

SPECIFICATION

A method and apparatus for the continuous extrusion and blowing of thin films of plastic material in particular rigid PVC

The present invention relates to a method of and an apparatus for the continuous extrusion and blowing of thin films of plastics material in particular of films of rigid polyvinyl chloride (PVC) having a thickness from 10 μ to 60 μ in which the raw material in the form of powder is introduced continuously after an intensive mixing with stabilizers and slipping agents in the inlet opening of a monoscrew extruder.

The production of rigid films is at present in continuous development. The goal to be achieved is the increase in the passages, through extruders operating in a continuous manner, and the reliability of the manufacture guaranteeing a high level of quality with reduction of costs.

PVC (Polyvinyl chloride) is very sensitive thermally above 100°C. Beyond this temperature it is damaged to an increasing extent with the separation of hydrochloric acid. Due to granulation temperatures of the mass of about 175-190°C occur and for the manufacture (extrusion) temperatures of about 185-220°C. Granulation and extrusion are only possible by adding to the mass stabilizers and slipping agents which are partially consumed during the thermal stresses.

The said stabilizers and slipping agents may influence negatively the quality of the product. With the elimination of the granulation, that is, using the powders according to the present invention the PVC only once undergoes a high thermal stress and that is during the single extrusion. For that reason discolorations, reticulations and other defects can be diminished or obviated by having recourse to powders.

The quantity of additives, that is of stabilizers and slipping agents may also be diminished if the granulation is avoided which, besides a better final product, there is also an economic advantage, since these additives are very expensive.

The heating of the rigid PVC powder in the extrusion machine has however difficulties as the field of temperatures permitted is very limited either due to the resistance opposed to the flow of the material to be plasticized or due to the limited thermal stability.

It is possible that local over-heating may occur in particular in those parts of the extrusion machine having low thermal conductivity which lead to thermal damage of the already prestressed mass.

The working of rigid PVC in extruders is furthermore very limited by the low thermal stability of the mass. To the requirement of achieving a thermal stress as low as possible is added that of obtaining products qualitatively unexceptionable by means of high working temperatures and for that reason low resistances to flow. High temperatures of the mass are only possible for short intervals of time so that the mass is not damaged.

The thermal decomposition of the PVC during the manufacture is characterised as indicated by the

separation of hydrochloric acid, by self-oxidation and by reticulation. Low thermal damage which does not influence the method of extrusion may instead cause discoloration as well as diminution of the mechanical qualities leading to uselessness of the product. Considerable thermal damage may be noted in the form of streaks which are firstly of a light chestnut colour and then become dark chestnut before completely carbonized pieces arrive on extrusion. Once the centre of damage has arisen a part of the damaged mass remains attached to the surface of the metal of the extruder and causes an extrusion of the so-called "burning" on the whole mass.

Upon the appearance of the above-mentioned streaks it is generally necessary to interrupt the production. After dismantling the drawplate and the screw, all the parts which come in contact with the mass must be carefully cleaned. After the renewal of the extruder it requires hours, according to the size of the machine, to return to normal production so that the said work of assembly and clearing mean a considerable loss of time and therefore of production.

The method and the apparatus according to the present invention permit of overcoming the difficulties referred to, rendering possible the optimum working of the rigid PVC powder with monoscrew extruders and the production of treated films and with thin walls of uniform thickness, films which are thermo-weldable, perfectly printable and having good resistance to printing inks.

The advantages of the method in question consist in the fact that too long a heating of the material and therefore its carbonisation are avoided. That is due, not only to the subdivision in a plasticization zone and in a homogenization zone but also in the relatively short forcing of the material into the plastization zone.

According to one aspect of the invention therefore, there is provided a method for the continuous extrusion and blowing of thin films of plastics material, in particular of rigid polyvinyl chloride, having a thickness of 10 μ to 60 μ by continuously introducing the raw material after mixing with stabilizers and slipping agents into the feed opening of a monoscrew extruder, characterised in that the raw material in the form of powder is

(a) fed precompressed continuously, in the cold state, into the extrusion screw and subsequently;
(b) compressed through the said extrusion screw without or with limited addition of heat and after which it is;

(c) heated below 190°C in a homogenisation/plasticisation phase and led through a throttling opening which increases the pressure of the material and forces it to be plasticised without further increasing the temperature, and is successively;

(d) decompressed;
(e) degassed;
(f) subjected to increased pressure and
(g) passed to an expulsion phase, the desired thickness of the film being controlled by stretching widthwise and lengthwise.

According to a further aspect, the invention provides apparatus for performing the method aforesaid characterised in that it comprises a monoscrew extruder fed continuously by a feed screw (18 Figure 2) for supplying cold powder under pressure mixed with stabilizer and slipping agent; the said monoscrew extruder having 7 different zones:

- an introduction zone (E) in which the extrusion screw has outer and inner diameter and pitch substantially constant;
- a heated compression zone (K_1) in which the screw has a constant outer diameter, and increasing inner diameter and constant pitch;
- a heated homogenisation/plasticisation zone (H) in which the screw has constant outer and inner diameter and pitch;
- a heated decompression zone (D) in which the screw has a constant outer diameter, a decreasing inner diameter and constant pitch;
- a heated degassification zone (G) in which the screw has a constant outer diameter, a constant inner diameter but reduced in respect of the preceding diameters and a constant pitch;
- a heated compression zone (K_2) in which the screw has a constant outer diameter, an increasing inner diameter and a constant pitch;
- a heated expulsion zone (A) in which the screw has a constant outer diameter over part of its length, a constant inner diameter over the same length, after which the screw is tapered at the end in the region of the extrusion head.

Preferably the apparatus is characterised in that coaxially with the extrusion screw in the homogenization/plasticisation zone (H) there is inserted at least one break flow ring (3), Figure 8 having calibrated bores (4 and 5) which obstruct the efflux of the material forcing it to plasticise without having to increase subsequently the temperature after which follows decompression (D) degassification (G), subsequent compression (K_2) and expulsion (A) through the extruder.

From the outset, starting from the raw material in powder form, the difficulties for its fluidifying are substantial, and the method in question provides for inserting in the course of the extruder after the material has been duly heated, compressed and homogenised, an obstacle having calibrated openings which force the flow of material transported by the screw of the extruder to slow down, that is, to change speed and consequently to plasticize, but without increasing the temperature after which follows the decompression, degasifying, the subsequent compression and the expulsion through the extruder.

The apparatus which permits of realizing the method in question has for this purpose coaxially with the extrusion screw after the compression and in the homogenization zone a breakflow ring with bores which slow the efflux of the material forcing it to plasticize after which follows the decompression, degasifying, subsequent compression zone and expulsion through the extruder.

The invention will now be further explained in the following two embodiments of the apparatus, that is,

the extruder which permits of realizing the method in question.

The drawings show: in

Figure 1 an extruder according to a first embodiment of the invention in very diagrammatic form in longitudinal section; in

Figure 2 a section along the line II-II of Figure 1 on an enlarged scale; in

Figure 3 the longitudinal section of the central zone of the extruder according to Figure 1 on an enlarged scale corresponding to the degasifying zone adjacent to this; in

Figure 4 the section along the line IV-IV of Figure 3 through the degasifying pump on an enlarged scale; in

Figure 5 the partial section V-V of Figure 4 through the piston of the degasifying pump on an enlarged scale; in

Figure 6 the diagram of the course of the stem of the degasifying pump as a function of the time.

Figures 7a, 7b, 7c, 7d show the various sections constituting the single screw of the extruder in a second embodiment of the invention.

Figure 8 shows the enlarged detail of the break flow ring illustrated on a reduced scale in Figure 7b.

Figure 9 shows the front end of the extrusion screw and

Figure 10 shows the extrusion head in axial section.

The extruder indicated in general in Figure 1 with the reference number 10 shows the extrusion screw 12 lodged in the cylinder of the extruder 14. From a feed hopper 16 the work material, that is the resin in powder form mixed with stabilizers and slipping agent is fed through the feed screw 20 (Figure 2) arranged in the channel 18 to the extrusion screw 12 illustrated in Figure 1 passing through the inlet opening 24 (Figure 2).

The extrusion screw 12 has seven different zones (see Figures 1 and 3).

In the area of the feed hopper 16 of the material is provided the introduction zone E. In this zone the extrusion screw 12 has almost constant outer diameter, inner diameter and pitch and is preferably without heating. A first compression zone K_1 , slightly heated follows the introduction zone E in which the screw has a constant outer diameter, an increasing inner diameter (conical nucleus) and constant pitch. A heated homogenization plasticisation zone H follows the first compression zone K_1 in which the screw has constant outer diameter and inner diameter and pitch. A heated decompression zone D in which the screw has a constant outer diameter, a greatly increasing inner diameter and a constant pitch, and a heated degasification zone (G) in which the screw has a constant inner diameter but reduced in respect of the aforesaid diameters and constant pitch follow the homogenization zone.

A second heated compression zone K_2 in which the screw has a constant diameter, an increasing inner diameter (conical nucleus) and constant pitch follows the degasifying zone G.

A heated expulsion zone A, in which the screw has a constant outer diameter but limited to a certain length, a constant inner diameter of the same length

and narrowed at the end in the proximity of the extrusion head follows the second compression zone K₂. The mass leaves zone A in tubular form perfectly plasticized, and becomes thinned by means of blowing of the tube in radial direction and stretching in axial direction.

In the diagram of Figure 6, as already indicated, is shown the course in millimetres of the stem of the degasifying pump as a function of time in seconds.

As can be seen the piston stroke occurs very rapidly corresponding to the time t , is kept constant in the time between t_1 and t_2 and returns abruptly to the starting point at the time t_2 - just as much for the times t_3 and t_4 .

On the extrusion screw illustrated in Figures 7a, 7b, 7c, 7d, the distance E corresponds to the introduction zone of the polyvinyl chloride powder mixed with stabilizers and slipping agents. The introduction takes place at a very low temperature.

The compression zone K, follows, in which the outer diameter of the screw is constant, but the inner diameter increases, only the pitch being constant so as to determine the compression.

The homogenisation plasticisation take place in the following zone H. In this the outer and inner diameters of the screw and the pitch are constant.

Towards the end of the homogenisation plasticisation zone is interposed the break flow ring 3 (see Figure 8) having the calibrated bores 4 and 5 so as to cause an obstacle to the normal flow of the plastic material along the extrusion screw to force it to become plastic without having to increase the temperature.

This constitutes a particularly advantageous part of the present invention as it brings about a considerable improvement in the working conditions of the plastic material especially of rigid polyvinyl chloride which is very sensitive to the increases of temperature and is capable of being made plastic at relatively low temperature only with difficulty, without the intervention of the apparatus now referred to.

The decompression zone D in which the outer diameter and the pitch of the screw are constant whilst the inner diameter decreases rapidly to reduce abruptly the pressure follows the homogenization plasticisation zone H.

In the following degasifying zone G the outer diameter and inner diameter of the screw are constant and thus also the pitch whilst a suitable pump, not illustrated, provides for removing the gases.

In the following zone K₂ there is a further compression for which the outer diameter and the pitch of the screw are constant whilst the inner diameter increases.

Finally in the expulsion zone A the outer diameter, the inner diameter and the pitch are constant.

The screw terminates in pointed head 6 (Figure 9) whilst the raw material, perfectly plasticised, passes through the drawplate 7 (Figure 10), the channel 8, the opening 9 of circular section and leaves at 10 in the form of a tube the thickness of which is gradually diminished by blowing in radial direction and by axial traction.

The drawplate illustrated in Figure 10 can be classified among those of the so-called "with radii" type and has the advantage of a better distribution of the mass compared to the known "heart-shaped", "spiral-shape" etc., extrusion drawplates in which the course of the extrusion mass is simpler and the expulsion speed greater.

Wishing to work the polyvinyl chloride with the known extruders, the drawplate with radii is the least adapted to the effects of burning and decolouration since the mass is reduced if the expulsion speed from the drawplate is too low.

On the contrary with the extruder according to the present invention in which there is not any reduction of the mass the drawplate with radii is really suitable because it permits of an optimum distribution of the mass coming out and therefore a perfect thickness of the film.

It is arranged for the breakflow ring 3 (Figure 8) to be capable of being realised also in a completely different manner provided that there are present openings calibrated to the passage of the flow of plastic material which break the said flow, that is partly obstruct it, to favour the plasticization without increasing the temperature.

CLAIMS

1. A method for the continuous extrusion and blowing of thin films of plastics material, in particular of rigid polyvinyl chloride, having a thickness of 10 μ to 60 μ by continuously introducing the raw material after mixing with stabilizers and slipping agents into the feed opening of a monoscrew extruder, characterised in that the raw material in the form of powder is

(a) fed precompressed continuously, in the cold state, into the extrusion screw and subsequently;
(b) compressed through the said extrusion screw without or with limited addition of heat and after which it is;

(c) heated below 190°C in a homogenisation/plasticisation phase and led through a throttling opening which increases the pressure of the material and forces it to be plasticised without further increasing the temperature, and is successively;

(d) decompressed;
(e) degassed;
(f) subjected to increased pressure and
(g) passed to an expulsion phase, the desired thickness of the film being controlled by stretching widthwise and lengthwise.

2. Apparatus for performing the method according to Claim 1, characterised in that it comprises a monoscrew extruder fed continuously by a feed screw for supplying cold powder under pressure mixed with stabilizer and slipping agent; the said monoscrew extruder having 7 different zones:

an introduction zone (E) in which the extrusion screw has outer and inner diameter and pitch substantially constant;
a heated compression zone (K₁) in which the screw has a constant outer diameter, and increasing inner



and narrowed at the end in the proximity of the extrusion head follows the second compression zone K₂. The mass leaves zone A in tubular form perfectly plasticized, and becomes thinned by means of blowing of the tube in radial direction and stretching in axial direction.

In the diagram of Figure 6, as already indicated, is shown the course in millimetres of the stem of the degasifying pump as a function of time in seconds.

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On the extrusion screw illustrated in Figures 7a, 7b, 7c, 7d, the distance E corresponds to the introduction zone of the polyvinyl chloride powder mixed with stabilizers and slipping agents. The introduction takes place at a very low temperature.

The compression zone K, follows, in which the outer diameter of the screw is constant, but the inner diameter increases, only the pitch being constant so as to determine the compression.

The homogenisation plasticisation take place in the following zone H. In this the outer and inner diameters of the screw and the pitch are constant.

Towards the end of the homogenisation plasticisation zone is interposed the break flow ring 3 (see Figure 8) having the calibrated bores 4 and 5 so as to cause an obstacle to the normal flow of the plastic material along the extrusion screw to force it to become plastic without having to increase the temperature.

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In the following degasifying zone G the outer diameter and inner diameter of the screw are constant and thus also the pitch whilst a suitable pump, not illustrated, provides for removing the gases.

In the following zone K₂ there is a further compression for which the outer diameter and the pitch of the screw are constant whilst the inner diameter increases.

Finally in the expulsion zone A the outer diameter, the inner diameter and the pitch are constant.

The screw terminates in pointed head 6 (Figure 9) whilst the raw material, perfectly plasticised, passes through the drawplate 7 (Figure 10), the channel 8, the opening 9 of circular section and leaves at 10 in the form of a tube the thickness of which is gradually diminished by blowing in radial direction and by axial traction.

The drawplate illustrated in Figure 10 can be classified among those of the so-called "with radii" type and has the advantage of a better distribution of the mass compared to the known "heart-shaped", "spiral-shape" etc., extrusion drawplates in which the course of the extrusion mass is simpler and the expulsion speed greater.

Wishing to work the polyvinyl chloride with the known extruders, the drawplate with radii is the least adapted to the effects of burning and decolouration since the mass is reduced if the expulsion speed from the drawplate is too low.

On the contrary with the extruder according to the present invention in which there is not any reduction of the mass the drawplate with radii is really suitable because it permits of an optimum distribution of the mass coming out and therefore a perfect thickness of the film.

It is arranged for the breakflow ring 3 (Figure 8) to be capable of being realised also in a completely different manner provided that there are present openings calibrated to the passage of the flow of plastic material which break the said flow, that is partly obstruct it, to favour the plasticization without increasing the temperature.

CLAIMS

1. A method for the continuous extrusion and blowing of thin films of plastics material, in particular of rigid polyvinyl chloride, having a thickness of $10\text{ }\mu$ to $60\text{ }\mu$ by continuously introducing the raw material after mixing with stabilizers and slipping agents into the feed opening of a monoscrew extruder, characterised in that the raw material in the form of powder is

(a) fed precompressed continuously, in the cold state, into the extrusion screw and subsequently;

(b) compressed through the said extrusion screw without or with limited addition of heat and after which it is;

(c) heated below 190°C in a homogenisation/plasticisation phase and led through a throttling opening which increases the pressure of the material and forces it to be plasticised without further increasing the temperature, and is successively;

(d) decompressed;

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(f) subjected to increased pressure and (g) passed to an expulsion phase, the desired thickness of the film being controlled by stretching widthwise and lengthwise.

2. Apparatus for performing the method according to Claim 1, characterised in that it comprises a monoscrew extruder fed continuously by a feed screw for supplying cold powder under pressure mixed with stabilizer and slipping agent; the said monoscrew extruder having 7 different zones:

an introduction zone (E) in which the extrusion screw has outer and inner diameter and pitch substantially constant;

a heated compression zone (K₁) in which the screw has a constant outer diameter, and increasing inner



- diameter and constant pitch;
a heated homogenisation/plasticisation zone (H) in which the screw has constant outer and inner diameter and pitch;
- 5 a heated decompression zone (D) in which the screw has a constant outer diameter, a decreasing inner diameter and constant pitch;
a heated degassification zone (G) in which the screw has a constant outer diameter, a constant
- 10 inner diameter but reduced in respect of the preceding diameters and a constant pitch;
a heated compression zone (K2) in which the screw has a constant outer diameter, an increasing inner diameter and a constant pitch;
- 15 a heated expulsion zone (A) in which the screw has a constant outer diameter over part of its length, a constant inner diameter over the same length, after which the screw is tapered at the end in the region of the extrusion head.
- 20 3. Apparatus according to Claim 2 wherein the introduction zone has no heating means.
4. An apparatus according to Claim 2 or Claim 3, characterised in that, to provide a throttling opening, at least one break flow ring is inserted coaxially with
- 25 the extrusion screw in the homogenization/plasticisation zone (H), said at least one break flow ring having calibrated bores which obstruct the efflux of the material forcing it to plasticise without further increase of temperature.
- 30 5. A method for the continuous extrusion and blowing of thin films of plastics material, in particular of rigid polyvinyl chloride, having a thickness of 10 to 60 by continuously introducing the raw material after mixing with stabilizers and
- 35 slipping agents into the feed opening of a monoscrew extruder, substantially as described with reference to the drawings.
6. Apparatus for performing the method according to Claim 1 or Claim 5, substantially as
- 40 described with reference to the drawings.