

Method and apparatus for joining sheet- or ribbon formed flows in a coextrusion process.

The invention concerns a coextrusion method of the type defined in the introduction to Claim 1 and the apparatus to carry out such method. It is applicable to the extrusion of generally all materials which can be extruded, such as e.g. thermoplastic polymers, inorganic pastes, for instance for forming ceramic materials, and several kinds of foodstuff.

The invention has three different aspects in connection with three different objectives. One aspect ("the first aspect") concerns the use of coextrusion for cover, on one or both sides, of an extrudable material A which during the extrusion has a high apparent viscosity, with a thin layer or thin layers of a material B having a much lower apparent viscosity. In such cases the cover will normally become very uneven or may even be missing over a part of the surface, when conventional technology is used, because the energy required to make B flow evenly distributed in a thin stream is higher than that required to make B flow in narrow thicker streams.

Another aspect of the invention ("the second aspect") concerns coextrusion of sheets or pipes in which segments of one component alternate with segments of another component, the alternation taking place along the direction of extrusion. As an important example this can be a pipe in which stiff segments alternate with flexible segments (the relative stiffness being referred to being in the product).

Still another aspect of the invention ("the third aspect") concerns coextrusion of a flow of solid generally dry particles with a flow of truly fluid material in such a way that the fluid material becomes absorbed in the flow of solid particles (that is becomes blended with the solid particles).

As an important example this can be a method of blending Teflon (polytetrafluoroethylene PTFE) particles with molten polyamide and extruding sheets, ribbons or pipes from the blend. Furthermore this aspect of the invention can be used to produce special ceramic products, especially porous products, through a process in which solid inorganic particles e.g. comprising short reinforcement fibres become blended with a prepolymer, which later is cured, or with an aqueous solution or dispersion of an inorganic material which after drying and heat treatment will act as a binder. In an analogous way, the third aspect of the invention can be used to coextrude a strand of medial material, which can be chopped up to pills.

US-A-3,761,211 (Parkinson), US-A-4,152,387 (Cloeren), US-A-4,197,069 (Cloeren) and US-A-4,533,308 (Cloeren) address the problem how to avoid or minimize what in Cloeren's patents is referred to as "the curtaining effect", i.e. a profiling of coextruded film which appears as a transverse line pattern formed where two sheet-formed flows join each other if these flows have different rheologies, and especially if they are also coextruded in about equal amounts. These four patents make use of one or more flaps, which can be pivoted and which end where the flows join each other. The first mentioned three patents have means for adjustment of the flaps, so that the ratio between the velocities of the flows where they meet, can be adapted to the rheological properties and the throughputs of the components. The last mentioned patent makes use of one or more free floating, pivoting flaps, which automatical adjust to different rheologies and throughputs of the components, namely so that the pressure becomes the same on the two sides of a flap. The "curtaining effect" which these four patents counteract is a problem different from the problem which the first aspect of the present invention addresses (see above), and which results in a longitudinal instead of transverse striation. The inventor of the present invention has found by experimentation that the precautions disclosed in the mentioned four patents do not solve the said problem.

2a

US-A-4,469,475 (Krysiak) discloses an extruder suitable for making food products comprising a core and an encrusting shell. The extruder comprises a closure to prevent the encrusting material flowing into the passageway through which the filling is extruded. The closure is close to the exit from the extruder.

In WO-A-0060959, there is a description of an extruder and a method falling within the scope of the claims of the present application. The subject matter is entitled to priority from the filing date of the PCT application, from which the present application claims priority. The disclosure does not constitute prior art to the claims of the present application therefore.

The three different objectives are basically achieved each by similar means, namely by providing a new method of coextruding a sheet- or ribbon formed flow of extrudable material A with a sheet- or ribbon formed flow of extrudable material B in a zone of joining in a coextrusion die (which term includes an adaptor upstream of the final product forming die) in which B is extruded on A through a port (3) and the two materials proceed together through a passageway (7) towards an exit (8) of the die, wherein the separation wall between said flows, immediately before it ends in port (3) is formed as a flap closure (4) adapted to act as no-return valve for the flow of B onto A, characterised in that the extrusion of B through (3) takes place in pulses.

In the first aspect of the invention the pulsations take place shock-like to distribute B evenly on A over the length of port (3), and the irregularities along the direction of flow produced by the pulsations are evened out, at least in part, during the common flow of components A and B through the end of the coextrusion die - as further dealt with below.

In the second aspect of the invention, the process is adapted to make the flap closure (or closures, if there is coextruded B-material onto both sides of A) act as shutters which stop, at least substantially, the flow of A during

each pulse of B-extrusion. This adaption is also dealt with in further detail below. In the third aspect of the invention A is propelled by means of a ram (22) directly upstream of the location where the flows are joined.

5 In the present specification, a flap or a flap closure refers to a component which is pivoted or tethered along one side and which can move about the pivot, for instance under influence of actuating means or pressure from fluid exerted on the flap. In each of the three aspects of the
10 invention the flap closure is preferably substantially flat and is generally a springy blade, optionally with a thicker or harder section at its downstream end (claim 2). The springy blade can be of steel or other suitable metal and can even be made of a rubber material if the temperature of
15 extrusion is sufficiently low to allow this. The optional thicker or harder section at the downstream end serves to stabilize the opening and closing of the flap and may be almost mandatory if a rubber material is chosen to act as flexible blade (hinge). The pulsation in the flow B is
20 normally best effected upstream of the flap closure by one or more rams or by opening and closing valves (claim 3). Alternatively, this pulsation can be effected by opening and/or closing the flap closure through mechanical transmission means (claim 4). The former option is
25 illustrated in figs 1. and 3c, and the latter option in fig. 4a.

In order to achieve the most regular merging of the components A and B, they should preferably both be planar flows at least in the immediate vicinity of the part where
30 they merge and here be generally parallel to the flap, (claim 5).

The invention can immediately be applied to coextrusion of a flat sheet or ribbon from a flat coextrusion die (claim 6) while the application in a
35 circular die may require special precautions taken. In such circular dies the components usually (but not in all cases) flow in a generally axial direction at the location where

they are joined and the wall which separate the components before the joining ends in a generally circular cylindrical shape. In connection with the present invention this would mean that the springy blade would have to form a ring of
5 generally cylindrical shape, and such shape would generally resist bending so much that the B component would become unevenly applied on the A component.

This problem can be solved by making the flap closure ring formed with its surfaces generally perpendicular to
10 said axis (claim 7).

In this connection the two components are preferably, at least in the immediate vicinity of the location where they join, made to flow generally in radial direction (which may be outwardly or inwardly seen in relation to the
15 axis of the circular die), and following the joining of the flows, the latter may be directed into generally axial direction and exit generally axially from a final product forming circular exit orifice (claim 8). However, the present invention can also be used in connection with so-
20 called "peripheral" dies, i.e. dies in which the material is extruded radially out of a circular exit slot, a slot in a cylindrical wall of the die. Such "peripheral" dies are known from extrusion of food products. In this application the two flows may after merging, proceed generally radially
25 the whole way through to the final product forming exit orifice.

As a preferred embodiment of the said circular extrusion a method of extrusion through spiral flows is claimed (claim 24) and the extrusion die for that method is
30 claimed in claim 39.

As mentioned above, the extrusion of B takes place in pulses which should normally be effected upstream of the flap closure (4) and be established by one or more rams or by opening and closing of valves. These devices should
35 preferably be close to the location where the components are joined. They should normally cooperate with (conventional) preceding pumping or extruding means. If a

ram is used, there is preferably used a no-return valve to prevent the ram from pumping the wrong way (claim 9).

5 The term "no return valve" is here meant to comprise, not only a valve which closes by virtue of the back pressure, but also a valve which is acted on by control means to close it at the right time of the process cycle.

10 In most cases the invention can with advantage be used to apply, not only one B-flow but also two B-flows (B1 and B2) unto the A-flow, B1 on one side and B2 on the other side of A. B1 and B2 may be identical or different in composition (claim 10).

15 As mentioned in the introduction the first aspect of the invention concerns a coextrusion aiming to cover material A which during the extrusion has a high apparent viscosity, with thin layers of a material B having a much lower apparent viscosity.

20 The problems in this connection, and the solution by use of the present invention were explained in the introduction. The solution is more precisely stated in claim 11, and further specified in claim 12. The need for a substantial pressure difference in each pulse between the B-flow or flows and the A-flow - in other words the need for shock-like pulsations depends on the difference in apparent viscosities. The velocity of each B-flow when it
25 meets the A-flow should preferably in most but not all cases be on generally the same level or higher than that of the A-flow multiplied by the ratio between the apparent viscosity of A and that of B (under the actual conditions). "Shock-like" refers to a pulsation of short duration but
30 high amplitude, i.e. velocity.

In this way it can become economically feasible to use even very expensive copolymers for the modification of surface properties on cheap, tough polymers - reference in this connection to claims 13 and 14.

35 In such cases, there should preferably be at least 5 pulses per second.

The term "generally even" means that B should cover the surface of A substantially continuously, but furthermore the ratio of the thickness of B:A, should preferably not vary by more than $\pm 50\%$, and more preferably by no more than $\pm 25\%$ of the average value of B:A.

Furthermore, the B1 and B2 components applied as stated in claim 11 can have an important lubricating effect and thereby reduce the back pressure, e.g. in the combinations claimed in claim 13 and 14.

The second aspect of the invention, which already has been dealt with in the introduction is defined in claims 15, 16 and 17. In this aspect the passageway from the zone of joining to the exit from the coextrusion die should preferably be short in order to maintain a distinct segmental structure.

In the third aspect of the invention, the process in which a flow of solid generally dry particles is coextruded with a flow of truly fluid material, the flow of solid particles which is the A-component is propelled by a ram (22) in a conduit (18) which directly leads to the port or ports (3) through which the truly fluid material, which is the B material, is coextruded (claim 18 and figures 5a and b). When B has joint A, the composite flow of A and B is preferably subjected to blending and/or compacting by means of one or more stamps or flaps (24 and 25) which reciprocate in directions transverse of the main direction of the composite flow (claim 19).

In each of the three aspects of the invention the coextrusion process may further continue so that several B/A or B1/A/B2 flows become joined to a "flat sandwich", a term which indicates that the smallest dimension in the final product is parallel to the smallest dimension of the individual layers, or alternatively the flows may become joined to a "high sandwich", that is the smallest dimension in the final product is generally perpendicular to the smallest dimension of the individual layers. In patent

literature (eg the applicant's earlier patents) the latter is referred to as "lamellar extrusion".

In case the present invention is used in a "lamellar extrusion" set up, so that there will be a multitude of exits (8) arranged in a lineary or circular array, the composite flows when leaving these exits may be mechanically divided into segments and interspersed with segments of different material extruded out of other exits in the same linear or circular array to form a cell-like structure, as this is explained in the applicant's copending patent applications, see WO00/60959.

As it appears from the foregoing the present invention is not limited to the coextrusion of synthetic polymers, but also in many cases applicable to coextrusion of food components (claim 20) or the manufacture through coextrusion either of a ceramic product (claim 22) or medical pills (claim 23). In the last mentioned two cases component A may either be extruded as a flow of solid generally dry particles propelled by a ram as explained above, or may be extruded as a paste comprising particulate solids.

With respect to coextrusion of food components, it can often with conventional means be very difficult or impossible to "tailor make" their rheologies to the extend which is needed for obtaining a sufficient evenness of layer thickness, and in such cases the present invention is of special importance. Thus, B may be molten chocolate, sugar or caramel, while A is a material of a higher apparent viscosity (claim 21). Reference in this connection to the example, in which thin layers of molten, relatively fluid chocolate are extruded onto marzipan of plastic consistency.

As an example of the use of the present invention in a coextrusion process forming ceramic products, can be mentioned the manufacture of porous membranes.

The invention shall now be described in further detail with reference to the drawings, of which:

Fig. 1 shows the characteristic part of a flat coextrusion die in operation according to the invention. The drawing represents a section parallel to the machine direction and perpendicular to the main surfaces of the sheet formed or ribbon formed flows A, B1 and B2.

Fig. 2a and b are diagrammatical flow-sheet like sketches of circular dies for the coextruding of tubes according to the invention. In 2a the flows move generally from the outside towards the inside, and in fig. 2b generally the opposite way.

Figs. 3a and b show suitable constructions of the distribution sections of figs 2a and b, respectively. They are views through the distribution channels for component A.

Fig. 3c which is a modification of fig. 1 shows the section for merging (including rams and exit) in the die according to the sketch fig. 2a. The drawing shows a section through the axis (9) of the circular die, but the distribution part of the die is omitted. The drawing also represents the section for merging in the die according to fig. 2b but then the axis (9) must be considered laying outside the sheet and under the drawing.

Figs. 4a, b, c and d show different modifications of the section for merging of the components, these modifications relating to the flat die arrangement according to fig. 1 and/or the circular arrangement according to fig. 3.

Figs. 5a and b show a modification of the die in figure 1, adapted to perform with generally dry, particular A-component and propelling this by use of a ram. Figure 5a is a section corresponding to that of figure 1 while figure 5b, which only represents the vicinity of this ram, shows section a-a of figure 5a.

In fig. 1, the three components A, B1 and B2 are fed into this characteristic part of the coextrusion die as shown by the three arrows. This feeding is established by primary, conventional feeding means (extruders or pumps),

which are not shown in the drawing. Between these extruders or pumps and the apparatus shown there may be conventional distribution means to ensure that the components become evenly distributed over the width.

5 Normally A flows in steady manner (but may in some cases be extruded in pulses) while B1 and B2 are extruded in pulses established by rams (1), which superpose the flows produced by the primary feeding means. The no-return valves (2) which ensure that the rams work the right way can e.g. be
10 made of springy blades.

At the ports (3) where B1 and B2 enter the chamber for A, there are two springy blades (4), which are extensions of or connected with the wall (4a) of the chamber for A. The blades (4) are installed as no-return valves. When
15 under a sufficient pressure from B1 and/or B2 they may even act as shutters for A, so that after joining of the flows, segments of A will alternate with segments of B1 + B2 (the two may be of identical composition). However, this does not take place in the embodiment of the invention shown in
20 the drawing. Here B1. and B2 are joined with A as "lumps" (5) on each of its surfaces. Since the flows A, B1 and B2 are sheet-formed or ribbon formed and the shape of blade (4) is adapted to this, these "lumps" will be transverse "filaments" with their major direction perpendicular to the
25 view plane. The drawing shows the situation at the end of the pulse, when the blades (4) are just about to close the ports (3). Rams (1) are still pressing and the no-return valves (2) therefore are closed. The previously coextruded "lump" is shown as (6). In this application of the
30 invention, the apparent viscosities of B1 and B2 are essentially lower than that of A, which will have the effect that the "lumps" gradually will be smeared or sheared out to practically even layers while the B1-A-B2 flow moves through the common passageway (7) towards the
35 exit (8) of the coextrusion die.

Therefore, (6) is shown smaller than (5) and there is not shown any "lump" further downstream.

Each of the rams (1) can extend over the full width of the generally sheet formed or ribbon formed flows B1 and B2, or there may preferably be a row of rams for B1 and one for B2 (depending on the mechanical construction). However
5 it must hereby be ensured that there is established an even pressure from side to side in each of the flows when they meet the port (3). This is a matter of the dimensions of the chambers for B1 and B2, the distance between the rams, and the pressures of B1 and B2 during the process.

10 In case the rams (1) extend over the full width of flow A, the inlet channels (4b) for B1 and B2 upstream of the valves (2) should also extend so, but if there is arranged rows of rams, each ram should preferably be fed from a separate channel. Along the length of the flap
15 closure (4), the distance from this flap to the opposite wall of channel 4b may need to be very short relative to the length of flap (4) since otherwise this flap may be bent excessively towards the opposite wall when the pressure of B1 or B2 is at minimum and the pressure in A is
20 high.

In some cases, especially in connection with the second aspect of the invention, in which the frequency of the pulsations is generally not as high as in the first and third aspect, it is possible to use only one pulsating,
25 narrow ram (1) for each of the B components, to serve the entire width of the coextrusion, even when this width is sizeable, provided there is arranged for an efficient distribution between this ram and the port (3) where the components merge.

30 The flow-sheet like sketches 2a and b indicate the successive sections in suitable dies for circular coextrusion according to the invention while the drawings fig. 3a and b as already mentioned illustrate the preferred corresponding distribution system for component A. This
35 starts with a branching-out system, which first has been described in U.S. patent 2.820.249 in which patent it is used in connection with coating of items by coextrusion.

Component A is fed into this system through port (10), then branches out to two partflows in channels (11), continues as 4 partflows in channel (12) and 8 partflows in channels (13). (Depending on the dimensions of the die there can of course be formed a bigger or smaller number of partflows but in any case a power of 2.) The part-flows in (13) continue in a "spiral" distribution system, through grooves (14) whereby a proper balance is established by rheological calculations between the flows through the spiral grooves (14) and an over-flow between the latter, which takes place in narrow gaps in the spaces (15) the beginning of which are shown by the lines (16).

A similar branching-out system can conveniently be used for components B1 and B2, however when there is used a circular array of rams, as shown, and the latter are sufficiently close together, there is no need for spiral distribution of these components, since each of the partflows which result from the dividing out, then more practically can go directly to a ram. Furthermore, if the viscosities of B1 and B2 are much lower than that of A, a lower degree of branching of these two components will be sufficient

In practice, the distribution systems for A, which are shown in figs. 3a and b, may be carried out in a die or die-section consisting of two discs, which are screwed together. The channels (grooves) may be formed in one of these discs only, or preferably a part of each channel is formed in one and another part in the other disc, with these channel parts fitting together.

However, as mentioned in connection with fig. 1, one ram for each B-component can under circumstances be sufficient, but then an efficient distribution between this ram and port (3) is needed.

As mentioned fig. 3a, which shows in detail fig. 2a's "section for merging", is a modification of fig. 1. The reference numbers have the same significance. It should be

noted that the springy blades (4) are plane like in fig. 1, but now of course in the form of flat disc-formed rings.

Similarly, if the chambers for B1 and B2 immediately upstream of the no-return valves (2) are circular chambers around the entire die, as they can be, then the two valves (2) are also formed as flat, disc-formed rings and can be set-up in a system as here shown, however as it appears from the foregoing it is usually more practical to let each of the part-flows which result from the dividing-out go directly to a ram through a separate conduit, and in that case an arrangement as that shown in fig. 1 is also applicable.

As shown in the drawing, the circular die should normally be adapted to extrude the composite flow B1/A/B2 out in a generally axial direction when leaving the exit (8).

The rams (1) can be operated by direct mechanical, by hydraulic, pneumatic or electromagnetic means. Hydraulic operation will normally be most convenient. In the inwardly extruding system (fig. 2a) the rams are easily accessible from the outside of the die, but in the outwardly extruding system (fig. 2b) one array of rams must be operated through the open bore in the middle of the die. This open bore can also be used for other conduits or connections, e.g. a conduit for internal cooling of the extruded tube. Obviously the die set-up in which the flows move inwardly (fig. 2a) is best suited for manufacture of tubular sheeting or pipes of a relatively small diameter down to 10mm or less, while the other set-up (fig. 2b) is best when a relatively large diameter of the product is wanted for instance up to 5m or more.

When producing pipes in which stiff segments alternate with soft segments, the set-up shown in fig. 2a should be used.

The modifications shown in figures 4b, c and d can be seen as modifications of the flat die shown in fig. 1 and also as modifications of the circular die shown in fig. 3.

The modification shown in fig. 4a relates only to flat dies (to fig. 1) since a flap closure becomes conical if it is considered circular, and of course in that form it cannot work.

5 The significant reduction of thickness of flow which appears from fig. 4a can be advantageous if there is a particular need to reduce the back pressure in component A and still under use of the lubricating effect of B1 and B2, end with a relatively thin sheet.

10 Fig. 4a also illustrates the feature that the opening and/or closing of the flap closure (4) can be effected through mechanical transmission means (4c) instead of by induced pressure variations in component B (or B1 and B2), and furthermore fig. 4a, as well as figs 4b-d, show the
15 flap closure (4) as a flexible blade ending in a thicker or harder portion (4b) for the purpose of reinforcement and stabilization. In fact this portion (4b) can be the main part of the flap (4) while the shorter flexible part acts as a hinge.

20 Going back to the mechanical transmission means (17) in fig. 4a, they are here shown as rods which push on the thicker or harder part (18) of the flap closure. When a substantial pressure difference between component B (or B1 and B2) and component A is required (see claim 11) then
25 obviously the flap closure (4) must be adapted to withstand this pressure difference and keep the port closed when not mechanically activated. Alternatively, (17) can be hinged on (18) and may act by pulling or push-pulling.

30 The different arrangements of the channels shown in figs. 4b, c and d may be chosen in cases when there may be constructional problems in arranging the flows of the A and B components generally parallel with each other prior to the merging. However, the abrupt bending of flows shown in these sketches may under inappropriate circumstances cause
35 a harmful stagnation.

 In figs. 5a and b a generally dry particulate product (A) which e.g. may be a raw material for ceramics, plastics

e.g. PTFE composites, foodstuff or medical pills, is fed by gravity from a hopper through feeding chamber (17) into the A-extrusion channel (18). The hopper is preferably evacuated, since air can cause problems in the coextrusion, blending and compacting processes.

In fig. 5a the upstream and downstream boundaries of the feeding location is shown by the dash lines 19 and 20. The feeding of A by gravity may be assisted by a vibrator or by other agitation means (not shown). A is propelled through the channel (18) by means of a ram (21). In the most backward position of this ram, its front generally coincides with the backward boundary of the feeding location (dash line 19). Before moving ram (21) forward to propel A, the connection between the hopper and channel (18) is closed by a gliding-closure (22) as indicated by arrow (23).

Fluid components B1 and B2 (which normally are identical) are coextruded in pulsations by means of the two rams (1) through the B1 and B2 extrusion channels (4b) to port (3) comprising the no-return valve (4), which is a flap closure, all as explained in connection with fig. 1.

The movements of the three rams, one (21) for A and two (1) for B1 and B2, may be simple reciprocations, but especially for B1 and B2 it will usually be advantageous to work in series of forward strokes followed by a continuous retraction to the starting position. Ram (21) is preferably lubricated either with B1/B2 component or with a fluid which for purposes which depend on the intended use of the final product can be considered as compatible with B1 and B2. This lubricant can be injected from behind the ram or otherwise in well-known manner. Means for this are not shown.

The lubricant should preferably be pumped into the coextrusion system in amounts which are sufficient not only for lubricating ram (21) but also for lubricating the propelled flow of A during its passage towards port (3).

The fluid B1 and B2 components, which are coextruded on the two surfaces of the dry, particulate flow, may be able to penetrate to the middle of flow A without any use of mechanical blending means, but usually such means are
5 needed if a reasonably homogenous blending of A, B1 and B2 is wanted. In the drawing these means are the flaps (24), which vibrate fast in mutually synchronized manner and thereby subject the composite flow to a shear which is transverse to the main flow direction. Transmission rods
10 (24a) for these vibrations are shown.

The combined coextrusion and blending according to this aspect of the invention is in particular advantageous if the proportion between the fluid components (B1 and B2) and the generally dry, particulate component (A) is
15 relatively low so that blended product on the whole still appears particulate (as distinguished from a paste). When the composite flow has this character, there may be a need to compact the material before the exit from the extrusion die. If only a slight compression is needed a narrowing of
20 conduit (7) may be sufficient, but the tendency of such particulate products to block a narrowing passageway is very high, and increased pressure on ram (21) may not overcome such blocking. This problem is solved by carrying out the compression transversely by means of fast vibrating
25 stamps (25), which are oppositely synchronized, so that they alternately move towards and away from each other. These stamps cover the full width of the composite flow, and the front of at least one of them is biased in relation to the main direction of the flow so that they gradually
30 reduce the gap of the conduit. In the position where the stamps are closest together they should preferably be slightly closer together than the gap of exit 8.

Instead of two stamps (25) there may be one only.

In this drawing the blending means (24) are shown as
35 flaps but can alternatively be stamps, (i.e. comprising a component which mixes in a generally rectilinear

direction), and the means for compression are shown as stamps but can alternatively be flaps.

5 In fig. 5a the surfaces of flaps (24) and the fronts of stamps (25) are with some approximation generally parallel with the surfaces of the coextruded B1 and B2 layers. However this third aspect of the invention can also be carried out in a way which will appear if the apparatus part downstream of the dash line 26 is understood as turned 90° around an axis parallel with
10 the main direction of flow. In this way it will be possible to make a composite extrusion device with several exits (8) close together in array as required for the "lamellar coextrusion" which has been mentioned above. The "lamellar extrusion" using this embodiment of the invention
15 can e.g. be used as an improved method to make medical pills which release the active substances in the body in several steps at predetermined time intervals, a function of pills which in itself is well-known.

Example

20 This example demonstrates the use of the invention for manufacture of a novel confectionery product, which can be expected to have good sales appeal, namely corrugated (waved) chips of marzipan covered on both sides with thin layers of dark chocolate. In the principle this could be
25 done by ordinary coextrusion, when the chocolate is in semi-molten, high viscosity state with an apparent viscosity reasonably close to the apparent viscosity of the plastic marzipan mass. However, the melting range of the dark chocolate is very narrow and the chocolate has high
30 tendency to become supercooled and therefore remaining truly fluid instead of becoming part-solidified, when it gradually cools down from the molten state. This means that it is very difficult to "tailormake" the rheology of the dark chocolate for such a coextrusion. Therefore the
35 present invention is used, and the chocolate is maintained truly molten and fluid while it is coextruded with the plastic marzipan mass.

The process is carried out in a pilot-coextrusion line in which the die is constructed essentially as shown in fig. 1, however the exit of the die, beginning where the conduit (7) begins to narrow down, is gradually changed into the corrugated shape, that is the sides of the slot are parallel and have the shape of a wave, with the angle at the midpoints being about 30° to the wave direction. The gap of exit (8) is 2,5 mm, and the width of this and of the corresponding channels in the die is 30 mm. The depth of channel (7) before the narrowing is 4,0 mm, depth of channel for A (marzipan) before the merging is 3,0 mm. The depth of the two channels for component B (chocolate) is 2,0 mm at the beginning, but changes to 1,0 mm along the blades (4). This low depth is chosen in order to secure that the blades (4) do not bend in an irregular manner under the pressure from component A. The length of the blades (4) is 16 mm and thickness of the latter is 0,20 mm over the first 5 mm and 0,40 mm over the rest. The length of channel (7) before the narrowing is 100 mm.

A (marzipan) is constantly fed by means of a conventional ram extruder, hydraulically driven, and B (molten chocolate) is also primarily fed by means of a conventional ram extruder (not shown), but in this case pneumatically driven. The reason for driving the A-ram hydraulically is the relatively high pressure required, while the reason for driving the B-ram pneumatically, partly is the lower pressure needed, and partly the need to obtain a certain "buffer" effect, so that the pressure in B upstream of the non-return valves (2) does not raise excessively when these valves are closed.

Due to the very low width of the die in this pilot line, there is not used distribution means between these primary rams and the die parts shown in fig. 1.

Each of the (secondary) rams (1) immediately upstream of the merging zone cover the full width of the flows. Their pistons are of a rectangular section with cross-sectional dimensions 29,95 mm x 1,95 mm. Their movements

are directly mechanically driven with adjustable strokes. They perform a series of 10 strokes forward followed by return to the starting position.

5 The temperature of B is kept at 40°C and the temperature of A at 15°C until these components enter the die. The reason for using this relatively low temperature is to assist in the cooling of B.

10 The temperature of the die is maintained at 32°C, under conditions of equilibrium the chocolate will be part molten at this temperature, but under the actual conditions of this extrusion it becomes supercooled and remains truly fluid, except where it immediately contacts the cold marzipan.

15 The pressure in the A-ram is adjusted to produce a throughput of 15 g/s. Under actual conditions this corresponds to about 50 bar (5×10^6 Pa). The primary B-ram is extruding under a pressure of about 10 bar (1×10^6 Pa).

20 The secondary rams for B (1) work in strokes of about 0,05 sec duration with a period (stroke + interruption) of 0,1 sec corresponding to 10 strokes per second. The amplitude of the strokes is adjusted to make a 0,4 mm coating of chocolate on each side of the marzipan.

25 The corrugated "tape" of marzipan covered with chocolate is relatively stiff when it leaves the exit (8) of the die. It travels 2 mm unsupported and is then conveyed by a belt. Cold air is blown for cooling. While on the conveyor belt the "tape" is cut to short lengths.

CLAIMS

1. A method of coextruding a sheet- or ribbon formed flow of extrudable material A with a sheet- or ribbon formed flow of extrudable material B in a zone of joining in a coextrusion die (which term includes an adaptor upstream of the final product forming die) in which B is extruded on A through a port (3) and the two materials proceed together through a passageway (7) towards an exit (8) of the die, wherein the separation wall between said flows, immediately before it ends in port (3) is formed as a flap closure (4) adapted to act as no-return valve for the flow of B onto A, characterised in that the extrusion of B through the port (3) takes place in pulses.

2. A method according to claim 1, characterized in that said closure is a springy blade, optionally with a thicker or harder section at its downstream end (4b in figs. 4a to d).

3. A method according to claims 1 or 2, characterized in that the said pulses are effected by one or more rams (1) or by opening and closing valves upstream of the closure (4).

4. A method according to claims 1 or 2 characterized in that the said pulses are effected by opening and/or closing the closure (4) through mechanical transmission means (4c).

5. A method according to any preceding claim, characterized in that at least in the immediate vicinity of port (3) flows A and B both are planar flows which are generally parallel to the closure (4).

6. A method according to any preceding claim, characterized in that the coextrusion die is a flat die extruding a flat sheet or ribbon.

7. A method according to any of claims 1 to 5, characterized in that A and B at the location of joining each form tubular flows and the coextrusion die is a circular die in which the closure (4) is ringformed with its surfaces generally perpendicular to the axis of the die.

8. A method according to claim 7, characterized in that A and B at least in the immediate vicinity of port (3) flow outwardly or inwardly generally in radial direction and, following the joining of the flows, the latter are
5 directed into generally axial direction and exiting generally axially from a final product forming circular exit orifice (8).

9. A method according to any of the preceding claims, under use of a ram or rams (1) in cooperation with
10 preceding pumping or extruding means, characterized in that a no-return valve (2) prevents the ram from pumping back towards said preceding means.

10. A method according to any of the preceding claims, characterized by joining of two flows B1 and B2 on both
15 major surfaces of A.

11. A method according to any of the proceeding claims, in which B or B1 and B2 have lower apparent viscosity than A, characterized in that during each pulse the difference between the pressure in the B-flow or flows
20 "and" the A-flow is sufficient to effect even deposition of B on A over the length of port (3), and that the dimensions of the common passageway (7) are adapted to produce a shear sufficient to make the layer thicknesses of B1 and B2 generally even before the exit (8) at the end of the
25 passageway (7).

12. A method according to claim 11, characterized in that the cross-sectional area of the said passageway (7) is reduced towards the downstream end (8).

13. A method according to claim 12, characterized in that A consists of high molecular weight polyethylene or
30 high molecular weight polypropylene and B or B1 and B2 consist of a polymer or mixture of polymers which adheres to A in the final product and exhibits or exhibit melt flow index at least 10 times and preferably at least 20 times as
35 high as that of A.

14. A method according to claim 13, characterized in that B1 and B2 together occupy less than 10% of the thickness of the joined flow.

15. A method according to any of the claims 1 to 10, characterized in that in each pulse the pressure of A and B on the closure (3) is sufficient to substantially stop the flow of A so as to achieve a segmental flow of the A and B components referring to the extrusion direction.

16. A method according to claim 15, characterized in that A and B have generally the same apparent viscosity.

17. A method according to claim 15 or 16 in which the combined flow is solidified after extrusion characterized in that A and B in the final solid form of the manufactured product have different coefficients of elasticity.

18. A method according to any of the claims 1 to 10, characterized in that A consists of solid generally dry particles and B consists of a truly fluid material, and the flow of A is propelled by a ram (21) in a conduit (18) which directly leads to the port or ports (3) through which B is coextruded.

19. A method according to claim 18, characterized in that subsequent to the joining of B with A the joined flow is subjected to blending and/or compacting by means of one or more stamps or flaps (24 and 25) which reciprocate in directions transverse of the main direction of the composite flow.

20. A method according to any of claims 1 to 12, characterized in that A and B consist of food components.

21. A method according to claim 20, characterized in that B is molten chocolate, sugar or caramel and A is a material having a higher apparent viscosity than B.

22. A method according to any of the claims 1 to 10, 18 or 19, characterized in that at least component A comprises particulate solids for forming ceramic.

23. A method according to any of the claims 1 to 10, 18 or 19, characterized in that at least component A comprises particulate solids for forming medical pills.

24. A method according to claim 7 or 8 carried out by means of a circular extrusion die having an inlet and a generally circular exit orifice in which process, for the purpose of equalising the flow of the material through said

orifice over the circumference of the latter, the flow of material between the inlet and exit is divided on a number of part-flows of spiral-form or spiral-like form with an adjusted possibility of overflow between said part-flows, and said part-flows with over-flows gradually joint to one common, circular flow.

25. Method according to claim 24 in which the inlet is located closer to the axis of the circular die than the exit orifice and the extrudable material flows outwards towards the exit orifice (Fig. 3b).

26. Method according to claim 24 in which the exit orifice is located closer to the axis of the circular die than the inlet and the extrudable material flows inwards towards the exit orifice (Fig. 3a).

27. Extruder comprising a coextrusion die for coextruding a sheet- or ribbon-flow of extrudable material A with a sheet- or ribbon-formed flow of extrudable material B, the die comprising a zone of joining in which B is extruded on A through a port (3), an exit (8) and a passageway (7) through which the joined materials A and B flow from the port (3) to the exit (8), wherein the separation wall between said flows, immediately before it ends in port (3) is formed as a flap closure (4) adapted to act as no-return valve for the flow of B into A, characterised by comprising means for carrying out the extrusion of B through port (3) in pulses.

28. Extruder according to claim 27, characterized in that said closure is a springy blade, optionally with a thicker or harder section at its downstream end (4b in figs. 4a to d).

29. Extruder according to claims 27 or 28, characterized in that the said means for imposing pulses comprises one or more rams or actuatable valves upstream of the closure (4).

30. Extruder according to claims 27 or 28 characterized in that the said means for imposing pulses comprises mechanical transmission means (4c) opening and/or closing the closure (4).

31. Extruder according to any of claims 27 to 30,
characterized in that at least in the immediate vicinity of
port (3) the die is configured so that flows A and B both
are planar flows which are generally parallel to the
5 closure (4).

32. Extruder according to any of claims 27 to 31,
characterized in that the coextrusion die is a flat die for
extruding a flat sheet or ribbon.

33. Extruder according to any of claims 27 to 31,
10 characterized in that the coextrusion die is a circular die
for coextrusion of tubular flows in which the closure (4)
is ringformed with its surfaces generally perpendicular to
the axis of the die.

34. Extruder according to claim 33, characterized in
15 that the die is configured so that A and B at least in the
immediate vicinity of port (3) flow outwardly or inwardly
generally in radial direction and, following the joining of
the flows, the latter are directed into generally axial
direction and exiting generally axially from a final
20 product forming circular exit orifice (8).

35. Extruder according to any of claims 27 to 34, in
which the means for imposing pulses comprises a ram or rams
(3) with preceding cooperating pumping or extruding means,
characterized in that a no-return valve (2) prevents the
25 ram from pumping back towards said preceding means.

36. Extruder according to any of claims 27 to 35,
suitable for joining of two flows B1 and B2 on both major
surfaces of A.

37. Extruder according to any of claims 27 to 35,
30 characterized in that the dimensions of the common
passageway (7) are adapted to produce a shear sufficient to
make the layer thicknesses of B1 and B2 generally even
before the exit (8) at the end of the passageway (7).

38. Extruder according to claim 37, characterized in
35 that the cross-sectional area of the said passageway (7) is
reduced towards the downstream end (8).

39. Extruder according to claim 33 or 34, comprising
an extrusion die having an inlet (10) for extrudable

material and a generally circular exit orifice spaced at different radial distances from the axis of the die and, between the inlet and outlet, channels for flow of extrudable material therethrough, in which a single inlet
5 channel from the inlet branches at least once to form at least two partflow channels (11, 12, 13) each for a partflow of extrudable material, the partflow channels (11, 12, 13) having a spiral slope, characterised in that the spiral partflow channels are arranged generally in a plane
10 or on the surface of a cone, and in which the partflow channels gradually join together.

40. Extruder according to claim 39 in which the exit orifice is radially inboard relative to the inlet and in which the partflow channels spiral inwards towards the exit
15 orifice.

41. Extruder according to claim 39 in which the exit orifice is radially outboard relative to the inlet and in which the partflow channels spiral outwards towards the exit orifice.

20 42. Extruder according to any of claims 39 to 41 in which the partflow channels (11) succeeding the inlet channel each branch to form two further partflow channels (12).

25 43. Extruder according to claim 42 in which the further partflow channels (12) each branch to form two exit partflow channels (13) which extend to the exit orifice.

44. Extruder according to claim 27 which the means for extruding A comprises a ram (2) in a conduit (18) leading directly to the port (3).

30 45. Extruder according to claim 44 which, downstream of port 3, comprises one or more stamp or flap (24 and 25) which reciprocate in a direction transverse to the direction of flow of extrudate so as to blend and/or compact the joined flow of B and A.