

PATENT SPECIFICATION

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(54) METHOD AND APPARATUS FOR MOLDING EXPANDED PLASTICS MATERIAL ARTICLES

(71) We, SELENE TRUST, a Body Corporate organized under the Laws of the Principality of Liechtenstein, of Postfach 34613, Vaduz 9490, Principality of Liechtenstein, 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:—

10 The present invention relates to a molding method and apparatus for molding articles of expanded plastics material.

Molding methods for articles of expanded thermoplastic material have been known heretofore and especially methods for manufacturing articles obtained by agglomerating pre-expanded polystyrene beads.

Presently these methods are commonly used for manufacturing blocks, supports or shells for packaging food products, machinery or household electrical appliances etc . . . They have excellent impact resistance, they are weather resistant and their cost is relatively low.

25 Usually, the known molding techniques include the following steps:

—filling a molding cavity of a mold with pre-expanded polystyrene beads

30 —injecting steam for heating said beads to the softening temperature of the polymer and above the boiling point of the pore producing fluid which is contained in said beads. Said steam causes the beads to expand and bring them to a partially molded state causing them to agglomerate into a homogeneous cellular mass.

40 —cooling the product obtained in a cellular state contained in the mold in order to prevent a second expansion or a distortion of the molded article; and, once the mold is cooled

—withdrawing the molded article from the mold, after which the mold can be heated again for the next molding cycle;

45 This method involves the use of a large

capacity heating system and means for rapidly cooling the mold in order that the two alternate steps, i.e. heating the mold and cooling thereof, do not increase excessively the manufacturing of the articles. 50

However, since the article is made from an excellent heat insulating material, this method results in a very limited production rate, and reduces drastically the efficiency and the profitability of the molding equipment. 55

Another disadvantage which affects this method is the consumption of energy. For example, for a medium size article when heating 0.150 kg of thermoplastic material contained in the mold it is also necessary to heat, at each molding cycle, the 150 kg of the mold material itself. It can be realized that this mass ratio of about 1 to 1000, brings in a considerable loss of energy which heavily affects the cost of the finished product. 65

In order to reduce the manufacturing cost it has been proposed to provide molds with multiple molding cavities. This approach is valid for small size articles only and on the other hand the design and the manufacturing of the molds which have to be machined accurately, from a good heat conducting material, such as aluminum, are very expensive. 75

Also the expenses for unavoidable servicing and maintenance of so complex an equipment have to be taken into consideration. In order to carry out successive cooling operations, the mold is provided with internal passages which allow the cooling water to circulate. If this water is not treated, calcium deposits will block the injection nozzles and attack the walls of the mold or of its auxiliary equipment. Further, for economical reasons, the factories that are using the known method, use cooling systems which operate in close circuit and consequently include storage containers, 90

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tanks for water treatment, water cooling towers and pumping stations which considerably affect the production cost of the molded articles of expanded polystyrene produced by mass production.

It is therefore an object of the present invention to provide a method and apparatus overcoming the above mentioned disadvantages.

10 The method of this invention includes the following steps:

—injecting a predetermined amount of partially pre-expanded beads of thermoplastic material into a mold, at least a portion of which is maintained at a temperature between 90°C and 130°C;

15 — heating said pre-expanded beads in said mold to a temperature effective to cause them to expand, partially melt and agglomerate together;

20 — withdrawing the preformed article from said mold, said article being still at a temperature above its temperature softening state, while the article is allowed to further expand;

— inserting the preformed article into a mold at least a portion of which is at a temperature lower than 90°C; and,

25 — withdrawing the article from the last said mold and cooling it to the ambient temperature.

In a first form, the apparatus of the invention includes a first mold comprising a molding cavity having at least approximately the shape and size of the article to be produced; means for maintaining this mold at a constant temperature between 90°C and 130°C, and preferably about 120°C; an injection device for introducing particles of thermoplastic material into the molding cavity; one or more injection nozzles for injecting steam into the molding cavity; a mechanical or pneumatic device for removing the preformed article from the heated mold; means for transferring and introducing said article into a cooled second mold comprising a molding cavity having the exact shape and size of the article to be produced, this mold being maintained at a temperature lower than that of the first heated mold; and mechanical or pneumatic means for removing the article from said cooled mold.

35 In a second form the apparatus of the invention includes a single mold comprising a molding cavity having the exact configuration and size of the article to be produced; means for heating said mold to a temperature between 90°C and 130°C; injection means for introducing particles of thermoplastic material into the molding cavity of said mold; one or more injection nozzles for injecting steam into the molding cavity of said mold; means for withdrawing the preformed article from said heated

mold; means for cooling a portion of said mold adjacent to the surface of its molding cavity, means for reinserting the preformed article into the mold partially cooled and, means for removing the article from said mold.

The material used for this mold is preferably low heat conductive material so that instantaneous cooling of the surface of the molding cavity does not cool the whole mold and consequently does not constitute an important loss of energy.

The method of the invention has many advantages over the prior art since it enables the production time to be reduced, the production cost, and considerably simplify the installation lay-out to increase its efficiency and profitability; in addition, with the method of the present invention, lower density materials can be obtained hence permitting material savings.

According to a preferred embodiment of the present invention, the article formed or premolded inside the heated mold is withdrawn as soon as the first molding step is completed for being transferred in the cold mold. From this very moment, a new article can be injected in the heated mold thus permitting to reduce considerably the total molding cycle time, this time being reduced to about 10 seconds/article, for medium sized items.

When using a heated mold and a cooled mold, the molds are no longer subject to stresses due to repeated and substantial temperature variations, and can be constructed from any material including metals, synthetic materials or even wood. The construction of the mold is only limited by well known design and techniques of the injection or compression molds. The mold design is simplified in that the passages for circulating cooling water into the mold which are necessary with the conventional methods and apparatuses are eliminated in the apparatus of the invention or are at least of a much simplified structure.

The invention will now be further described by way of example, with reference to the accompanying drawings in which:

Figure 1 is a schematic view of an embodiment of the apparatus of the invention,

Figures 2 and 3 show details of the transfer mechanism of the apparatus of figure 1,

Figure 4 is a sectional view of an embodiment of the heated mold shown in its closed position,

Figure 5 is a sectional view of an embodiment of the cold mold shown in its open position,

Figure 6 is a sectional view of a second embodiment of the heated mold of the invention, shown in closed position, during

molding operation.

Figure 7 is a sectional view of the molded article during its transfer from the heated mold to the cold mold, and,

- 5 Figure 8 is a sectional view of the second embodiment of the cold mold of the invention shown in closed position during the final molding operation.

Referring now to figure 1, the apparatus of the invention for manufacturing expanded thermoplastic material articles includes a frame 1, made from tubes or steel sections supporting a container 2 to store the raw material in the form of expanded polystyrene beads 3, a container 4 for collecting the articles produced, and various units for the transformation of the raw material and for the control of the apparatus.

- 20 These various units comprise essentially the male portion 5 and the female portion (not shown) of a heated mold, the male portion 6 and female portion 7 of the cold mold (described in detail with reference to figures 4 and 5) and one member 8 to transfer the article from the heated mold into the cold mold. The polystyrene beads 3 are supplied to the heated mold from the container 2. The male portion 5 of the heated mold is mounted at the lower end of the member 8 which is positioned so that it can slide on a shaft 9 under the action of a piston 10 received in a housing 11 of prismatic configuration. In addition, the member 8 can pivot in its plane like a pendulum about said shaft 9 between a first position into which the male portion 5 of the heated mold is placed in front of its corresponding female portion and a second position wherein the portion 5 is in front of the portion 7 of the cold mold to effect the transfer of the article and introduce it into mold portion 7. This swinging motion is obtained through a mechanism 12 which is shown in more details in figures 2 and 3.

- 45 The male portion 6 of the cold mold is mounted on the free end of a piston rod 13 which is slidably received into a cylinder 14 to reciprocate horizontally. Also supported by the frame 1 is a control panel 15 for the control of various elements of the apparatus.

- The transfer mechanism will be now described with reference to figures 2 and 3. 55 The mechanism 12 substantially comprises two slides 16, 17 and a plate 18 which can slide vertically in slides 16 and 17 under the action of a piston 19 slidably received into a cylinder 20 and connected to the plate 18 by a rod 21. A curvilinear opening 22 is formed in the plate 18 into which is engaged the end of a pin 23 connected to the housing 11. Once the piston 19 is moved downwards (as shown on figure 3) by a 65 fluid under pressure fed to the cylinder

20, the end of pin 23 is guided in the curvilinear opening acting as a cam and driving the housing 11 together with the pin to a position 11' shown in dotted lines. The housing 11 rigidly fixed to the member 8, 70 the pendulum or swinging motion of the latter is derived from the mechanism 12. The position 11' (as shown in figure 3) of the housing 11 corresponds to the new position 18' of the plate 18 and 23' of the 75 pin end 23.

Figure 4 shows schematically an embodiment of the heated mold which comprises a male portion 41 and a female portion 42 into which is formed a molding cavity 43 80 to be filled with thermoplastic material. An inlet passage 44 for steam in the male portion 41 is connected to internal passages 45 which themselves terminate into nozzles 46. The purpose of these nozzles 85 is to inject steam into the molding cavity 43 to expand the thermoplastic beads therein. The female portion 42 is also provided with a tapered injection inlet passage 47 for the thermoplastic material and with 90 steam exhaust nozzles 48 for the excess steam. The nozzles 48 are in communication with the outlet steam ports 49, and with a condensed water exhaust port 50.

Figure 5 shows schematically an embodiment of a cold mold including a male portion 51 and a female portion 52 of this mold. Both members are constructed so that the molding cavity has exactly the configuration and size of the article 53 to 100 be produced. The mold portion 52 is equipped with pushing means adapted to eject the finished article out of the cold mold. This means comprises a plate 54 which can be mechanically moved by a 105 rod 55 or pneumatically pushed by a device connected to the port 56.

In operation of the device described above, the male portion 5 of the heated mold is urged against the female portion 110 of said heated mold by means of a piston 10, thus providing a molding cavity having approximately the configuration of the article to be produced. This mold is heated by well-known means not represented. 115 Once the heated mold is ready for the injection process the pre-expanded polystyrene beads 3 contained in the storing container are introduced into the molding cavity through an injector. The expansion 120 and agglomeration of the thermoplastic material beads are obtained by means of steam injected into the heated mold through the injection nozzles 46. As soon as the expansion of the material is completed, the 125 male portion 5, (41) of the heated mold integral with the member 8 is moved to the left (as shown on figure 1) by means of the piston 10; the article formed in the molding cavity remains on this male por- 130

tion of the heated mold and can freely further expand thus providing stress relief.

Thereafter, the piston 19 is moved downwards (as seen on figure 3) inside the cylinder 20 moving together with the plate 18 thus moving the end of pin 23 from its initial position shown in figure 2 to its final position 23' shown in dotted lines in figure 3. The motion of pin 23 pivotably moves simultaneously the housing 11 and the member 8 about shaft 9. In the final position of the member 8, the male portion 5, (41) of the heated mold is aligned with the female portion 7, (52) of the cold mold into which the now completely relaxed molded article will be partially engaged when the member 8 is moved to the right by the piston 10. At that time the piston 19 is moved again upwards causing simultaneously the housing 11 and the element 8 to swing back to their initial positions. For completely inserting the pre-formed article into the cold mold, a fluid under pressure is injected into the cylinder 14 in order to move the piston 13 to the right (as seen on figure 1). The male portion 6, (51) which is rigidly fixed to the free end of the piston rod 13 will forcibly engage the preformed article 53 into the molding cavity of the cold mold which has exactly the configuration and size of the article which is sought to be obtained. Thereafter the piston 13 will move to the left (as seen on figure 1) and the article 53 formed exactly to the size and configuration of the cold mold will be ejected by means of a mechanical action on said push rod 55 or by the pneumatic means to finally be collected in the collecting container 4.

Another embodiment of the apparatus of the present invention will now be described with reference to figures 6, 7 and 8. Specifically, in figure 6 is shown the first step of the process for the premolding injection step in the heated mold. The reference numeral 61 shows the female part of the heated mold for preforming the article, reference 62 shows the male portion of the mold, Reference 63 shows the molding cavity, reference 64 shows the injection device through which the pre-expanded material beads are forced into the molding cavity reference 65 shows the injector body, reference 66 shows heating bands and references 67 and 68 are inlet and exhaust passages for steam.

Figure 7 is a sectional view of the molded article at the time of its transfer from the first heated mold to the second and final cold mold.

Figure 8 shows the second and final molding step in the cold mold. In this figure reference 69 shows the female portion of the cold mold, reference 70 shows the male

portion of same, references 71 and 72 show passages for circulation of cooling water, reference 73 shows the molding cavity and reference 74 shows the ejector for the finished article.

While the present invention has been described with reference to two preferred embodiments, many alternatives changes and modifications will appear to those skilled in the art such as particularly:

— as the transfer time of the pre-formed article from the heated mold to the cold mold is not critical per se, it is possible to design a machine having two stations, one station for hot moulding positioned at some distance from a second station for cold molding, both stations being connected by transfer means, for example a conveyor belt.

— the preformed articles can be molded under vacuum in the cold mold. This technique makes it possible to considerably increase the relative pressure inside the expanded thermoplastic material beads which permits easier production of low density articles.

— both molds can be on the same molding press or on separate presses,

— one first preforming heated mold can be provided for serving several second cooled molds or vice-versa

— the transfer device between molds can be mechanical, pneumatic or of another type

— heat transfer from the heating mold to the thermoplastic material can be made by any known means such as electrical resistors, steam, or heated oil.

Further to the multiple advantages already mentioned, the method of the invention enables articles to be obtained having a higher density which are more resilient than similar articles molded with the standard method. These articles are more flexible and less brittle, which gives them an improved ability for acting as shock or impact absorbing pads, especially when they are used for packaging.

WHAT WE CLAIM IS:

1. A method for molding articles of expanded plastics material including the steps of:

a) injecting a predetermined amount of partially pre-expanded beads of thermoplastic material into a mold, at least a portion of which is maintained at a temperature between 90°C and 130°C;

b) heating said pre-expanded beads in said mold to a temperature effective to cause said beads to expand, partially melt and agglomerate together;

c) withdrawing the preformed article from said mold, said article being still at a temperature above its temperature softening state, while the article is allowed to

tion of the heated mold and can freely further expand thus providing stress relief.

Thereafter, the piston 19 is moved downwards (as seen on figure 3) inside the cylinder 20 moving together with the plate 18 thus moving the end of pin 23 from its initial position shown in figure 2 to its final position 23' shown in dotted lines in figure 3. The motion of pin 23 pivotably moves simultaneously the housing 11 and the member 8 about shaft 9. In the final position of the member 8, the male portion 5, (41) of the heated mold is aligned with the female portion 7, (52) of the cold mold into which the now completely relaxed molded article will be partially engaged when the member 8 is moved to the right by the piston 10. At that time the piston 19 is moved again upwards causing simultaneously the housing 11 and the element 8 to swing back to their initial positions. For completely inserting the preformed article into the cold mold, a fluid under pressure is injected into the cylinder 14 in order to move the piston 13 to the right (as seen on figure 1). The male portion 6, (51) which is rigidly fixed to the free end of the piston rod 13 will forcibly engage the preformed article 53 into the molding cavity of the cold mold which has exactly the configuration and size of the article which is sought to be obtained. Thereafter the piston 13 will move to the left (as seen on figure 1) and the article 53 formed exactly to the size and configuration of the cold mold will be ejected by means of a mechanical action on said push rod 55 or by the pneumatic means to finally be collected in the collecting container 4.

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WHAT WE CLAIM IS:

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a) injecting a predetermined amount of partially pre-expanded beads of thermoplastic material into a mold, at least a portion of which is maintained at a temperature between 90°C and 130°C;

b) heating said pre-expanded beads in said mold to a temperature effective to cause said beads to expand, partially melt and agglomerate together;

c) withdrawing the preformed article from said mold, said article being still at a temperature above its temperature softening state, while the article is allowed to



further expand;

d) inserting the preformed article in a mold at least a portion of which is at a temperature lower than 90°C; and,

5 e) withdrawing the article from said last mold and cooling it to the ambient temperature.

2. A method according to Claim 1, wherein two molds are used, a first of
10 said molds having at least a portion maintained at a temperature between 90 and 130°C and comprising a molding cavity having at least the approximate configuration and size of the article to be produced
15 and the second of said molds being at a temperature lower than 90°C and having the exact configuration and size of the article to be produced.

3. A method according to Claim 2,
20 wherein said first mold is maintained at a temperature of 120°C.

4. A method according to Claim 2 or Claim 3 wherein the molding cavity of said second mold is maintained under partial
25 vacuum during at least part of the time of the final forming step.

5. A method according to Claim 1, wherein a single mold is used, said mold being temporarily cooled in a portion adjacent to the inner surface of its mold cavity
30 during a period of time corresponding at least partly to steps c and d of the method of claim 1.

6. A method according to any one of
35 Claims 1 to 5 wherein the article preformed within the mold at least a portion of which is maintained at a temperature between 90°C and 130°C is transferred to the mold at a temperature lower than 90°C by means
40 of a part of one of said molds.

7. An apparatus for molding articles made from expanded plastics material including: a first mold, comprising a molding cavity having approximately the configuration
45 tion and size of the article to be produced;

means for maintaining said mold at a constant temperature between 90°C and 130°C; injection means for introducing particles of thermoplastic material into the molding cavity; one or more injection nozzles for injecting steam into the molding cavity; a
55 means for removing the preformed article from the heated mold; means for transferring and introducing said preformed article into a cooled second mold comprising a molding cavity having the exact configuration
60 tion and size of the article to be produced and which is maintained at a temperature lower than that of said heated mold; and, means for removing the final article from said cooled mold. 65

8. An apparatus according to claim 7 wherein said heated mold is maintained at a temperature of 120°C.

9. An apparatus for molding articles made from expanded plastics material including a single mold comprising a molding cavity having the exact configuration and size of the article to be produced; means for heating said mold to a temperature between 90°C and 130°C; injection
75 means for introducing particles of thermoplastic material into the molding cavity of said mold; one or more injection nozzles for injecting steam into the molding cavity of said mold; means for withdrawing the
80 preformed article from said heated mold; means for cooling a portion of said mold adjacent to the surface of its molding cavity, means for reinserting the preformed article into the mold partially cooled and, means
85 for removing the article from said mold.

10. An apparatus according to claim 9 characterized in that the mold is made from a low heat conductive material.

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