and 2 show a stretching and blow-moulding apparatus having a frame on which two separate sets of clamping devices 20a and 20b, and 21a and 21b are located. Each set of clamping devices comprises an upper clamping part 20a, 21a and a lower clamping part 20b, 21b. In both sets of clamping devices, the upper clamping part can be moved transversely to the longitudinal axis of the apparatus between an open position and a closed position. In the closed position, each set of clamping devices holds a respective end of a tube 50. The two sets of clamping devices can be moved longitudinally from the starting position shown in Figure 1 towards one another to an inward position in which they are arranged to accommodate the length of the tube 50 (Figure 2). The clamping devices can also be moved back from the inward position to the starting position. In the starting position, each upper clamping part is in its open position and remains in the open position until the two sets of clamping devices have been moved towards one another to the inward position. In the inward position, the upper clamping parts assume the closed position and each covers a relatively large length of the tube 50. Hence, a large length of the tube 50 is both surrounded by and held by the sets of clamping devices. With the upper clamping parts still in their closed positions, the two sets of clamping devices are subsequently moved

back to the starting position.

The transverse movement of the upper clamping parts 20a, 21a of the two sets of clamping devices is effected by means of a respective drive mechanism 25, 26. In addition, a drive mechanism 24 is provided for moving the two sets of clamping devices longitudinally and with respect to one another. The two upper clamping parts slide in grooves 22, 23 provided in the lower parts, whilst the lower parts slide in grooves 13a and 13b provided in the frame 11.

A gripper 28 is provided for inserting and removing the tube 50 from the clamping devices. When the two sets of clamping devices are at their inward position a heating element consisting of the two heating jaws 29a and 29b is brought into a position in which it can heat the central sections of the tube 50. The motion of the heating jaws is effected by means of a drive mechanism 33 including a reciprocable rod. A lead 31 for supplying energy to the heating jaws, for example for supplying electrical power, is shown in the figures.

A cylindrical forming and blowing mandrel 27 is provided adjoining one of the two sets of clamping devices. This mandrel 27 is movable by means of a drive mechanism 39 from and to a position in which the cylindrical part of the mandrel projects a little into an opening of the other set of clamping devices. The mandrel projects into the said opening even when the two sets of clamping devices are in their starting positions.

The external diameter of the mandrel and the internal diameter of the tube 50 are arranged such that the mandrel can be introduced into the tube. Moreover, the mandrel is provided with a row of orifices 40 which communicate with a cavity in the interior of the mandrel, which cavity is connected to a line 32 for supplying a pressure medium.

A pressure medium is also fed via lines 30a, 30b, 30c, 30e (the pressure line 30d is not shown in the figure) to the individual drive mechanisms 24, 25, 26, 33 and 39.

In Figure 3, the two sets of clamping devices 20a, 20b, 21a, 21b are shown in their inward position. In addition, Figure 3 shows the cavity 42 in the mandrel 27, a gasket 41 between one end of the tube 50 and the set of clamping devices 21a, 21b, and a gasket 34 between the other end of the tube 50 and the set of clamping devices 20a and 20b. A gasket 35 is also provided between the mandrel 27 and the set of clamping devices 20a, 20b. An outlet valve 36 is located in the lower clamping device 21b. Thus, a sealed space which can be subjected to pressure through the orifices 40 is formed around the mandrel 27 within the tube 50.

Figure 4 shows the two sets of clamping devices moved back to their starting position with the surrounded parts of the tube 50 still held firmly by the clamping devices. The Figure illustrates that the mandrel 27 continues to project into the set of clamping devices 21a, 21b. A central zone 51 of the tube 50 has been stretched in the axial direction by the movement of the clamping devices and has a smaller wall thickness than the remainder of the tube.

In Figure 5, the central zone 51 has been blow-

moulded against a two-part mould 57a, 57b. The shaping surface of the mould corresponds to the form of two mouth parts 52a, 52b, facing one another, for containers which are to be formed from the pre-mouldings in the process of manufacture.

Figure 6 shows the mandrel 27 in its starting position. A severing disc 58 is located in position for severing the tube 50, that is at the transition between the two moulded mouth parts 52a and 52b.

Figure 7 shows a turntable 10 which is rotatable about a bearing 12. A number of positions A-U are indicated around the turntable. One frame 11 with its associated sets of clamping devices, drive mechanisms, tubular mandrel, heating device and the like as described above is located on the turntable at each position. In each position, the particular working step is indicated diagrammatically by the position of mandrel, heating jaws, sets of clamping devices and the like.

Figure 8 shows an apparatus which is particularly suitable for cold-drawing of the tube 50. An annular heating element 38 is located between the two sets of clamping devices. By means of this heating element, an annular zone of the central section of the tube 50 is heated to an elevated temperature.

Figures 9 to 10 show the subsequent cold-drawing of the tube 50. In Figure 9, the formation of a centrally located drawn zone 53 has started, whilst in Figure 10 the entire centrally located drawn zone 54 has been formed.

Figures 11 and 12 show an apparatus wherein a centrally located stretched zone 51a of the tube 50 is formed which is longer than in the previously described embodiments. Figures 11 and 12 show only one of the two sets of clamping devices. Figure 11 shows the position after drawing of the tube has been completed, whilst Figure 12 shows the central zone 51a (Figure 11) after it has been blow-moulded against an outer mould 59. The moulding surface of the outer mould corresponds to the shape of two mutually facing mouth parts (only one 52a, is shown in the Figure) and parts of the adjacent future neck section 60a of the containers which are to be formed from the pre-mouldings which are in the process of production. A zone 56, having the largest diameter in the moulded future neck sections, preferably has a diameter which is at least three times the original diameter of the tube.

Figures 13 and 14 show completed tubular pre-mouldings, the pre-moulding shown in Figure 13 having been formed from a blank part as shown in Figure 5, and the pre-moulding shown in Figure 14 having been formed from a blank part as shown in Figure 12. At one end, the pre-mouldings have a mouth part 62a, 62b with an adjacent neck section 63a, 63b. At the other end the pre-mouldings have a closure 61a, 61b. A tubular section 64a, 64b can be seen between the closure 61a, 61b and the neck sections 63a, 63b.

Figures 1 to 6 show successive steps in the formation of a pre-moulding according to the invention. Initially, a tube 50 is brought into the position shown in Figure 1 with the aid of the gripper 28. The two sets of clamping devices 20 and 21 are shifted towards one another with the aid of the drive

mechanism 24 until the two ends of the tube are in contact with the gaskets 34 and 41 and the gripper 28 is removed. The upper clamping devices are brought into their closed position with the aid of the drive mechanisms 25, 26 the tube 50 being firmly held at both its ends and at the same time being enclosed over a relatively large part. This situation is shown in Figure 2. The mandrel 27 is then moved within the tube 50. Alternatively, the mandrel 27 may be inserted within the tube during the preceding steps. When the tube is clamped and the mandrel is in position as shown in Figure 3, the heating jaws 29 are positioned around the central section of the tube. Energy is supplied to the heating jaws for such a period as is necessary to heat the material in the central section of the tube to a temperature below the glass transition temperature T_g . The drive element 24 then moves the two sets of clamping devices away from one another, and the central section of the tube is thus stretched, with simultaneous thinning of the tube wall. The stretched central section of the tube is shown in Figure 4. Preferably, the central section is stretched by at least a factor of 3, and the corresponding reduction in wall thickness is thus and also amounts by at least a factor of 3. During the entire drawing step, the mandrel 27 remains within the interior of the tube, within the stretched zone, and this prevents the stretched zone from assuming an undesirably small diameter.

The sealed space within the interior of the tube is then subjected to pressure, and the material in the corresponding section of the tube is expanded until it makes contact with the outer mould 57. In this step, future mouth parts and parts of adjacent neck sections in two blank parts connected to one another are shaped to give pre-mouldings. On contact with the surfaces of the outer mould, the material in the tube is cooled so that it becomes dimensionally stable. With simultaneous retraction of the mandrel 27 into its starting position, the outer mould is opened and a severing disc 28 divides the tube at the transition between the two future mouth parts. This produces two separate blank parts which are closed at one end by reshaping and are provided with the requisite closing surfaces at the other end by reworking. In this way, a tubular pre-moulding as shown in Figure 13 is obtained.

Apparatus for closing one end, and for performing any reworking of the mouth part which may be necessary is not shown in the drawings as conventional apparatus known in the art can be used. Normally, closing is effected by heating the material at the one end of the tube to a temperature above the glass transition temperature T_g , after which the end is forced in the axial direction against a substantially spherical shell which compresses the soft material and closes the end. Subsequently, the gripper 28 grips the two blank parts formed and removes the two blank parts from the apparatus after the two sets of clamping devices have released the pre-mouldings. The process described above can then be repeated.

Preferably, the process described above is carried out using the apparatus shown in Figure 7. In

position A, a tube is fed to the two sets of clamping devices, in position B the two sets of clamping devices are moved towards one another, whilst the mandrel is simultaneously introduced into the tube.

- 5 In positions C to E the central zone of the tube is heated, and the heating process is interrupted at position F. In positions G to H, the central sections of the tube are stretched. In position I the outer moulds move into the moulding position and in position J the interior of the tube is subjected to pressure and is formed to give the future mouth parts with the adjacent neck sections. In position K, the outer moulds open, whilst in position L the mandrel is retracted into its starting position. Position M is a cooling position for stabilising the form of the tube or, alternatively, is a reserve position, whilst in position N the tube is severed into two blank parts. In position O, the two future mouth parts are heated for reworking, if appropriate, and they obtain their final form in position P. In position R, the devices for reworking the mouth parts have assumed again their starting position, and subsequently, in position S, the blank parts have been shifted in the direction towards one another in order to enable the gripper to engage in position T and to enable the clamping devices to open in position U, so that the mouldings formed can be removed from the apparatus shown in Figure 7. Advantageously, the gripper device here transfers the blanks to devices for closing one of their ends. Such devices can either be provided independently of the apparatus of Figure 7 or they can form part of this apparatus.

In the latter case, the apparatus must be provided with a further number of positions.

- 35 During cold-drawing of the central zone of the tube, the material is heated before the drawing step with the aid of an annular heating element 38 (Figure 8) over an annular zone within the central section. This heating element is preferably arranged to heat 40 the central section as far as one of the sets of clamping devices. To control the direction of displacement during the flow which sets in on drawing, the material is normally cooled immediately next to the heated annulus in that direction in which it is intended that the flow step should not propagate. In the embodiments in which the entire material of the tube is to be drawn between the two sets of jaws, the required cooling is obtained by the cooled jaws. In other embodiments, annular cooling devices are used which, in principle, are arranged in a manner corresponding to the arrangement of the heating device 38.

On warm-drawing of the central zone of the tube, one or several annular heating elements are used in certain embodiments in order to produce the desired temperature profile in the central section of the tube before the latter is drawn. The annular heating elements may comprise zones of elevated temperature in the heating jaws 29.

- 60 On cold-drawing of the material in the central section of the tube, flow of the material sets in first in the annular zone which has been heated by the annular heating element 38. On further stretching of the central zone of the tube, the flow zone of the material is displaced in the direction of the other set

of clamping devices, see Figure 9, so that, after completion of the stretching step, a central drawn zone has formed, the appearance of which is shown in Figure 10. On cold-drawing, the central zone has no tendency towards a reduction of the internal diameter of the tube, as long as stretching is limited to about a factor of 3. In this case it is thus not necessary to cause the mandrel 27 to assume its position in the tube before the actual stretching step.

- 75 Figures 11-12 show an apparatus in which the stretched central zone 51a of the tube is formed to have a greater length than in the embodiments so far described. When the interior of the tube is subjected to pressure, parts of adjacent neck sections are also formed, in addition to the two future mouth parts, these neck sections being given a greater diameter than that of the actual mouth part. At this stage, it is preferable to allow the future neck section to be shaped to such an extent that the greatest rise in diameter is at least 3-fold. This has the advantage that a relatively dimensionally stable neck section is formed which, during the subsequent heating in conjunction with the shaping of the remaining part of the container, is affected only to a small extent. 90 The appearance of a pre-moulding, which was formed from a blank part partially shown in Figure 12, can be seen in Figure 14.

In the above description, it has been explained how the blank parts are formed by severing the drawn and shaped tube. Preferably, severing of the blank parts from one another is effected with the aid of one or more severing discs which revolve under pressure about the circumferential surface of the tube formed at the transition between the two future mouth parts.

- 100 In the processes described above, heating of the central section of the tube is effected by heating jaws. To obtain the most uniform heating of the material possible, the tube should preferably rotate relative to the heating element. To make this possible, the clamping devices are modified, if appropriate having cone-type bearings or having heating jaws which revolve about the tube.

- 105 In the case where the central section of the tube is drawn at an initial temperature which is below the glass transition temperature T_g , the material is heated after the drawing step to a temperature above the glass transition temperature T_g , after which the future mouth part and parts of the adjacent neck sections are shaped.

A process and apparatus for manufacturing tubular pre-mouldings of thermoplastic material are described in copending application No. 8219963 which was divided out of the present application.

120 CLAIMS

1. A tubular pre-moulding of thermoplastic material comprising a tubular section having a mouth part and an adjacent neck section at one end, the other end of the tubular section being closed, the tubular section and the closed end being formed substantially of amorphous unoriented material having a crystallinity of less than 5%, wherein the material of the mouth part and the adjacent neck

position A, a tube is fed to the two sets of clamping devices, in position B the two sets of clamping devices are moved towards one another, whilst the mandrel is simultaneously introduced into the tube.

- 5 In positions C to E the central zone of the tube is heated, and the heating process is interrupted at position F. In positions G to H, the central sections of the tube are stretched. In position I the outer moulds move into the moulding position and in position J the interior of the tube is subjected to pressure and is formed to give the future mouth parts with the adjacent neck sections. In position K, the outer moulds open, whilst in position L the mandrel is retracted into its starting position. Position M is a cooling position for stabilising the form of the tube or, alternatively, is a reserve position, whilst in position N the tube is severed into two blank parts. In position O, the two future mouth parts are heated for reworking, if appropriate, and they obtain their final form in position P. In position R, the devices for reworking the mouth parts have assumed again their starting position, and subsequently, in position S, the blank parts have been shifted in the direction towards one another in order to enable the gripper to engage in position T and to enable the clamping devices to open in position U, so that the mouldings formed can be removed from the apparatus shown in Figure 7. Advantageously, the gripper device here transfers the blanks to devices for closing one of their ends. Such devices can either be provided independently of the apparatus of Figure 7 or they can form part of this apparatus.

In the latter case, the apparatus must be provided with a further number of positions.

- 35 During cold-drawing of the central zone of the tube, the material is heated before the drawing step with the aid of an annular heating element 38 (Figure 8) over an annular zone within the central section. This heating element is preferably arranged to heat the central section as far as one of the sets of clamping devices. To control the direction of displacement during the flow which sets in on drawing, the material is normally cooled immediately next to the heated annulus in that direction in which it is intended that the flow step should not propagate. In the embodiments in which the entire material of the tube is to be drawn between the two sets of jaws, the required cooling is obtained by the cooled jaws. In other embodiments, annular cooling devices are used which, in principle, are arranged in a manner corresponding to the arrangement of the heating device 38.

- On warm-drawing of the central zone of the tube, one or several annular heating elements are used in certain embodiments in order to produce the desired temperature profile in the central section of the tube before the latter is drawn. The annular heating elements may comprise zones of elevated temperature in the heating jaws 29.

- 60 On cold-drawing of the material in the central section of the tube, flow of the material sets in first in the annular zone which has been heated by the annular heating element 38. On further stretching of the central zone of the tube, the flow zone of the material is displaced in the direction of the other set

of clamping devices, see Figure 9, so that, after completion of the stretching step, a central drawn zone has formed, the appearance of which is shown in Figure 10. On cold-drawing, the central zone has no tendency towards a reduction of the internal diameter of the tube, as long as stretching is limited to about a factor of 3. In this case it is thus not necessary to cause the mandrel 27 to assume its position in the tube before the actual stretching step. Figures 11-12 show an apparatus in which the stretched central zone 51a of the tube is formed to have a greater length than in the embodiments so far described. When the interior of the tube is subjected to pressure, parts of adjacent neck sections are also formed, in addition to the two future mouth parts, these neck sections being given a greater diameter than that of the actual mouth part. At this stage, it is preferable to allow the future neck section to be shaped to such an extent that the greatest rise in diameter is at least 3-fold. This has the advantage that a relatively dimensionally stable neck section is formed which, during the subsequent heating in conjunction with the shaping of the remaining part of the container, is affected only to a small extent. The appearance of a pre-moulding, which was formed from a blank part partially shown in Figure 12, can be seen in Figure 14.

- In the above description, it has been explained how the blank parts are formed by severing the drawn and shaped tube. Preferably, severing of the blank parts from one another is effected with the aid of one or more severing discs which revolve under pressure about the circumferential surface of the tube formed at the transition between the two future mouth parts.

- In the processes described above, heating of the central section of the tube is effected by heating jaws. To obtain the most uniform heating of the material possible, the tube should preferably rotate relative to the heating element. To make this possible, the clamping devices are modified, if appropriate having cone-type bearings or having heating jaws which revolve about the tube.

- In the case where the central section of the tube is drawn at an initial temperature which is below the glass transition temperature T_g , the material is heated after the drawing step to a temperature above the glass transition temperature T_g , after which the future mouth part and parts of the adjacent neck sections are shaped.

- A process and apparatus for manufacturing tubular pre-mouldings of thermoplastic material are described in copending application No. 8219963 which was divided out of the present application.

120 CLAIMS

1. A tubular pre-moulding of thermoplastic material comprising a tubular section having a mouth part and an adjacent neck section at one end, the other end of the tubular section being closed, the tubular section and the closed end being formed substantially of amorphous unoriented material having a crystallinity of less than 5%, wherein the material of the mouth part and the adjacent neck



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section has been oriented substantially in the axial direction of the pre-moulding by reducing the thickness of the material, and wherein the crystallinity of the material in the mouth part and the adjacent neck section is at most 50%.

2. A tubular pre-moulding as claimed in Claim 1, wherein the material of the mouth part and the neck section has been oriented by reducing the thickness of the material by a factor of at least 3.

10 3. A tubular pre-moulding as claimed in Claim 1 or 2, wherein the material of the mouth part is also oriented in the circumferential direction of the pre-moulding, and wherein the crystallinity of the material in the mouth part and the adjacent neck section is between 10% and 35%.

15 4. A tubular pre-moulding as claimed in Claim 1, 2 or 3, wherein the material in the neck section has been oriented in the circumferential direction of the pre-moulding by means of a blow-moulding process whilst the material is at a temperature below the glass transition temperature.

20 5. A tubular pre-moulding as claimed in any preceding claim, wherein the material of the mouth part has a crystallinity deriving from the orientation which is at most 20%.

25 6. A tubular pre-moulding as claimed in Claim 5, wherein the material of the mouth part has a crystallinity between 10% and 17%.

30 7. A tubular pre-moulding as claimed in any preceding claim, wherein the material of the neck section has a crystallinity deriving from the orientation which is at most 34%.

35 8. A tubular pre-moulding as claimed in Claim 7, wherein the material of the neck section has a crystallinity between 12% and 30%.

9. A tubular pre-moulding of thermoplastic material substantially as hereinbefore described with reference to and as illustrated in Figures 13 and 14 of the accompanying drawings.