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COMPLETE SPECIFICATION

The Inventors of this invention in the sense of being the actual devisers thereof within the meaning of Section 16 of the Patents Act 1949 are:—Lloyd Edward Lefevre, of 3743, Boy Scout Road, Bay City, County of Bay, State of Michigan, United States of America, and Peter Breidt, Jr. of 3601 Westbrier Terrace, Midland, County of Midland, State of Michigan, United States of America, both Citizens of the United States of America.

Method and Apparatus for Forming a Composite Sheet of Thermoplastic Resinous Material

We, THE DOW CHEMICAL COMPANY, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of Midland, County of Midland, State of Michigan, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a method and apparatus for the coextrusion of two or more thermoplastic, resinous streams into a composite sheet having a plurality of parallel layers.

The apparatus in accordance with the present invention comprises an extrusion adaptor which can be inserted between the discharge ends of at least two extruders and a sheeting die, the adaptor comprising a housing, the housing defining at least a first inlet and a second inlet, a first passageway and a second passageway, a first discharge and a second discharge. The first inlet and first discharge are in communication by means of the first passageway, and the second inlet and second discharge are in communication by means of the second passageway. The first discharge and second discharge are coaxially arranged, and the first passageway surrounds at least a portion of the second passageway.

Also within the scope of the present invention is a method of forming a composite multi-layer film comprising providing first and second heat plastified streams

of synthetic resinous material, passing the streams to a sheeting die having an elongate slot-like orifice and passing the resultant composite stream from the orifice and cooling characterized in that the first and second streams are coaxially arranged before entering the sheeting die.

The invention will be further illustrated with reference to the accompanying drawing wherein:

Figure 1 is a sectional view of an apparatus in accordance with the invention;

Figure 2 is an end view of the apparatus of Figure 1 taken along the line 2-2 of Figure 1;

Figure 3 is a sectional view of a die suitable for use with the apparatus of Figure 1; and

Figure 4 is a sectional view of the die of Figure 3 taken along the line 4-4.

Figure 5 is a schematic illustration of apparatus of the invention in use.

Figure 6 is an alternative arrangement of feed flow.

In Figure 1 there is illustrated an apparatus generally designated by the reference numeral 10. The apparatus 10 comprises in cooperative combination a housing generally designated by the reference numeral 11. The housing 11 comprises a first body piece 12. The body piece 12 defines an internal cylindrical passageway 13 generally coaxial with the body 12. The passageway 13 has a discharge end 14 and an inlet end 15. The body portion 12 defines a generally radially extending sur-

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face 16 which defines a hemi-toroidal recess 18. Adjacent to and in sealing engagement with the body portion 12 is a body portion 20. The body portion 20 defines an internal cylindrical passageway 21, a first radially extending surface 22 having defining therein a hemi-toroidal passageway 23 adapted to mate with the hemi-toroidal passage or groove 18 to form a toroidal plenum 25. The surfaces 16 and 22 adjacent the inlet end 15 of the passageway 13 of the body portion 12 define an annular radially extending passageway 27 providing communication between the toroidal passageway 25 and the cylindrical passageway 13. An inlet passageway 30 is defined by the body portion 20. The inlet passageway 30 terminates at one end at the toroidal plenum 25 and remote from the toroidal plenum at a plastic supply means 31. Disposed within the passageway 21 of the housing portion 20 is a bushing or die 32. The die 32 defines an elongate rectangular extrusion orifice 34 in communication with an internal passage 35. The passage 35 terminates in a generally cylindrical passage 37 remotely disposed from the elongate rectangular opening 34. The body portion 20 defines a generally radially extending surface 39 generally parallel to the surface 22 and remotely disposed therefrom. The surface 39 defines a hemi-toroidal annular cavity 40. A third body portion 42 is disposed adjacent the surface 39 of the second body portion 20. The third body portion 42 defines a generally centrally disposed passageway 43 which is in substantially coaxial relationship with the passageway 13 of the body portion 12 and the passageway 21 of the body 20. A generally radially extending surface 45 is defined by the body portion 42 and is adapted to engage in sealing engagement a portion of the surface 39 of the body portion 20. The surface 39 of the body portion 20 defines a hemi-toroidal annular cavity 47 which is adapted to cooperate with the cavity 40 of the body portion 20 to define a second plenum 49 between the body portions 20 and 42. The surfaces 45 and 39 define a radially extending annular passageway 50 which provides communication between the passageway 37 and the second plenum 49. A bushing 52 is disposed within the passageway 43. The bushing 52 defines a centrally disposed passageway 53 which terminates in a generally rectangular extrusion orifice 55 disposed generally adjacent the bushing 32 and a generally circular opening 56 remote from the bushing 32. The circular opening 56 of the passageway 53 is in operative communication with a source 59 of heat-plastified, thermoplastic, synthetic, resinous material. The body portions 12, 20 and

42 are maintained in sealing engagement by the bolts 60 (one shown). The inlet to plenum 49 is not shown.

In Figure 2 there is illustrated a schematic end view of the apparatus 10 taken along the line 2-2 looking into the passageway 13 illustrating the relative location of the bushing 32 and its extrusion orifice 34 and showing the relationship of the extrusion orifice 55 of the bushing 52.

In Figure 3 there is illustrated one embodiment of a die generally designated by the reference numeral 65 which is suitable for use with the apparatus 10. The die 65 comprises a housing 67 having defined therein an internal cavity 68. A passage 69 provides communication between the cavity 68 and the exterior of the die 67. The cavity 68 terminates in an extrusion orifice 70 which is an elongate slot particularly suited for the extrusion of a sheet of material entering into the passage 69. The discharge end 14 is shown in sealing engagement with the die housing 67 or in communication with the passage 69.

Figure 4 depicts a view of the die 67 taken along the line 4-4 illustrating the relationship between the passageway 69, the cavity 68, and the extrusion orifice 70 defined by the housing 67.

In Figure 5 there is schematically illustrated an apparatus illustrating the operation of the invention. The apparatus comprises a first extruder 76, a second extruder 77, a third extruder 78 or similar sources of heat-plastified, thermoplastic, resinous material. Extruders or polymer sources 76, 77, and 78 are in operative communication with a device 10a such as is illustrated in Figure 5 by means of the conduits 80, 81 and 82. The discharge portion of the device 10a is in communication with a sheeting die 84 by means of a conduit 85. The sheeting die 84 has an elongate extrusion orifice 86. The orifice 86 is generally coplanar like the rectangular internal extrusion orifices 34 and 55 shown in Figure 1.

Figure 6 depicts a cross-sectional configuration of a stream generally designated by the reference numeral 90, the stream 90 comprises a third generally cylindrical stream 91, a second generally annular stream 92, disposed about the third stream 91 and a first generally annular stream 93 disposed about the stream 92.

The embodiment, of the invention, set forth in Figures 1-4 is particularly suited and adapted to produce composite sheet or film having exceptional uniformity of layer thickness from thermoplastic resinous extruded materials and compositions which tend to differ in melt viscosity at the temperatures at which they are extruded. The use of the inner rectangular orifice provides

a substantial and significant increase in uniformity of distribution of material across the opening of the die.

In operation of the apparatus and in the practice of the method of the present invention an apparatus such as the apparatus 10 is incorporated into an assembly such as shown in Figure 5 wherein two or more sources of an extrudable material are supplied to the appropriate supply passages of the device 10. A first extrudable material is supplied to the passageway 53 from which it is extruded through the orifice 55 as a rectangular or elongate stream. Extrudable material supplied to the passageway or plenum 49 flows about the bushing 52 and encapsulates the stream issuing therefrom. This composite stream is subsequently extruded from the orifice 34 in a rectangular configuration where it is encapsulated within a material supplied from a third polymer source to the plenum 25. Thus, the stream flowing in the passageway 13 has a configuration (assuming extrusion at constant linear velocity of all streams) generally identical to the configuration of the passage and orifices illustrated in Figure 2. Such a stream on entering a sheeting die, such as the die illustrated in Figures 3 and 4, maintains its layered configuration and the outer material supplied from plenum 25 through the annular passageway 27 is deformed from a circular configuration to a rectangular configuration as it moves toward the extrusion orifice 70. The deformation appears to occur largely in the exterior or circular stream in the conduit 13 and the extrudable materials of the inner stream or streams, maintains its configuration and is distributed generally uniformly across the width of the die.

As is readily apparent, the apparatus in accordance with the invention may be utilized for the preparation of sheeting having 1, 2 or 3 components therein, the number of components depending upon the number of streams fed into the apparatus such as the apparatus 10. If desired, housing portions such as the housing portion 20 may be added to the assembly to permit the preparation of film having 4, 5 or even more components as may be desired. The relative dimension of the various layers appearing in the extruded product is readily controlled within reasonable limits by varying the feed rate of the various polymer sources. For example, if it is desired to maintain a relatively thick inner layer, the material from the source 59 of Figure 1 would be supplied at a substantially higher rate than material from the plenum 49, thus providing a thick inner layer, a thin intermediate layer, and an outer layer proportional in thickness to the feed rate from the plenum 25. In extrusion of sheet-

ing, it is necessary that a suitable temperature for extrusion be maintained for the material in the outer layer. The inner layer or layers may be extruded under conditions which would not normally result in a satisfactory product, as the surface finish of the sheet or film is dependent primarily upon the conditions employed for the extrusion of the outer layer. However, the temperatures of the material forming the inner layers must be sufficiently high to permit extrusion under reasonable pressures and rates. Employing an apparatus substantially as shown in Figure 1 in cooperation with supplies of diverse polymeric material, multi-layer, thermoplastic, resinous film of several varieties is readily produced.

The embodiment of Figure 6, which is readily achieved by altering the orifice such as 34 and 55 to a circular configuration is generally employed when the flow viscosities of the various layers are relatively close. Oftentimes for many composite sheets, it is not essential that a uniform distribution of the diverse materials be obtained across the width of the sheet and the streams having generally concentric circular configuration is satisfactory. Two, three or more component multi-layer sheets are readily prepared using the essential coaxial feed arrangement depicted in Figure 6 with a wide variety of sheeting dies.

Generally it is advantageous to employ a sheeting die having an internal cavity which is deep relative to the width of the extrusion slot, in order that adequate spreading of the stream is obtained, however, satisfactory composite sheets have been prepared utilizing dies which are relatively short or shallow, that is the distance from the feed port to the die opening is short relative to the length of the extrusion orifice.

Employing the arrangement of the present invention, including the embodiment of Figures 1-4 and also the feed arrangement as shown in Figure 6, satisfactory composite films and sheets have been prepared employing diverse combinations as polyethylene-polypropylene wherein the polypropylene is centrally disposed within the polyethylene, polyethylene encapsulating a vinylidene chloride-vinyl chloride polymer, polyethylene encapsulating polystyrene, polyethylene encapsulating a layer of a copolymer of 25 per cent ethyl acrylate and 75 per cent ethylene which in turn encapsulates a copolymer of vinylidene chloride and vinyl chloride. In one embodiment of the invention a heat-plastified adhesive stream is supplied about the periphery of a vinylidene chloride and vinyl chloride copolymer, the adhesive stream being adapted to adhere a polyethylene layer to said vinylidene chloride and vinyl chloride copolymer. The composite films and sheets

prepared employing the embodiment of Figures 1-4 generally exhibit the most uniform distribution of material throughout the width of the sheet. Although the die illustrated in Figures 3 and 4 is relatively deep, that is the distance from the die lips to the rear of the cavity is greater relative to the width of the extrusion orifice, much shorter dies may be employed.

10 WHAT WE CLAIM IS:—

1. A method of forming a composite thin multilayer film which comprises at least providing a first and second stream of heat plastified synthetic resinous material, coaxially arranging the streams, passing the streams to a sheeting die having an elongated slot-like orifice and passing the resultant composite stream from the orifice and cooling the composite stream.

20 2. A method as claimed in claim 1 which comprises forming the second heat plastified stream into a rectangular elongated configuration, encapsulating the second stream within the first stream to provide a composite stream having the material of the first stream disposed in a generally circular configuration about a centrally disposed elongated rectangular configuration, supplying the composite stream to an extrusion die defining an elongated slot-like orifice maintaining the elongated rectangular configuration of the first stream parallel to the elongated slot-like orifice of the die, forming the composite stream into a sheet configuration by passing the composite stream through the extrusion orifice of the die and subsequently cooling the composite stream below its thermoplastic resinous temperature.

3. A method as claimed in claim 2 wherein the second stream is a copolymer of vinylidene chloride and vinyl chloride.

4. A method as claimed in claims 2 or 3 wherein the second stream is polyethylene.

5. A method as claimed in claim 4 which includes the further step of supplying a heat-plastified adhesive stream about the periphery of the second stream, the adhesive stream being adapted to adhere the polyethylene to the vinylidene chloride polymer.

6. Extrusion apparatus comprising an extrusion adaptor to be disposed between at least two sources of heat plastified synthetic thermoplastic resinous material and a sheeting die, the adaptor comprising a housing assembly defining at least a first inlet and a second inlet, a first passageway and a second passageway, a first discharge outlet and a second discharge outlet, the first inlet and first discharge means being in communication by means of the first passageway, the second inlet and the second discharge outlet being in communication by means of the second passageway, the

first discharge outlet and second discharge outlet being coaxially arranged, and the first passageway surrounding at least a portion of the second passageway.

7. Apparatus as claimed in claim 6 wherein the first passageway includes a plenum having a generally toroidal configuration and being generally symmetrically disposed about the second discharge means.

8. Apparatus as claimed in claims 6 or 7 wherein the second discharge outlet is elongated and has a rectangular configuration and the first passageway has a generally circular configuration.

9. Apparatus as claimed in claim 8 wherein a plurality of annular plenums and annular passageways are in communication with the first passageway.

10. Apparatus as claimed in any one of claims 6 to 9 wherein the housing assembly comprises a plurality of housing portions each of the housing portions defining a passageway each of the passageways being in substantially coaxial arrangement the first passageway having a first passageway inlet adapted to be connected to an extruder, the first passageway outlet adapted to be connected to a sheeting die having an elongated extrusion orifice, the housing portions defining at least one internal plenum, the plenum being in communication with the first passageway by means of an annular passageway, a bushing disposed within the first passageway, the bushing so constructed and arranged so as to define an internal bushing passageway, terminating adjacent the inlet of the first passageway in a generally rectangular opening, the rectangular opening and the bushing being disposed between the annular passageway and the discharge means of the first passageway.

11. Apparatus as claimed in claim 10 wherein the housing portions define at least two annular passageways and at least two internal plenums, the internal plenums communicating with the first passageway by means of annular passageways, a bushing disposed adjacent each of the annular passageways, each of the bushings terminating in a generally elongated extrusion orifice at a location between the annular passageways associated therewith and the discharge means of the first passageway.

12. Apparatus as claimed in claim 11 wherein the internal plenums are toroidal.

13. Apparatus as claimed in claim 11 in operative association with at least a first extruder and a second extruder, and a sheeting die having an elongated extrusion orifice, the extrusion orifice of the sheeting die being substantially parallel to the elongated bushing orifice.

14. Extrusion apparatus as claimed in

prepared employing the embodiment of Figures 1-4 generally exhibit the most uniform distribution of material throughout the width of the sheet. Although the die illustrated in Figures 3 and 4 is relatively deep, that is the distance from the die lips to the rear of the cavity is greater relative to the width of the extrusion orifice, much shorter dies may be employed.

10 WHAT WE CLAIM IS:—

1. A method of forming a composite thin multilayer film which comprises at least providing a first and second stream of heat plastified synthetic resinous material, coaxially arranging the streams, passing the streams to a sheeting die having an elongated slot-like orifice and passing the resultant composite stream from the orifice and cooling the composite stream.

20 2. A method as claimed in claim 1 which comprises forming the second heat plastified stream into a rectangular elongated configuration, encapsulating the second stream within the first stream to provide a composite stream having the material of the first stream disposed in a generally circular configuration about a centrally disposed elongated rectangular configuration, supplying the composite stream to an extrusion die defining an elongated slot-like orifice maintaining the elongated rectangular configuration of the first stream parallel to the elongated slot-like orifice of the die, forming the composite stream into a sheet configuration by passing the composite stream through the extrusion orifice of the die and subsequently cooling the composite stream below its thermoplastic resinous temperature.

3. A method as claimed in claim 2 wherein the second stream is a copolymer of vinylidene chloride and vinyl chloride.

4. A method as claimed in claims 2 or 3 wherein the second stream is polyethylene.

5. A method as claimed in claim 4 which includes the further step of supplying a heat-plastified adhesive stream about the periphery of the second stream, the adhesive stream being adapted to adhere the polyethylene to the vinylidene chloride polymer.

6. Extrusion apparatus comprising an extrusion adaptor to be disposed between at least two sources of heat plastified synthetic thermoplastic resinous material and a sheeting die, the adaptor comprising a housing assembly defining at least a first inlet and a second inlet, a first passageway and a second passageway, a first discharge outlet and a second discharge outlet, the first inlet and first discharge means being in communication by means of the first passageway, the second inlet and the second discharge outlet being in communication by means of the second passageway, the

first discharge outlet and second discharge outlet being coaxially arranged, and the first passageway surrounding at least a portion of the second passageway.

7. Apparatus as claimed in claim 6 wherein the first passageway includes a plenum having a generally toroidal configuration and being generally symmetrically disposed about the second discharge means.

8. Apparatus as claimed in claims 6 or 7 wherein the second discharge outlet is elongated and has a rectangular configuration and the first passageway has a generally circular configuration.

9. Apparatus as claimed in claim 8 wherein a plurality of annular plenums and annular passageways are in communication with the first passageway.

10. Apparatus as claimed in any one of claims 6 to 9 wherein the housing assembly comprises a plurality of housing portions each of the housing portions defining a passageway each of the passageways being in substantially coaxial arrangement the first passageway having a first passageway inlet adapted to be connected to an extruder, the first passageway outlet adapted to be connected to a sheeting die having an elongated extrusion orifice, the housing portions defining at least one internal plenum, the plenum being in communication with the first passageway by means of an annular passageway, a bushing disposed within the first passageway, the bushing so constructed and arranged so as to define an internal bushing passageway, terminating adjacent the inlet of the first passageway in a generally rectangular opening, the rectangular opening and the bushing being disposed between the annular passageway and the discharge means of the first passageway.

11. Apparatus as claimed in claim 10 wherein the housing portions define at least two annular passageways and at least two internal plenums, the internal plenums communicating with the first passageway by means of annular passageways, a bushing disposed adjacent each of the annular passageways, each of the bushings terminating in a generally elongated extrusion orifice at a location between the annular passageways associated therewith and the discharge means of the first passageway.

12. Apparatus as claimed in claim 11 wherein the internal plenums are toroidal.

13. Apparatus as claimed in claim 11 in operative association with at least a first extruder and a second extruder, and a sheeting die having an elongated extrusion orifice, the extrusion orifice of the sheeting die being substantially parallel to the elongated bushing orifice.

14. Extrusion apparatus as claimed in



claim 6 substantially as hereinbefore described with reference to the accompanying drawing.

15. A method as claimed in claim 1 of 5 forming a composite multilayer film substantially as hereinbefore described.

16. Multilayer film whenever produced by the method claimed in any one of claims 1 to 5 or 15.

17. Multilayer film whenever produced 10 by means of the apparatus claimed in any one of claims 6 to 14.

BOULT, WADE, & TENNANT,

111 & 112, Hatton Garden, London, E.C.1.

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Agents for the Applicants.

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