Method of and apparatus for runnerless injection-compression molding thermosetting materials.

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The present invention relates to a method and apparatus for molding thermosetting materials and, more particularly, to the molding of thermosetting synthetic resin compositions.

Injection molding is an advantageous method of forming articles of synthetic resin. In general terms, injection molding is a process wherein the molding composition, in a melted or plasticized state, is injected into a mold cavity. Typically, cold molding composition in granular or nodular form is fed from a hopper into a heated cylinder containing a screw. The molding composition is heated, melted and plasticized on the screw flights, and then the screw, acting as a ram, injects the melted and plasticized material into a mold cavity. In the case of thermosetting material, the molded material is cured in the mold by compaction and by heat added to the mold cavity. After curing, the article is ejected from the mold and the process repeated.

Injection molding offers the advantages of reduced molding cycles, better control of process variables, and increased productivity as compared with conventional compression and transfer molding processes. The major disadvantage with the injection molding of thermosetting materials is the generation of a considerable amount of waste material, particularly when multiple cavity systems are employed. The waste material is generated by thermosetting material that has cured, become infusible, in the runner and sprue systems and cannot be reused. The amount of non-reusable waste material generated in this fashion can be substantial, ranging typically from about 15 to about 80 percent of the total amount of material required to mold an article.

A more recent technical advance in the molding art has been the adaptation of the runnerless injection, or cold manifold, process to the injection molding of thermosetting resins. In the cold manifold process, the material in the sprue and manifold system is maintained at a temperature sufficient to maintain the material in a plasticized condition, without causing the material to prematurely cure or "set-up". Thus, when a cured part is removed from the mold cavity, the material in the sprue and manifold becomes part of the next molding, instead of being discarded as in conventional injection molding operations. The runnerless injection process, therefore, provides for significant savings in material.

The thermosetting materials usually employed in runnerless injection processes differ in some respects from materials normally employed in conventional injection processes because of the different requirements of each process. One significant difference is that a standard injection molding material typically has a stiffer plasticity for faster molding cycles.

In contrast, a runnerless injection material is adapted to remain in a plasticized or fused condition in the feed system for extended periods of time without prematurely curing, usually at temperatures between 104° and 116°C. (220° to 240°F.) while also being capable of rapidly curing in the mold cavity at the molding temperature, usually about 170°C. (340°F.). An example of a suitable runnerless injection molding composition comprises a phenol-aldehyde resin component wherein (a) from 55% to 90% of the available theoretical para-phenyl linkages in the resin chain are bridged to a phenyl group, (b) the carbon chains linked between adjacent hydroxyl-substituted phenyl nuclei have 1 to 5 carbon atoms and (c) the hydroxyl-substituted phenyl nuclei are capable of chain growth at unsubstituted ortho- and para-positions of said nuclei. (See U.K. Patent Application No. 7919870.) Although such formulations are useful in the present invention, they are not required, and the molding compositions presently utilized may be selected from the more economical and more readily available standard thermosetting molding compositions.

Thermosetting molding materials useful in the present invention may suitably be selected from thermosetting synthetic resins and resin compositions typically used in molding operations, for example, phenolic; amino, such as urea, melamine and melamine/phenolic; polyester resins in granular, nodular, bulk or sheet forms; alkyd; epoxy; silicone; diallylphthalate; polyamides, or from thermosetting natural and synthetic rubber compositions. Phenolic resin compositions are especially useful as the feed material. Phenolic resin compositions used in molding operations are usually employed in the form of molding compositions. Phenolic molding compositions typically are particulate in form containing a molding grade phenolic resin, a cross-linking agent such as hexamethylenetetramine, and suitable filler materials.

The technique of injection-compression molding basically consists of injecting a charge of plasticized molding material into a partially open mold; the final fill, or mold fit, is accomplished by the subsequent complete closure of the mold. Injection-compression molding makes possible a combination of the positive attributes of compression molding, i.e. improved dimensional stability, uniform density, low shrinkage and impact strength, with the automation and fast cure of injection molding.

The technique of injection-compression molding can be exemplified by the disclosure of French Patent Specification No. 1,487,410 and the present invention is directed at incorporating therewith certain of the techniques of runnerless injection molding while still being
able to use standard phenolic molding compositions.

It has been suggested in United States Patent Specification No. 3,819,312 which exemplifies such a "runnerless" molding technique that injection molding can take place with the sprue and runners being maintained at a temperature that is insufficient to cure the molding material. However there has been no disclosure of the use of such a feeding mechanism with an injection-compression molding process and is provided by the combination of the present invention. Thus injection-compression molding as conventionally practised is somewhat wasteful in material although providing a very high quality finished article. The processes of molding using more careful temperature control, to provide so-called "runnerless" molding as shown by the United States Specification No. 3,819,312 is used as an economical process to reduce wastage with the knowledge that this will provide a product which is poorer in quality that products produced by conventional injection molding techniques even when such techniques are not being combined with compression molding to provide an even better quality product. Surprisingly the Applicants have discovered that by combining selected features from these diametrically opposed developments on injection-compression molding and runnerless "cold-sprue" molding one can obtain all the benefits of injection-compression molding without loss of quality and without necessarily have to use the very low melt viscosity special materials required for the runnerless or cold-sprue molding techniques.

As indicated above the only advantage of runnerless molding as compared with conventional injection molding is a reduction in wastage of molding material though this is counteracted by the special, low melt viscosity materials required and by the increased cycle times in that with runnerless injection a longer curing time is required as compared with that of the higher melt viscosity material used in conventional injection molding. The present invention has appreciated that this problem can be overcome in the combination of runnerless injection molding with injection-compression molding in that with the partly open mold during feed of material thereinto there is no substantial back pressure to be overcome and suitable materials can be used for making high quality, accurately formed products with the consequence that there is not the same lengthening of cycle time as occurs when a runnerless system is used with mold injection molding. Surprisingly a synergistic effect is achieved such that the results from using a runnerless injection molding with injection-compression molding not only provides the material saving which is achieved with runnerless techniques but also facilitates the use of standard phenolic molding compositions in such molding technique.

According to one aspect of the invention there is provided a method of injection-compression molding an article from thermosetting material comprising the steps of plasticizing a mass of thermosetting molding material, dividing a stream of said plasticized molding material into two or more smaller streams, injecting said smaller streams into two or more mold cavities comprised of partially open mold faces to substantially fill the space between said mold faces, said mold cavities being maintained at a temperature sufficient to cure said molding material, terminating said injection, completely closing said mold faces to cure the molding material in the internal configuration of said mold, and removing the cured, molded article from the mold. Characterized in this is a stream of plasticized molding material is passed through a temperature-controlled zone maintained at a temperature sufficiently low to prevent substantial curing of the molding material and sufficiently high to maintain the molding material in a plasticized condition, the division of said stream into two or more smaller streams taking place within said temperature controlled zone.

As described in greater detail hereinafter the thermosetting molding material, suitably a resin composition such as a phenolic molding composition, is initially heated and plasticized. The plasticized mass is then passed as a stream through a nozzle which is maintained at a temperature sufficiently high to keep the mass in a plasticized condition but sufficiently low to avoid any substantial curing or setting-up of the mass. The plasticized mass is then passed through a temperature-controlled manifold maintained at a temperature sufficiently high to keep the mass in a plasticized condition but sufficiently low to avoid any substantial curing or setting-up of the mass. By substantial curing or setting-up of the thermosetting molding material is meant the amount of premature polymerization which would adversely inhibit the plasticity or mobility of the molding material. In the manifold the plasticized stream is divided into two or more small streams which are passed through a plurality of runner channels, separate from the temperature-controlled manifold. The streams are subsequently injected to fill a plurality of partially opened, heated molds. The mold cavities are maintained at temperatures sufficiently high to cure the thermosetting molding material. When the partially open molds are full, the feed stream is interrupted, and the molds are then completely closed to press and cure the plasticized material enclosed within them. The cured, finished article is removed from the mold and the process repeated. In an alternative mode of the invention, the plasticized material from the temperature-controlled manifold is fed directly from the manifold into the molds.
The direct, positive mold system is comprised of two interfitting halves, or mold faces, which, when joined in register, define the mold cavity. The mold cavity, when fully closed, has the volume and configuration substantially identical to the desired finished molded article. In accord with the injection-compression technique employed in the present invention, the mold faces are not fully closed when the plasticized material is injected into the mold cavity. Thus, filling of the mold cavity is carried out against little or no back-pressure. The mold faces are heated to a temperature sufficiently high to cure the thermosetting molding material. The mass that is enclosed within the mold should remain sufficiently plastic so that, upon complete closure of the mold, the material will flow to fill every part of the mold cavity.

The present invention also relates to apparatus particularly suited to use in carrying out the present method. The apparatus, described more fully below, includes a distribution system for the plasticized material wherein the only scrap loss is a very short runner or gate. The distribution system comprises a stationary-temperature-controlled manifold in which the entering injection stream is divided or split into a plurality of streams to feed a plurality of mold cavities.

Thus, according to another aspect of the present invention there is provided apparatus for injection-compression molding of thermosetting material comprising: a stationary support plate and a movable support plate, each support plate having a heat plate mounted thereon with means to heat said heat plate and a plurality of mold faces mounted to be heated by the heat plate to have a cooking temperature between 135° and 216°C. Thus forming a stationary and a movable assembly, means to bring aligned mold faces on the different support plates into close proximity to form partially open mold cavities, means for feeding a supply of plasticized thermosetting molding material through a stationary supply manifold into said partially open mold cavities, means to interrupt the feed of thermosetting material, means for closing said partially open mold cavities to cure any thermosetting molding material enclosed therein by pressure and heat, and means for retracting said movable assembly to open said mold cavities and remove said heat plate mounted on the movable support plate and said manifold from contact, characterized in that the manifold is mounted on the heat plate carried by the stationary support plate or on said stationary support plate, said manifold having an entry orifice connected internally with a plurality of outlet orifices and being provided with means to control the temperature in said manifold at a temperature between 77° and 121°C, said mold faces being provided adjacent the periphery of the manifold.

Use of the present invention combines the positive attributes of runnerless injection and compression molding techniques which provide increased productivity and the production of products having improved capabilities. The present invention also provides an improved means to maintain the plasticized mass within the system in an uncured state for substantially longer periods of time than the distribution systems of the prior art. This is of particular importance when extra time is required to clean or clear a mold, or when the operation is interrupted because of equipment failure.

With the preferred apparatus of the present invention carefully controlled means are provided for controlling accurately the temperature of the material in the initial injection nozzle, in the manifold through which the material is run from the nozzle to the molds and in the molds themselves during the closing and curing cycle. Conveniently the mold faces are maintained at high curing temperatures by means of being mounted on heating plates which necessarily must also carry the manifold member and the nozzle. By providing appropriate temperature control of this member and nozzle also by providing appropriate insulation between the hot heating plates and the manifold member, material being injected can be maintained under very accurately controlled conditions at which it will remain plastic, without curing, and yet which will cure rapidly once it has been injected and is being compressed in the mold cavities upon full closure of the mold faces.

Various embodiments are disclosed with it being preferred that the connection from the orifices of the manifold and the mold cavities be maintained as short as possible to minimize wastage. In a particularly convenient construction the orifices are spaced around the periphery of the manifold and positioned to connect directly with the mold cavities.

Detailed description of the invention

The present invention will be illustrated and more fully described by reference to the accompanying drawings. Figure 1 is a cross-sectional, partly schematic view of an injection molding apparatus, particularly adapted to carry out the present process. As shown in Figure 1, the apparatus is in the fill stage of the molding cycle. In this stage, thermosetting molding material is fed into partially open, heated molds.

Figure 2 shows the apparatus of Figure 1 in the compression stage. In this stage, the molds are completely closed. The thermosetting material within the molds is pressed and heated to cure the material into the mold shape.

Figure 3 shows the apparatus of Figure 1 in an open position. In this position, the movable platen member has been actuated to move in a direction away from the stationary platen member to allow removal of the molded articles from the open mold and to facilitate
cleaning of the mold faces in preparation for repositioning the machine components in the fill stage as shown in Figure 1.

Figure 4 is a cross-sectional, partly schematic view of an injection molding apparatus shown in an alternate embodiment wherein the manifold component feeds directly into the mold gates. As shown in Figure 4, the apparatus is in the fill stage of the molding cycle.

Figure 5 is a cross-sectional, partly schematic view of an injection molding apparatus showing an alternate embodiment wherein the manifold component feeds through separate sprue bushings and runner channels into the mold cavities. As shown in Figure 5, the apparatus is in the fill stage of the molding cycle.

Looking now at Figure 1, thermosetting molding material is fed into feed hopper 11 and then into a plasticizing zone formed by the interior of heated barrel 13 and by the mechanical working of screw 15. A predetermined amount of plasticized molding material is subsequently injected by screw 15 acting as a ram, through injection nozzle 17. The material passes through orifice 19 of sprue bushing 21 and into entry orifice 35 of a temperature-controlled manifold 33. Temperature-controlled manifold 33 is preferably fabricated with a removable section 83 to facilitate inspection and cleaning of the internal orifices of the manifold without removing the entire manifold from the machine. During the molding operation, manifold plates 33 and 83 are fastened together, such as with bolts. The contact face of manifold 33 has a plurality of outlet orifices, such as 69, connected by internal orifices, such as 67, to entry orifice 35. Plates 23, 39 and 45 are heated to a temperature sufficiently high to set the thermosetting molding material. Heating may be accomplished by circulation of steam or hot oil through the plates, but more suitably, electrically. Temperatures ranging between 135°C and 216°C (275°F to 425°F) are generally useful, and, within this range, temperatures between 149°C and 199°C (300°F to 390°F) are aptly suited to use to cure a wide variety of thermosetting materials. The temperature in manifold 33 is controlled by the circulation of a liquid, such as water, through orifices, such as 37. The temperature in the manifold is maintained sufficiently low to prevent any substantial curing of the thermosetting molding material and, at the same time, maintaining the material in a plasticized state. Generally, temperatures in the range between 77°C to 121°C (170°F to 250°F) and, more preferably, from 99°C to 116°C (210°F to 240°F) are maintained in the manifold member.

The principal purpose of the temperature-controlled manifold 33 is to prevent curing while maintaining plasticity of the thermosetting molding material. The principal purpose of heat plates 23, 39 and 45 is to supply suf-
is heated, preferably electrically, to maintain a temperature corresponding to that of movable heat plate 45. Runner plate 49 is movable in and out of contact with the outer face of manifold 33 by reciprocal movement of rod 57 which is actuated by hydraulic means, not shown. The contact face of runner plate 49 has a plurality of passageways, such as 61 and 79, which is adapted to correspond to and be aligned with the outlet orifices, such as 59 and 81, in manifold 33 to form runner channels through which a flow of the thermosetting material may be directed from temperature-controlled manifold 33 through the runner channels and into the mold cavity formed by the partially open mold faces, such as 41 and 47. Preferably, runner plate 49 has a layer of insulation, e.g., insulation board, 63 along at least a portion of its contact face.

Movable heat plate 46 and runner plate 49 maintain a temperature at mold face 47 comparable to that maintained on mold face 41, which is a temperature sufficiently high to cure thermosetting material upon complete closure of the mold. Upon complete closure of the mold, the temperature in runner channel 61 also rises to cure the thermosetting material in the runner channel.

The shoot, or measured amount, of plasticized thermosetting molding material entering through nozzle 17 passes through sprue bushing 21, orifice 19, and into temperature-controlled manifold 33 through entry orifice 35. The plasticized molding material is then diverted by material distributor 65 into a plurality of orifices, such as 67. As shown in Figure 1, the plasticized material then enters a runner channel, such as 61, and into the area between partially open mold faces 41 and 47. Spacing between the partially open mold faces generally ranges between 0.06 and 0.5 inches (1.52 and 12.7 mm.) and, more preferably, between 0.10 and 0.2 inches (2.54 and 5.08 mm.). Openings less than about 0.06 inches (1.52 mm.) usually do not allow easy flow of the molding material into the mold cavity, and openings greater than about 0.5 inches (12.7 mm.) frequently yield an excess of flash in the area around the mold faces upon closure of the mold.

Upon filling of the mold cavity, mold faces 41 and 47 are then moved, suitably hydraulically, to close.

Figures 1, 2 and 3 illustrate another feature of the invention wherein sprue bushing 21 is separated from stationary heat plate 23 by space 99 to aid in preventing a temperature in the sprue bushing which would cure, or set up, the thermosetting molding material in sprue orifice 19. A further embodiment, illustrated in Figures 1, 2 and 3, is that sprue member 21 may also be provided with a temperature-control means, provided by orifices, such as 101, adapted to hold and circulate a reservoir of liquid, suitably water, maintained at a tempera-

ture sufficient to maintain the molding material in a plasticized state and insufficient to cause substantial curing of the molding material.

Figure 2 shows the apparatus of Figure 1 in a closed or compression stage of the molding cycle. Movable support plate 43 has moved toward stationary support plate 27 to close mold faces 41 and 47. Thermosetting molding material previously fed into the space between mold faces 41 and 47 is pressed and heated to cure the material enclosed in the mold. After the molding material is cured, the molds are opened by movement of the movable assembly in a direction away from the stationary assembly.

Figure 3 shows the apparatus of Figure 1 in an open position. In this position, temperature-controlled manifold 33 is disengaged from runner plate 49, and mold faces 41 and 47 are separated to facilitate removal of the molded article and to allow cleaning of the mold faces. Suitably, the molded article is removed from the mold by the action of one or more knock-out pins, such as 71 and 73, positioned in the mold face area. The only scrap of waste generated are small runners of molding material cured in the runner channels, e.g., 61. This material may be removed by action of a knock-out pin, such as 75.

It will be understood that the present invention provides for the use of a plurality of mold cavities fed by a single manifold, such as 33. The drawings contemplate, but do not show, additional mold capacity fed by orifices, such as 77, through additional runner channels, such as 79. Preferably, the molds positioned around the periphery of manifold 33 are balanced, that is, each of the molds requires substantially the same amount of plasticized material for filling.

Once the molded articles and cured runners are removed from the open molds, and the mold area is cleaned, the apparatus components are repositioned to the arrangement shown in Figure 1. Runner cut-off 22 is then retracted, allowing the next charge of thermosetting material to be injected into the space between mold faces 41 and 47.

Figure 4 shows an alternate embodiment of the apparatus shown in Figures 1, 2 and 3. In this embodiment, the temperature-controlled manifold directly feeds plasticized molding material into the gate area of a plurality of mold cavities positioned around the periphery of the manifold, eliminating the need for the independent runner plate 49 as shown in Figures 1, 2 and 3.

Looking now at Figure 4 in detail, wherein the apparatus components similar to those shown in Figures 1, 2 and 3 are similarly numbered. Thus, plasticized thermosetting molding material is fed from heated barrel 13, passing through injection nozzle 17, through orifice 19 of sprue bushing 21, and into entry orifice 85 of manifold 87. Manifold 87 has a plurality of runner channels, such as 89, which connect
internally with entry orifice 85 and exit along the periphery of manifold 87. Runner channels, such as 89, connect to gate 91 of mold cavities formed by mold faces, such as 41 and 47.

Similar to the embodiment shown in Figures 1, 2 and 3, the embodiment in Figure 4 includes a stationary assembly and a movable assembly.

The stationary assembly is comprised of a stationary support plate, or platen member, 27, which has a stationary heat plate 23 mounted thereon. Preferably, support plate 27 is separated from heat plate 23 by a layer of insulation 29, e.g., insulating board. Manifold 87 is mounted on heat plate 23 and is separated therefrom by a layer of insulation 31 suitably of insulating board. Heat plate 23 also has a plurality of mold faces, such as 41, mounted thereon surrounding the periphery of manifold 87. One or more runner channels, such as 89, in manifold 87 connect with gate areas, such as 91, of the mold faces.

The movable assembly is comprised of a movable support plate, or platen member, 43, which has a movable heat plate 45 mounted thereon. Heat plate 45 has a plurality of mold faces, such as 47, mounted thereon. Support blocks, such as 51, 53 and 55, are suitably utilized to insulate support plate 43 from heat plate 45. The movable assembly is adapted to be moved reciprocally, suitably by hydraulic means, not shown, to place the mold faces on the movable assembly in and out of aligned contact with the mold faces of the stationary assembly. During the fill and compression stages of the molding cycle, manifold member 87 is preferably maintained out of direct contact with movable heat plate 45 by means of an insulating layer, 95, e.g., insulating board, positioned along the portion of the face of heat plate 45 which is contiguous to manifold member 87.

As shown in Figure 4, the apparatus is in the fill stage of the molding cycle, that is, plasticized thermosetting molding material is fed from temperature-controlled manifold 87 into partially open mold cavities formed by mold faces 41 and 47. Manifold 87 has a temperature-controlling means therein comprising of internal channels, such as 93, which are adapted to hold and circulate a reservoir of liquid maintained at a temperature high enough to maintain the thermosetting molding material in a plasticized state and sufficiently low that no substantial curing of the molding material takes place. Generally, temperatures in the range from 77° to 121°C (170° to 250°F) and, more preferably from 99° to 116°C (210° to 240°F) are used. Manifold member 87 is preferably fabricated of separable components to facilitate cleaning of the internal orifice system. Thus, manifold 87 may suitably have removable portion 97, the portions being held together as a unit by a bolt or screw means. The configuration of manifold 87 is not critical; however, circular or rectangular configurations are preferred to facilitate easier balancing of the runner and mold systems.

In the compression stage of the molding cycle, the mold faces, such as 41 and 47, are completely closed. The mold closing pressure and heat supplied by heat plates 23 and 45 are sufficient to cure the thermosetting material enclosed in the mold cavity to form a cured article.

After curing, the movable platen assembly is retracted, moved away from the stationary assembly, to allow removal of the molded article and cleaning of the mold face areas. In the embodiment shown in Figure 4, the only loss of the amount of cured material in the gate area, which is removed with the molded article. The material in the nozzle and manifold is maintained in a plasticized, substantially uncured, state, ready to be utilized in the next fill stage of the molding cycle.

Figure 4 also illustrates a further embodiment of the present invention, wherein sprue bushing 21 is separated from stationary heat plate 23 by space 99 to aid in preventing a temperature in the sprue member which would cure, or set up, the thermosetting molding material in sprue orifice 19. A further embodiment, illustrated in Figure 4, is that sprue bushing 21 may also be provided with a temperature-control means, provided by orifices, such as 101, adapted to hold and circulate a reservoir of liquid, suitably water, maintained at a temperature sufficient to maintain the molding material in a plasticized state and insufficient to cause substantial curing of the molding material.

Figure 5 illustrates a modification of the manifold arrangement shown in Figures 1 through 3. In Figure 5, the manifold member 103 is equipped with separate sprue bushings, such as 113 and 115 as outlet orifices to feed thermosetting molding material through a short runner channel, such as 117, into the mold cavities. As shown in Figure 5, the injection molding apparatus is in the fill or injection stage of the molding cycle. In this stage, thermosetting molding material enters sprue bushing 21 and into temperature-controlled manifold 103. For ease of fabrication and cleaning manifold member 103 preferably consists of separable parts 105 and 107. The thermosetting molding material entering manifold 103 is directed through distribution orifices, such as 109 and 111, and exits through temperature-controlled sprue bushings, such as 113 and 115. The thermosetting molding material then passes through short runner channels, such as 117 and 119, which, in turn, connect with the mold cavities, such as 121 and 123. The orifices in sprue bushings 113 and 115 taper to a slightly narrower opening at the point of contact with the runner channels, and the runner channels taper to a slightly narrower opening at the point of contact with the orifice in the sprue
bushings. As a further aid in maintaining the desired temperature in outlet sprue bushings, such as 113 and 115, especially during the injection and compression stages, the sprue bushings may be separated along at least a portion of the outer periphery of the bushings from direct physical contact with heated mold faces such as 42 and 44 and, if desired, from manifold 103 by spaces, such as 125.

In the mode shown in Figure 5, manifold member 103, which includes inlet sprue bushing 27 and outlet sprue bushings 113 and 115, is maintained at a temperature sufficiently high to maintain the thermosetting molding material in a plasticized condition but sufficiently low to avoid any substantial curing or setting of the material. Generally, temperatures in the range between about 77° and about 121°C, and, more preferably, between about 99° and about 116°C, are useful. Manifold member 103 may be maintained within the desired temperature range by the internal circulation of a temperature-controlled liquid, such as water, through the manifold member. The components of the stationary platen assembly in this mode are stationary support plate 27, manifold member 103, heat plate 127, heated retainer plate 129 and mold face 41. Preferably, manifold member 103 is separated from stationary support plate 27 by insulation layer, such as 29, and from heat plate 127 by insulation layer, such as 131. It will be understood that heat plate 127 and heated retainer plate 129 may be fabricated as a single component. Heater plate 127 and retainer plate 129 are positioned around the periphery of mold faces, such as 41, and supply sufficient heat to the mold face areas to cure the thermosetting molding material in the mold cavities during the compression step. The movable platen assembly consists of movable support plate 43, heat plate 45, if desired, a retainer plate, such as 133, and mold faces, such as 47. Preferably, support plate 43 is separated from heat plate 45 by blocks, such as 51, 53 and 55.

After the injection stage, as shown in Figure 5, the movable platen assembly is moved toward the stationary platen assembly applying sufficient heat and pressure to cure the thermosetting molding material within the mold cavities. The molding material within the runner channels, such as 117, is also cured, blocking further backflow through the system. After curing, the movable assembly is moved away from the stationary assembly to expose the mold faces. The thermosetting material cured in the runner channels separates from the uncured thermosetting material at or near the junction of the runner channels and the temperature-controlled sprue bushings and is removed with the molded article. The molded article, in turn, is removed from the movable assembly by means of knock-out pins, such as 71 and 73.

Although, for purposes of simplicity, the present invention has been described in terms of a horizontal clamping arrangement, it will be appreciated and understood that the invention is equally adapted to, and useful in, vertical clamping arrangements.

In the above-described drawings the visible edges and exposed surfaces behind the cutting plane have been omitted in the vicinity of the mold cavities to simplify the drawings and facilitate the understanding of the apparatus of the invention.

Claims

1. A method of injection-compression molding an article from thermosetting material comprising the steps of plasticizing a mass of thermosetting molding material, dividing a stream of said plasticized molding material into two or more smaller streams, injecting said smaller streams into two or more mold cavities comprised of partially open mold faces (41, 47) to substantially fill the space between said mold faces, said mold cavities being maintained at a temperature sufficient to cure said molding material, terminating said injection, completely closing said mold faces to cure the molding material in the internal configuration of said mold, and removing the cured, molded article from the mold, characterised in that said stream of plasticized molding material is passed through a temperature-controlled zone maintained at a temperature sufficiently low to prevent substantial curing of the molding material and sufficiently high to maintain the molding material in a plasticized condition, the division of said stream into two or more smaller streams taking place within said temperature controlled zone.

2. Apparatus for injection-compression molding of thermosetting material comprising: a stationary support plate (27) and a movable support plate (43), each support plate having a heat plate (45, 23, 39, 127) mounted thereon with means to heat said heat plate and a plurality of mold faces (41, 47, 42, 44) mounted to be heated by the heat plate (45, 39) to have a cooking temperature between 135°C and 218°C. Thus forming a stationary and a movable assembly, means to bring aligned mold faces on the different support plates into close proximity to form partially open mold cavities, means (51) for feeding a supply of plasticized thermosetting molding material through a stationary supply manifold (33, 83, 87, 97, 103) into said partially open mold cavities, means to interrupt the feed of thermosetting material, means (92, 117, 119) for closing said partially open mold cavities to cure any thermosetting molding material enclosed therein by pressure and heat, and means for retracting said movable assembly to open said mold cavities and remove said heat plate mounted on the movable support plate (43) and manifold from contact, characterized in that the said manifold is mounted on the heat plate (23)
Patentansprüche

1. Verfahren zum Spritz-Formpressen eines Gegenstandes aus einem wärmehältbaren Material, wobei eine Masse aus wärmehältbarem Formmaterial plastifiziert wird, ein Strom dieser plastifizierten Formmasse in zwei oder mehrere kleinere Ströme geteilt wird, diese kleineren Ströme in zwei oder mehr aus teilweise offenen Formflächen (41, 47) gebildete auf einer zur Hälfte der Formmasse ausreichenden Temperatur gehaltene Formhöhlungen eingespritzt werden, um den Raum zwischen diesen Formflächen auszufüllen, das Einspritzzen beendet wird, die Formflächen zur Aushärtung der Formmasse in der Innengestalt der Form vollständig geschlossen werden und der gehärtete, geformte Gegenstand aus der Form entfernt wird, dadurch gekennzeichnet, daß der Strom der plastifizierten Formmasse durch eine temperaturgesteuerte Zone geführt wird, die auf einer ausreichend niedrigen Temperatur, um ein tatsächliches Härten der Formmasse zu vermeiden, und auf einer ausreichend hohen Temperatur, um die Formmasse im plastifizierten Zustand zu belassen, gehalten wird, und daß die Teilung des Stroms in zwei oder mehrere kleinere Ströme innerhalb dieser temperaturgesteuerten Zone erfolgt.

2. Vorrichtung zum Spritz-Formpressen von wärmehältbarem Material mit einer ortsfesten Tragplatte (27) sowie einer bewegbaren Tragplatte (43), deren jede eine daran befestigte Heizplatte (45, 23, 39, 127) mit Mitteln zum Heizen der Heizplatte und eine Mehrzahl von Formflächen (41, 47, 42, 44) hat, die für eine Behizung durch die Heizplatte (45, 39) auf eine Kochtemperatur zwischen 135° und 216°C festgesetzt sind, und die eine ortsfeste und eine bewegliche Baugruppe bilden, mit einer der ausgerichteten Formflächen an den verschiedenen Tragplatten zur Bildung von teilweise offenen Formhöhlungen in enge Annäherung bringenden Einrichtung, mit einer Einrichtung zur Zufuhr eines Vorrats an plastifizierter wärmehältbarer Formmasse durch Druck und Hitze zu härten, schließenden Einrichtung (92, 117, 129) und mit einer die bewegbare Baugruppe zurückziehenden Einrichtung, um die Formhöhlungen zu öffnen und die an der bewegbaren Tragplatte (43) befestigte Heizplatte und den Verteiler außer Berührung zu bringen, dadurch gekennzeichnet, daß der Verteiler an der von der ortsfesten Tragplatte (27) getragenen Heizplatte (23) oder an der ortsfesten Tragplatte gehalten ist und daß der Verteiler eine Einlaßöffnung (35, 85), die innenseitig mit einer Mehrzahl von Auslaßöffnungen (59, 81) verbunden ist, besitzt und

carried by the stationary support plate (27) or on said stationary support plate, said manifold having an entry orifice (35, 85) connected internally with a plurality of outlet orifices (59, 81) and being provided with means (37, 93) to control the temperature in said manifold at a temperature between 77° and 121°C, said mold faces being provided adjacent the periphery of the manifold.

3. The apparatus of claim 2, characterized by means (37, 93) for circulating liquid in the manifold (33, 83, 87, 97, 103) to control the temperature thereof.

4. The apparatus of claim 2 or 3, characterized in that the means for feeding a supply of plasticized thermosetting molding material comprises a nozzle (17) in contact with a sprue bushing (21) provided with temperature control means (101).

5. The apparatus of claim 4, characterized in that the sprue bushing (21) extends through the heat plate (23) carried by said stationary support plate (27), said sprue bushing and said heat plate being spacedly positioned along at least a portion of the outer periphery of the sprue bushing within said heat plate.

6. The apparatus of claim 2, 3, 4 or 5, characterized in that the outlet orifices (59, 81) in said manifold (33, 83) are positioned on the contact face thereof, and the apparatus includes an independently movable runner plate (49) having a plurality of runner channels (61, 79) therein adapted to correspond to and be aligned with said outlet orifices, and means (67) to move said runner plate into contact with and away from said manifold.

7. The apparatus of claim 6, characterized in that a layer (63) of insulation is provided on the runner plate (49) between the runner plate and the manifold (33, 83).

8. The apparatus of any one of claims 2 to 5, characterized in that said manifold (87, 97) has outlet orifices (59, 81) along the periphery thereof, said orifices positioned to connect directly to said mold cavities.

9. The apparatus of claim 8, characterized in that a layer (31) of insulation is provided between the manifold (87, 97) and the heat plate (23) upon which it is mounted.

10. The apparatus of any one of claims 2 to 5, characterized in that the outlet orifices of said manifold (103) are temperature-controlled sprue bushings (113, 115).

11. The apparatus of claim 10, characterized in that said sprue bushings (113, 115) are spaced along at least a portion of their outer peripheries from contact with said mold faces (42, 44).

12. The apparatus of claim 10 or 11, characterized in that said sprue bushings (113, 115) contain orifices tapering to narrower outlet openings in contact with a runner channel (117, 119), said runner channel tapering to a narrower dimension at said point of contact.
mit Mitteln (37, 93) zur Steuerung der Temperatur in diesem Verteiler auf eine Temperatur zwischen 77° und 121°C versehen ist, wobei die Formflächen angrenzend an den Umfang des Verteilers vorgesehen sind.

3. Die Vorrichtung nach Anspruch 2, gekennzeichnet durch eine Einrichtung (37, 93) zum Umlauf einer Flüssigkeit in dem Verteiler (33, 83, 87, 97, 103) zu dessen Temperatursteuerung.

4. Die Vorrichtung nach Anspruch 2 oder 3, dadurch gekennzeichnet, daß die Einrichtung zur Zufuhr eines Vorratts an plastifizierter wärmehärbarer Formmasse eine Düse (17) umfaßt, die mit einer eine Temperatursteuer-einrichtung (101) aufweisenden Angelbüchse (21) in Berührung ist.

5. Die Vorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß sich dieAngelbüchse (21) durch die von der ortsfesten Tragplatte (27) getragene Heizplatte (23) erstreckt, wobei dieAngelbüchse und die Heizplatte entlang wenigstens eines Teils des Außenumfanges der Angelbüchse innerhalb der Heizplatte zueinander befestigt sind.

6. Die Vorrichtung nach Anspruch 2, 3, 4 oder 5, dadurch gekennzeichnet, daß die Auslaßöffnungen (59, 81) im Verteiler (33, 83) an dessen Berührungsfläche angeordnet sind und daß die Vorrichtung eine unabhängig bewegbare Gießplatte (49) mit einer Mehrzahl von darin gelegenen Gießkanälen (61, 79), die mit den Auslaßöffnungen zur Übereinstimmung und zum Fluchten zu bringen sind, und eine Einrichtung (57) zur Bewegung der Gießflächen in sowie außer Berührung mit dem Verteiler enthält.

7. Die Vorrichtung nach Anspruch 6, dadurch gekennzeichnet, daß eine Isolierrichtung (63) an der Gießflächen (49) zwischen dieser und dem Verteiler (33, 83) vorgesehen ist.

8. Die Vorrichtung nach einem der Ansprüche 2 bis 5, dadurch gekennzeichnet, daß der Verteiler (87, 97) längs seines Umfangs Auslaßöffnungen (59, 81) hat, die für eine unmittelbare Verbindung zu den Formhöhlungen angeordnet sind.

9. Die Vorrichtung nach Anspruch 8, dadurch gekennzeichnet, daß eine Isolierrichtung (31) zwischen dem Verteiler (87, 97) und der Heizplatte (23), an der er befestigt ist, vorgesehen ist.

10. Die Vorrichtung nach einem der Ansprüche 2 bis 5, dadurch gekennzeichnet, daß die Auslaßöffnungen des Verteilers (103) temperaturgesteuerte Angelbüchsen (113, 115) sind.

11. Die Vorrichtung nach Anspruch 10, dadurch gekennzeichnet, daß die Angelbüchsen (113, 115) längs wenigstens eines Teils ihrer Außenumfänge gegen eine Berührung mit den Formflächen (42, 44) befestigt sind.


Ravendications

1. Procédé destiné à mouler un article par injection-compression à partir d’une matière thermorécussable et comprenant les phases consistant à plastifier une masse de matière à mouler thermorécussable, à diviser un courant de cette matière à mouler plastifiée en deux ou plusieurs courants plus petits, à injecter les courants plus petits dans deux ou plusieurs empreintes de moule formées de parois de moule partiellement ouvertes (41, 47), afin de remplir sensiblement l’espace entre ces parois de moule, lesdites empreintes de moule étant maintenues à une température suffisamment élevée pour faire subir une cuisson à la matière à mouler, à mettre fin à l’injection, à fermer complètement les parois de moule afin de faire subir une cuisson à la matière à mouler de façon à lui conférer la configuration intérieure de l’empreinte de moule, et à faire sortir l’article moulé ayant subi une cuisson du moule, caractérisé en ce que le courant de matière à mouler plastifiée est dirigé à travers une zone dont la température est réglée et maintenue suffisamment basse pour empêcher une cuisson notable de la matière à mouler et suffisamment élevée pour maintenir la matière à mouler dans un état plastifié, la division dudit courant en deux ou plusieurs courants plus petits s’effectuant à l’intérieur de ladite zone à température réglée.

2. Appareillage destiné à mouler par injection-compression une matière thermorécussable et comprenant une plaque-support fixe (27) et une plaque-support mobile (43), chaque plaque-support ayant montées sur elle une plaque chauffante (23, 45, 39, 127) avec des moyens pour chauffer la plaque chauffante et un certain nombre de parois de moule (41, 47, 42, 44) placées de manière à être chauffées par la plaque chauffante (45, 39) de façon à présenter une température de cuisson comprise entre 135 et 216°C, formant ainsi un ensemble fixe et un ensemble mobile, des organes permettant aux parois de moule alignées montées sur les différentes plaques-supports d’être amenées très près les unes des autres de façon à former des empreintes de moule partiellement ouvertes, des moyens (15) pour amener une masse de matière à mouler thermorécussable plastifiée à travers un plateau distributeur fixe (33, 83, 87, 97, 103) dans les empreintes de moule partiellement ouvertes, des moyens pour interrompre l’aménée de matière thermorécussable, des moyens (92, 117, 119) pour fermer les empreintes de moule partiellement ouvertes afin de faire subir à toute matière à mouler thermorécussable enfermée dans ces dernières une cuisson sous l’effet de la
pression et de la chaleur, et des organes pour retirer l’ensemble mobile afin d’ouvrir les empreintes de moule et d’amener la plaque chauffante montée sur la plaque-support mobile (43) et le plateau distributeur hors de contact l’un avec l’autre, caractérisé en ce que le plateau distributeur est monté sur la plaque chauffante (23) portée par la plaque-support fixe (27) ou sur cette plaque-support fixe, ledit plateau distributeur présentant un orifice d’entrée (35, 85) communiquant intérieurement avec un certain nombre d’orifices de sortie (59, 81) et étant muni de moyens (37, 93) pour régler la température dans le plateau distributeur à une valeur comprise entre 77 et 121°C, lesdites parois de moule étant situées au voisinage de la périphérie du plateau distributeur.

3. Appareil selon la revendication 2, caractérisé par des moyens (37, 93) pour faire circuler un liquide dans le plateau distributeur (33, 83, 87, 97, 103) afin de régler la température de celui-ci.

4. Appareil selon la revendication 2 ou 3, caractérisé en ce que les moyens pour amener une masse de matière à mouler thermorécupérable plastifiée comprend une buse (17) se trouvant en contact avec une douille de carotte (21) munie de moyens de réglage de température (101).

5. Appareil selon la revendication 4, caractérisé en ce que la douille de carotte (21) s’étend à travers la plaque chauffante (23) portée par la plaque-support fixe (27), la douille de carotte et ladite plaque chauffante étant, le long d’au moins une partie de la périphérie extérieure de la douille de carotte, espacées à l’intérieur de la plaque chauffante.

6. Appareil selon l’une quelconque des revendications 2 à 5, caractérisé en ce que les orifices de sortie (59, 81) du plateau distributeur (33, 83) sont disposés au niveau de la face de contact de ce dernier et en ce que l’appareil comprend une plaque à canaux secondaires (49) déplaçable indépendamment et dans laquelle sont ménagées un certain nombre de canaux secondaires (61, 79) destinés à correspondre aux orifices de sortie et à venir en coinçence avec ceux-ci, et un organe (57) pour amener la plaque à canaux secondaires en contact et hors de contact avec la plaque chauffante.

7. Appareil selon la revendication 6, caractérisé en ce qu’une couche d’isolation (63) est prévue sur la plaque chauffante au niveau de canaux (49) entre cette plaque et le plateau distributeur (33, 83).

8. Appareil selon l’une quelconque des revendications 2 à 5, caractérisé en ce que le plateau distributeur (87, 97) présente des orifices de sortie (59, 81) le long de sa périphérie, ces orifices étant disposés de façon à communiquer directement avec les empreintes de moule.

9. Appareil selon la revendication 8, caractérisé en ce qu’une couche d’isolation (31) est prévue entre le plateau distributeur (87, 97) et la plaque chauffante (23) sur laquelle celui-ci est monté.

10. Appareil selon l’une quelconque des revendications 2 à 5, caractérisé en ce que les passages de sortie du plateau distributeur (103) sont des douilles de carotte (113, 115) dont la température est réglée.

11. Appareil selon la revendication 10, caractérisé en ce que les douilles de carotte (113, 115) sont, au moins le long d’une partie de leur périphérie extérieure, séparées des parois de moule (42, 44) par un intervalle.

12. Appareil selon la revendication 10 ou 11, caractérisé en ce que les douilles de carotte (113, 115) contiennent des passages qui violent leur section diminuer de façon à former une ouverture de sortie plus étroite dans la zone de contact avec un canal secondaire (117, 119), lequel canal secondaire voit sa section diminuer jusqu’à une dimension plus faible dans ladite zone de contact.