

Method and Device for producing a tubular object from thermoplastic material

Description

The present invention relates to a method and a device for producing a tubular object from thermoplastic material, for example a bellows, the wall thickness thereof being adjustable over its length.

A method and a device of this type are, for example, known from EP 0 535 254 B1 of the applicant. The device disclosed therein comprises a die with a die land and a die body which, between them, form an annular die opening, the die body being movable relative to the die land, in order to alter the cross-sectional surface of the die opening, an extrusion device with a plunger, which during its movement extrudes a quantity of plasticised plastic material determined by the plunger path through the die, in order to produce a tubular plastic object, a withdrawal unit which may be moved from an initial position adjacent to the die in the direction away from the die, in order to guide the tubular plastic object emerging from the die during the extrusion process, the path of the withdrawal unit determining the length of the tubular plastic object.

In the device disclosed therein, control devices are provided for the drives of the die body, the plunger and the withdrawal unit, which comprise a computer and path sensors for these movements, the computer controlling the three drives according to a predeterminable program. The control is carried out such that the velocity increase of the withdrawal unit is controlled during its initial movement, and in that, during the further movement of the withdrawal unit, a gap width of the die opening which is controlled so as to increase and decrease in an oscillating manner is superimposed on a continuously controlled velocity characteristic of the withdrawal unit, such that the thickness of the wall formed is altered in a wave-like manner, over valleys and peaks. The object produced in this manner is a preform for blow-moulding a bellows.

The object of the present invention is to develop a method and a device of this type such that tubular objects made of thermoplastic material formed in any manner thereby, may be produced with a precisely adjustable wall thickness over the length of the object.

The method according to the present invention for achieving this object is defined in claim 1. The device according to the present invention for achieving this object is defined in claim 8.

According to the present invention, the movements of the withdrawal unit, the plunger and the die body are controlled, such that the movement of the withdrawal unit is carried out according to a freely adjustable velocity profile over the path of the withdrawal unit, such that the movement of the plunger is carried out according to a freely adjustable velocity profile over the path of the plunger, and such that the movement of the die body is carried out according to a freely adjustable position profile over the path of the withdrawal unit or the path of the plunger, so that the movement of the die body is carried out for the same duration as the movement of the withdrawal unit or the plunger.

In this manner, the velocity characteristic of the plunger on the one hand and the velocity characteristic of the withdrawal unit on the other hand, may be freely adjusted independently of one another, whilst the movement of the die body and thus the alteration of the die opening follows the movement of the plunger or the withdrawal unit as a "slave", so to speak.

As the velocity profiles for the movements of the plunger and the withdrawal unit are freely adjustable, influences impairing the production accuracy, such as subsequent swelling of the plasticised plastic material or sagging of the tubular plastic object may already be optimally considered during the process setting. In this manner, the wall thickness of the tubular plastic object and thus the finished tubular object are adjusted over their length with extremely high accuracy.

The method according to the invention offers the possibility of allowing the movements of the withdrawal unit and the plunger to start at the same time, but moreover, to be carried out asynchronously, such that the duration of the movement of the withdrawal unit and the duration of the movement of the plunger are then unequal. As a result, as already mentioned, influences impairing the process sequence may be optimally considered.

In principle, however, an automatic "synchronisation" of the movements of the plunger and of the injection-moulding die is also possible. To this end, in a further embodiment of the invention, the control unit may be adjusted such that the velocity

profile for the withdrawal unit is automatically adapted to the velocity profile for the movement of the plunger, or vice versa, in order to make the duration of the movements of the withdrawal unit and the plunger equal. This has the advantage that, with an alteration for example of the velocity profile of the plunger, no further manual adjustment of the velocity profile is required for the movement of the withdrawal unit. Preferably, the tubular plastic object produced by the method according to the invention is produced as a preform for a blow-moulding process in which, for example, a bellows is produced from the preform. Reference is, however, made to the fact that any tubular objects made from thermoplastic material may be produced by the method according to the invention, the wall thickness thereof being able to be altered over their length and being intended to be adjusted with a high degree of accuracy.

Further advantageous embodiments of the invention are revealed from the dependent patent claims.

An embodiment of the invention is described in more detail with reference to the drawings, in which:

Figure 1 shows an extensive schematic sectional view of a device for producing a preform for blow-moulding a bellows;

Figure 2 shows a very schematic view of a control unit for the device of Figure 1;

Figures 3 to 5 show diagrams for the movement path of the withdrawal unit, the plunger and the die body of the device in Figure 1.

The device shown in Figure 1 corresponds in its essential construction to the device according to the aforementioned EP 0 535 254 B1. It serves for producing a tubular object made of thermoplastic material in the form of a preform for blow-moulding a bellows. In this case, it is merely one embodiment of the invention. As already mentioned, by means of the method and device of the invention, any tubular objects may be produced from thermoplastic material, the wall thickness thereof being

intended to be adjusted over their length in a predetermined manner and with a high degree of accuracy.

As the principal construction of the device of Figure 1 is known from the aforementioned patent, the following description is restricted to the components which are essential for the description of the invention.

The device of Figure 1 consists of an extrusion device 2, indicated only in a fragmentary manner, a die 4, a withdrawal unit 6 and a blow mould 8.

The extrusion device 2 comprises a plunger 10 which may be moved in a linear manner, for ejecting plasticised plastic material through the die 4. The die 4 is made up of a die land 12 and an inner, partially conically configured die body 14, which form between them a die channel 16, which terminates in an annular die opening 17. As indicated by a double arrow, the die body 14 may be displaced in a linear manner relative to the die land 12, in order to alter the cross-sectional surface of the die opening 17.

The withdrawal unit 6 comprises a mould body 18 and a blow mandrel 20 arranged therein which, between them, define a mould cavity 22. As also indicated by a double arrow, the withdrawal unit 6 may be moved to and fro in a linear manner on the longitudinal axis of the die 4.

The blow mould 8 comprises two blow mould halves of which only one blow mould half 24 is shown and which, also indicated by a double arrow, are movable to and fro transversely to the longitudinal axis of the die 4 and the withdrawal unit 6.

For moving the plunger 10, the die body 14 and the withdrawal unit 6, one respective hydraulic drive 26 and/or 28 and/or 30 is provided in the form of a piston-cylinder-unit, the pressurisation thereof being respectively controlled by a control valve 32 and/or 34 and/or 36.

At the start of the production of the tubular plastic object K, the withdrawal unit 6 is in an initial position adjacent to the die 4. The plunger 10 is then moved in the ejection direction by its drive 26, whereby a quantity of plasticised plastic material, determined by the plunger path, is forced out of a melt reservoir (not shown) via the die channel 16 through the die opening 17. In this connection, a head part of the plastic object K to be produced is firstly created by an injection-moulding process in the mould cavity 22 of the withdrawal unit 6. After completing this head part, the

actual extrusion process is carried out, in which the withdrawal unit 6 is moved by its drive 30 from the initial position away from the die 4. In this connection, the withdrawal unit 6 guides the plastic object K on its head part, the path of the withdrawal unit 6 determining the length of the plastic object K.

During the extrusion process, the die body 14 is moved by its drive 28 relative to the die land 12, in order to alter the cross-sectional surface of the die opening 17 according to the wall thickness of the plastic object K to be adjusted. At the end of the extrusion process, the end of the plastic object K is pinched off by the die body 14 being brought to bear against the die land 12.

To control the movements of the plunger 10, the die body 14 and the withdrawal unit 6, a control unit is provided which, in the embodiment shown, comprises path sensors 38, 40, 42 for the movements of the plunger 10, the die body 14 and the withdrawal unit 6 as well as a production control unit in the form of a computer 44 (Figure 2). As indicated schematically in Figure 2, the output signals of the path sensors 38, 40, 42 are supplied to the computer 44, which contains a controller for generating control signals for the control valves 32, 34, 36 and thus for the drives 26, 28, 30 as is explained below in more detail:

Reference value curves for the movements of the plunger 10, the die body 14 and the withdrawal unit 6 are stored in the computer 44, as illustrated by way of example in Figures 3 to 5:

As the diagram of Figure 3 shows, a reference value curve is provided in the form of a velocity profile P_Z over the path of the withdrawal unit 6, for the movement of the withdrawal unit 6. The velocity profile P_Z thus represents the reference velocity of the withdrawal unit 6 over the path of the withdrawal unit 6, the velocity and the path being provided in the form of percentage figures.

As Figure 4 shows, a reference value curve in the form of a velocity profile P_S is provided for the velocity of the plunger 10, over the path of the plunger 10, the velocity and the path being provided again in the form of percentage figures.

Figure 5 shows that for the movement of the die body 14 a reference point curve in the form of a position profile P_D is provided over the path of the withdrawal unit 6 or the path of the plunger 10. The position (the path) rather than the velocity is therefore predetermined for the movement of the die body 14.

The diagrams of Figures 3 to 5, naturally only represent examples of the velocity profiles P_Z , P_S and the position profile P_D . In reality these profiles (reference value curves) are freely adjustable, in order to be able to adapt optimally the movements of the withdrawal unit, the plunger and the die body to the respective application.

Preferably the profiles P_Z , P_S and P_D are respectively adjusted over a larger number of segments. 101 segments have been selected in the disclosed embodiment. It is, however, understood that a different number of segments may also be selected.

Actual values for the velocity of the plunger 10 and the withdrawal unit 6 are detected from the path signals of the path sensors 38 and 42. This may be carried out in the path sensors 38 and 42 themselves or even in the computer 40. The path signals of the path sensor 40 may be directly used as actual values for the positions of the die body 14.

The controller of the computer 44, using the actual values derived by the path sensors and the stored reference values of the velocity profiles P_Z , P_S and the position profile P_D , may now determine control signals, by means of which the control valves 32, 34, 36 and thus the drives 26, 28, 30 of the plunger 10, the die body 14 and the withdrawal unit 6 are controlled. The withdrawal unit 6, the plunger 10 and the die body 14 thus carry out a movement according to the respective velocity profiles P_Z , P_S and/or position profile P_D .

The velocity profile P_Z for the withdrawal unit 6 and the velocity profile P_S for the plunger 10 are adjustable freely and thus independently of one another. The movements of the withdrawal unit 6 and the plunger 10, therefore, do not have to be carried out concurrently. The duration and the start and the end of their movements may, therefore, be selected to be unequal. In the embodiment, in which the device serves to produce a bellows, the velocity profiles P_Z and P_S are, for example, selected such that the movements of the withdrawal unit 6 and the plunger 10 start at the same time but end at different times.

As already mentioned above, however, an automatic "synchronisation" between the movements of the withdrawal unit 6 and the plunger 10 is possible, whereby it is automatically ensured that the duration of the movement of the plunger

and the duration of the withdrawal unit are equal. To this end, the computer 44 is programmed such that it is able to be adjusted between two operating states. In the one operating state, the velocity profiles P_Z and P_S may be adjusted independently of one another. In the other operating state the program of the computer 44 adapts automatically the velocity profile P_Z for the withdrawal unit to the velocity profile P_S for the plunger or vice-versa, in order to make the duration of the movements of the plunger and the withdrawal unit equal. If, for example, the velocity profile P_S is altered for the plunger, in order to produce a plastic object K of different wall thickness distribution, the program alters the velocity profile P_Z for the withdrawal unit automatically, such that by a corresponding displacement of P_Z the movements of the withdrawal unit and the plunger are carried out for the same duration.

As the position profile P_D for the die body 14 is fixed over the path of the withdrawal unit 6 or the path of the plunger 10, in its movement the die body 14 follows the withdrawal unit and/or the plunger as a "slave".

The velocity profiles P_Z , P_S and the position profile P_D are adjusted such that when producing the plastic body K (Figure 1) a desired wall thickness distribution results. In the example shown of the production of a bellows, of which the geometry is indicated by the blow mould half 24 in Figure 1, a tubular plastic object K results with a wall thickness which increases and decreases in an oscillating manner over its length.

The free adjustability of the velocity profiles P_Z , P_S and the position profile P_D allow an optimal consideration of the influences impairing the production process, such as for example a subsequent swelling of the plastic material or sagging of the tubular plastic object K.

A particularly critical point is the transition between the head part (mould cavity 22) and the central part of the plastic object K. As may be ascertained from the diagrams of Figures 3 and 4, this difficulty may be countered by a quite specific curve characteristic at the start of the extrusion process.

The end of the bellows produced from the plastic object K, must generally be cut off by a specific cutting process (not shown), in order to obtain a clean end of the bellows. The method according to the invention for controlling the velocities of the withdrawal die 6 and the plunger 10, as well as the position of the die body 14, allows

a specific and precise reduction of the wall thickness of the part of the plastic body K to be cut off, without this reduction in wall thickness impairing the transition between the part to be cut off and the remaining part of the plastic body K. Examples of appropriately selected velocity and position profiles P_Z , P_S and P_D towards the end of the extrusion process may be ascertained from the diagrams of Figures 3 to 5. As a result, the quantity of rejects occurring during the cutting-off process may be significantly reduced.

Reference is further made to the fact that the curves shown in the diagrams of Figures 3 to 5 are merely examples of possible profiles, as have been selected for producing a specific bellows. For producing other bellows and in particular for producing other tubular objects, the freely adjustable profiles P_Z , P_S and P_D may have a quite different curve characteristics.

Claims

1. Method for producing a tubular object from thermoplastic material by means of a device which comprises:

a die with a die land and a die body which form, between them, an annular die opening, the die body being movable relative to the die land in order to alter the cross-sectional surface of the die opening,

an extrusion device with a plunger which during its movement extrudes a specific quantity of plasticised plastic material determined by the plunger path through the die in order to produce a tubular plastic object,

a withdrawal unit which is movable from an initial position adjacent to the die in the direction away from the die, in order to guide the tubular plastic object emerging from the die, during the extrusion process, the path of the withdrawal unit determining the length of the tubular plastic object and

a control unit for controlling the movements of the die body, the plunger and the withdrawal unit, according to a predeterminable program for the purpose of adjusting the wall thickness of the tubular plastic object over its length,

in which method the movements of the withdrawal unit, the plunger and the die body are controlled such that

the movement of the withdrawal unit is carried out according to a freely adjustable velocity profile over the path of the withdrawal unit,

the movement of the plunger is carried out according to a freely adjustable velocity profile over the path of the plunger, and

the movement of the die body is carried out according to a freely adjustable position profile over the path of the withdrawal unit or the path of the plunger, so that the movement of the die body is carried out for the same duration as the movement of the withdrawal unit or the plunger.

2. Method according to Claim 1, characterised in that the velocity profiles for the movements of the withdrawal unit and the plunger are adjusted such that the duration of the movement of the withdrawal unit and the duration of the movement of the plunger are unequal.

3. Method according to Claim 1, characterised in that the velocity profiles for the movements of the withdrawal unit and the plunger are adjusted such that the duration of the movement of the withdrawal unit and the duration of the movement of the plunger are equal.

4. Method according to Claim 3, characterised in that the control unit may be adjusted such that the velocity profile for the withdrawal unit is automatically adapted to the velocity profile for the movement of the plunger or vice-versa, in order to make the duration of the movements of the withdrawal unit and the plunger equal.

5. Method according to Claim 2, characterised in that the velocity profiles for the movements of the withdrawal unit and the plunger are adjusted such that the movements of the withdrawal unit and the plunger start at the same time.

6. Method according to Claim 1, characterised in that the velocity profile for the movement of the withdrawal unit, the velocity profile for the movement of the plunger and the position profile for the movement of the die body may be respectively adjusted over a larger number of segments.

7. Method according to Claim 1, characterised in that, before the start of the extrusion process, in the withdrawal unit a head part is injection-moulded, on which the tubular plastic object is guided during the extrusion process by the withdrawal unit.

8. Method according to Claim 1, characterised in that the tubular plastic object serves as a preform for a blow-moulding process.

9. Device for producing a tubular object from thermoplastic material with:

a die with a die land and a die body which form, between them, an annular die opening, the die body being movable relative to the die land in order to alter the cross-sectional surface of the die opening,

an extrusion device with a plunger which, with an ejection movement, extrudes a specific quantity of plasticised plastic material through the die, determined by the plunger path, in order to produce a tubular plastic object,

a withdrawal unit which is movable from an initial position adjacent to the die in the direction away from the die, in order to guide the tubular plastic object emerging from the die, during the extrusion process, the path of the withdrawal unit determining the length of the plastic object, and

a control unit which controls the movements of the withdrawal unit, the plunger and the die body by means of a predeterminable program, such that

the movement of the withdrawal unit is carried out according to a freely adjustable velocity profile over the path of the withdrawal unit,

the movement of the plunger is carried out according to a freely adjustable velocity profile over the path of the plunger,

and the movement of the die body is carried out according to a freely adjustable position profile over the path of the withdrawal unit or the path of the plunger, so that the movement of the die body is carried out for the same duration as the movement of the withdrawal unit or the plunger.

10. Device according to Claim 9, characterised in that the control unit comprises:

a path sensor for determining actual values of the velocity of the withdrawal unit,

a path sensor for determining actual values of the velocity of the plunger,

a path sensor for determining actual values of the velocity of the positions of the die body, and

a computer with a controller which, depending on the differences between the actual values and the reference values of the velocity profiles for the movements of the withdrawal unit and the plunger as well as the position profile for the movements of the die body, generates control signals for drives of the withdrawal unit, the plunger and the die body.