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DESCRIPTION

METAL MOLD DEVICE FOR FORMING AN OPTICAL DISC

BACKGROUND OF THE INVENTION



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1. Field of the Invention

The present invention relates to a metal mold device for forming an optical disc such as a compact disc (CD) or digital video disc (DVD).

2. Description of the Related Art

The substrates of optical discs are typically injection molded from a resin. During this molding, a fixed mold and a movable mold respectively attached to a fixed plate and movable plate of an injection molding machine are closed, a product cavity is formed between the fixed mold and the movable mold, and molding material in the form of a molten thermoplastic resin injected from the nozzle of the injection molding machine is filled into the product cavity, and after the resin, namely an optical disc, has solidified inside the product cavity within the metal mold that has been adjusted to a prescribed low temperature, the fixed mold and movable mold are opened and the formed optical disc is removed. In addition, a temperature adjusting passage for allowing the passage of coolant is provided in the metal mold to adjust the temperature of the product cavity within the metal mold to the prescribed low temperature.

However, although high dimensional accuracy is required in the forming of optical discs, as mentioned above, during this forming, since a molten resin is filled at high speed by injecting into a product cavity and then cooled and solidified by a metal mold that has been adjusted to a prescribed low temperature by a coolant, there is the possibility of it becoming no longer possible to accurately maintain thickness due to contraction of the resin during cooling and so forth. This is because, in the case of conventional metal mold devices, since the distances of the temperature adjusting passage and surface of the product cavity are all formed to be identical, there is the possibility of inadequate temperature control on the surface of the product cavity, resulting in the temperature distribution on the surface of the product cavity becoming

non-uniform. In such metal mold devices, since cooling capacity per unit surface area of the product cavity becomes higher than average at, for example, those locations where the temperature adjusting passage is dense, it is necessary to lower the cooling capacity per unit surface area of the product cavity. On the other hand, since the cooling capacity per unit surface area of the product cavity becomes lower than average at, for example, those locations where the temperature adjusting passage is sparse, it is necessary to increase the cooling capacity per unit surface area of the product cavity. There is therefore a need to improve temperature adjustment at those locations where the metal mold temperature is non-uniform in this manner.

In order to solve the above problems, an object of the present invention is to provide a metal mold device for forming an optical disc capable of optimizing the metal mold temperature around the product cavity, thereby making it possible to improve the dimensional accuracy of optical discs.

SUMMARY OF THE INVENTION

The present invention is a metal mold device for forming an optical disc having a mold body provided with a fixed mold and a movable mold provided in opposition to the fixed mold, and together with a product cavity being formed between the fixed mold and movable mold, a temperature adjusting passage is provided in the mold body through which a coolant passes; wherein, the distance from the surface of the product cavity to the temperature adjusting passage is lengthened at those locations where the cooling capacity per unit surface area of the product cavity is lowered by the temperature adjusting passage, and the distance from the surface of the product cavity to the temperature adjusting passage is shortened at those locations where the cooling capacity per unit surface area of the product cavity is increased by the temperature adjusting passage.

According to this constitution, the dimensional accuracy of an optical disc can be improved by adjusting the cooling capacity at those locations where the cooling capacity per unit surface area of the product cavity is raised or lowered by the temperature adjusting passage to optimize the temperature distribution of the product

cavity.

Here, the temperature adjusting passage is preferably formed in the shape of a groove, and the above distance is the distance between the bottom of the groove-shaped temperature adjusting passage and the surface of the product cavity.

According to this constitution, the metal mold is cooled by allowing coolant to flow through the groove-shaped temperature adjusting passage. In addition, since the temperature adjusting passage is in the shape of a groove, the above distance can be set both easily and accurately.

In addition, together with a plurality of temperature adjusting passages being formed so as to be concentric with the product cavity, the above distance is more preferably increased in a communicating passage portion that connects a temperature adjusting passage portion located on the inside with a temperature adjusting passage portion located on the outside.

According to this constitution, the distance from the surface of the product cavity to the temperature adjusting passage is increased in a communicating passage portion where the cooling capacity per unit surface area is to be lowered. As a result, problems resulting from excessive cooling in the communication passage portion can be solved.

In addition, the above distance is even more preferably shortened at the outer peripheral side of the product cavity.

According to this constitution, the distance from the surface of the product cavity to a temperature adjusting passage is shortened at the outer peripheral side of the product cavity where the amount of radiated heat is large. As a result, the temperature distribution in the product cavity where the amount of radiated heat is large can be set uniformly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a metal mold device for forming an optical disc showing a first embodiment of the present invention.

FIG. 2 is an overhead view of the essential portion of the metal mold device for

forming an optical disc shown in FIG. 1.

FIG. 3 is a cross-sectional view of the deployed state of a temperature adjusting passage portion of the metal mold device for forming an optical disc shown in FIG. 1.

FIG. 4 is a cross-sectional view of a metal mold device for forming an optical disc showing a second embodiment of the present invention.

FIG. 5 is an overhead view of the essential portion of the metal mold device for forming an optical disc shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following provides an explanation of embodiments of the present invention with reference to the attached drawings. FIGS. 1 through 3 show a first embodiment of the present invention. In FIG. 1, reference symbol 1 indicates a fixed mold, reference symbol 2 indicates a movable mold, and this fixed mold 1 and movable mold 2 that constitute a mold body open and close by mutually moving in the vertical direction as shown in the drawings (direction of opening and closing), and when the mold body is closed, two product cavities 3 that form an optical disc are formed between them.

Fixed mold 1 is provided with a base in the form of a fixed side template 4, and a fixed side support plate 5 that acts as a base fixed on the opposite side (upper side in the drawings) of movable plate 2 in this fixed side template 4. In addition, a cold sprue bushing 6 corresponding to each product cavity 3 is fixed on the above fixed side support plate 5. A head portion 7 of this cold sprue bushing 6 fits into an indented portion 8 formed in fixed side support plate 5, and has a cylindrical ejecting portion 9 on the side of fixed side template 4. This ejecting portion 9 further passes through fixed side template 4 from fixed side support plate 5. In addition, a raw material supply nozzle 10 is provided on head portion 7 of cold sprue bushing 6. Moreover, a material passage in the form of a cold sprue 12 is formed inside cold sprue bushing 6 that extends from the bottom surface to which raw material supply nozzle 10 of head portion 7 is connected to the end surface of ejecting portion 9. This cold sprue 12 has a tapered shape in which the diameter increases moving towards the side of product

cavity 3, and is connected to product cavity 3. Reference symbol 13 indicates an indented portion in which raw material supply nozzle 10 is inserted.

Fixed side template 4 is composed of a positioning frame 14 which is fixed to the surface of fixed side support plate 5 on the side of movable mold 2, and a cavity block 15 that fits inside this positioning frame 14 and acts as a cavity forming member. Cavity block 15 forms product cavity 3, and a ring-shaped outer stamper clamp 16 is removably attached to the outer peripheral portion of cavity block 15. Furthermore, a cylindrical inner stamper clamp 17 is removably attached to the inner peripheral portion of cavity block 15. These stamper clamps 16 and 17 are for removably holding stampers that form the grooved portion and land portion of an optical disc in cavity block 15. In addition, an intermediate cylinder 18 is fit into inner stamper clamp 17 that passes through cavity block 15, and the above ejecting portion 9 of cold sprue bushing 6 fits into this intermediate cylinder 18. In addition, inner stamper clamp 17 and intermediate cylinder 18 form a portion of product cavity 3. Moreover, a temperature adjusting passage 19 through which water or other coolant (temperature adjusting liquid) flows is formed in cavity block 15.

Movable mold 2 is provided with a movable side bottom plate 20, which is attached to the movable side platen of an injection molding machine, a movable side support plate 21, which is fixed to the surface of this movable side bottom plate 20 on the side of fixed mold 1, and a movable side template 22, which is fixed to the surface of this movable side support plate 21 on the side of fixed mold 1. This movable side template 22 is composed of a positioning frame 23 which is fixed to the surface of movable side support plate 21 on the side of fixed mold 1, and a core block 24 which fits inside positioning frame 23 and acts as a cavity forming member. Core block 24 respectively forms the above product cavities 3, and positioning frame 23 taper-fits into positioning frame 14 of fixed mold 1. In addition, a temperature adjusting passage 25 through which the above coolant flows is formed in core block 24.

A contact ring 26 fits onto the outer peripheral portion of this core block 24. This contact ring 26 contacts outer stamper clamp 16 on the side of fixed mold 1 when the mold body is closed or forms the outer peripheral surface of product cavity 3.

In addition, a cylindrical air blow-off pin 27 is fixed in the inner peripheral portion of core block 24 in a state in which it passes through it, and a cylindrical ejector sleeve 28 is fit inside air blow-off pin 27 while allowing to slide freely only over a prescribed range along the direction of opening and closing of the mold body. A cylindrical gate cutting sleeve 29 is fit inside ejector sleeve 28 while allowing to slide freely only over a prescribed range along the direction of opening and closing of the mold body, and an ejector pin 30 is fit into gate cutting sleeve 29 while allowing to slide freely only over a prescribed range along the direction of opening and closing of the mold body. In addition, ejector sleeve 28 and gate cutting sleeve 29 respectively apply force to the opposite side of fixed mold 1.

A receiving portion 31 that passes through movable side bottom plate 20 is provided protruding from gate cutting sleeve 29. Gate cutting sleeve 29 moves to the side of fixed mold 1 as a result of this receiver portion 31 being pushed by a pushing rod (not shown) provided on the injection molding machine. In addition, ejector pin 30 is fixed on an ejector plate 32 which is provided in movable side bottom plate 20. Ejector pin 30 moves to the side of fixed mold 1 as a result of this ejector plate 32 being pushed by other pushing rod (not shown) provided on the injection molding machine. Moreover, ejector sleeve 28 moves to the side of fixed mold 1 as a result of a linking pin (not shown) fixed to ejector plate 32 pushing ejector sleeve 28.

Gate cutting sleeve 29 is then removably fit into intermediate cylinder 18 of fixed mold 1 to form an opening hole located in the center of the optical disc. Thus, ejector sleeve 28 and air blow-off pin 27 located on the outer peripheral side of gate cutting sleeve 29 form a portion of product cavity 3. In addition, a gate 34 that connects cold sprue 12 on the side of fixed mold 1 to product cavity 3 is formed between the outer peripheral portion of the end surface of ejecting portion 9 provided on cold sprue bushing 6 on the side of fixed mold 1 and the outer peripheral portion of the end surface of gate cutting sprue 29 of the side of movable mold 2.

First through third temperature adjusting passage portions 19A, 19B and 19C are concentrically provided in temperature adjusting passage 19 having a roughly C-shaped flat surface centered about central axis X of product cavity 3 and a diameter that

gradually becomes larger. A supply inlet 36 for a temperature adjusting fluid in the form of coolant W is provided on the starting end of first temperature adjusting passage portion 19A via a temperature adjusting fluid supply passage (not shown), while a first communicating passage portion 19D is provided on the terminal end that communicates with the starting end of second temperature adjusting passage portion 19B located to the outside towards the opposite side of central axis X. Moreover, a second communicating passage portion 19E is provided on the terminal end of second temperature adjusting passage portion 19B that communicates with the starting end of third temperature adjusting passage portion 19C located to the outside towards the opposite side of central axis X, while a discharge outlet 37 of coolant W is provided on the terminal end of third temperature adjusting passage portion 19C. In addition, discharge outlet 37 is connected to a temperature adjusting fluid discharge passage (not shown). These first through third temperature adjusting passage portions 19A, 19B and 19C along with first and second communicating passage portions 19D and 19E are formed into the shape of grooves by a ball end or other cutting apparatus 35 from the surface opposite product cavity 3.

In first through third temperature adjusting passage portions 19A, 19B and 19C, where the cooling capacity per unit surface area of product cavity 3 in cavity block 15 is average, distance A, which is the depth from surface 3A of product cavity 3 to the bottom surfaces of these temperature adjusting passage portions 19A, 19B and 19C, is the same for each of these temperature adjusting passage portions. On the other hand, in first communicating passage portion 19D, where it is necessary to lower the cooling capacity per unit surface area of product cavity 3 by temperature adjusting passage 19, distance B from surface 3A of product cavity 3 to the bottom surface of first communicating passage portion 19D is made to be longer than the above distance A. Furthermore, distance B is also made to be longer than distance A at those sites of first temperature adjusting passage portion 19A that are located close to first communicating passage portion 19D. Similarly, distance B from surface 3A of product cavity 3 to the bottom surface of second communicating passage portion 19E, where it is also necessary to lower the cooling capacity per unit surface area of product cavity 3 by

temperature adjusting passage 19, is also made to be longer than the above distance A, and distance B is also made to be longer than distance A at those sites of second temperature adjusting passage portion 19B that are located close to second communicating passage portion 19E. Adjustment of distances A and B is carried out during machining by cutting apparatus 35. Namely, temperature adjusting passage 19 corresponding to distance B covers the range indicated with arrows L and L' in FIGS. 2 and 3.

Similarly, in core block 24 as well, first through third temperature adjusting passage portions 25A, 25B and 25C are concentrically formed in temperature adjusting passage 25 from the inside towards the outside centered about central axis X of product cavity 3 and having a roughly C-shaped flat surface. A supply inlet 38 for coolant W is provided on the starting end of first temperature adjusting passage portion 25A, while a first communicating passage portion 25D is provided on the terminal end that communicates with the starting end of second temperature adjusting passage portion 25B towards the opposite side of central axis X. Moreover, a second communicating passage portion 25E is provided on the terminal end of second temperature adjusting passage portion 25B that communicates with the starting end of third temperature adjusting passage portion 25C towards the opposite side of central axis X, and a discharge outlet 39 of coolant W is provided on the terminal end of third temperature adjusting passage portion 25C. In addition, distance A', which is the respective depth from surface 3B of product cavity 3 in core block 24 to the bottom surfaces of first through third temperature adjusting passage portions 25A, 25B and 25C, is the same for all temperature adjusting passage portions. On the other hand, distance B' from surface 3B of product cavity 3 to the bottom surface of first communicating passage portion 25D is made to be longer than the above distance A'. Furthermore, distance B' is also made to be longer than distance A' at those sites of first temperature adjusting passage portion 25A located close to first communicating passage portion 25D. Similarly, distance B' from surface 3B of product cavity 3 to the end of second communicating passage portion 25E is made to be longer than the above distance A', and distance B' is also made to be longer than distance A' at those sites of second

temperature adjusting passage portion 25B located close to second communicating passage portion 25E.

Next, an explanation is provided of a method of forming an optical disc using the metal mold device described above. During forming, fixed mold 1 and movable mold 2 are first closed, and two product cavities 3 are formed between this fixed mold 1 and movable mold 2. Furthermore, in this state in which the mold body is closed, contact ring 26 of movable mold 2 contacts outer stamper clamp 16 of fixed mold 1, and positioning frames 14 and 23 of fixed mold 1 and movable mold 2 taper-fit together. Thermoplastic molding material in the form of molten thermoplastic resin is then injected from an injection molding machine. This resin flows from nozzle 10 sequentially through cold sprue 12 and into product cavity 3 from gate 34.

After resin has been filled into product cavity 3, receiving portion 31 of gate cutting sleeve 29 is pushed toward fixed mold 1 by a pushing rod not shown provided on the side of the injection molding machine. As a result, gate cutting sleeve 29 moves to the side of fixed mold 1 and fits into intermediate cylinder 18 of fixed mold 1. As a result, the resin inside cold sprue 12 and the resin inside product cavity 3, namely the optical disc, are severed in gate 34.

In addition, the resin inside product cavity 3 is cooled as a result of coolant supplied from supply inlets 36 and 38 passing through temperature adjusting passages 19 and 25. At this time, temperature adjusting passage 19 is dense, and in the vicinity of first and second communicating passage portions 19D and 19E where it is necessary to lower the cooling capacity per unit surface area of product cavity 3, distance B from surface 3A of product cavity 3 to the end of second communicating passage portion 19E is made to be longer than the above distance A, thereby increasing the heat conductive distance. As a result, the cooling capacity on surface 3A of product cavity 3 decreases correspondingly to a cooling capacity roughly equal to that of other locations. Similarly, temperature adjusting passage 25 is also dense, and in the vicinity of first and second communicating passage portions 25D and 25E where it is necessary to lower the cooling capacity per unit surface area of product cavity 3, distance B' from surface 3B of product cavity 3 to the end of second communicating passage portion 25E is made to

be longer than the above distance A', thereby increasing the heat conductive distance. As a result, the cooling capacity on surface 3B of product cavity 3 decreases correspondingly to a cooling capacity roughly equal to that of other locations.

After the resin in product cavity 3 has cooled and solidified, fixed mold 1 and movable mold 2 are opened. Accompanying this opening, the formed optical disc and solidified resin inside cold sprue 12 are first separated from fixed mold 1. Next, as a result of ejector plate 32 being pushed towards fixed mold 1 by a pushing rod not shown provided on the side of the injection molding machine, ejector pin 30 along with ejector plate 32 move towards the side of fixed mold 1, eject the resin solidified in cold sprue 12 and cause it to separate from movable mold 2. In addition, coupled with the movement of ejector plate 32, ejector sleeve 28 moves to the side of fixed mold 1 and pushes out the inner peripheral portion of the optical disc to separate it from movable mold 2. The released optical disc is then removed by a removal robot not shown. Subsequently, the mold body again closes and the above molding cycle is repeated.

According to the constitution of the present embodiment, in a metal mold device for forming an optical disc, which together with being provided with cavity block 15 and core block 24 provided in opposition to cavity block 15, and forming product cavity 3 between cavity block 15 and core block 24, is provided with temperature adjusting passages 19 and 25 through which coolant W flows in cavity block 15 and core block 24, as a result of increasing distances B and B' from surfaces 3A and 3B of product cavity 3 to communicating passage portions 19D, 19E, 25D and 25E in communicating passage portions 19D, 19E, 25D and 25E where it is necessary to lower the cooling capacity per unit surface area of product cavity 3 by temperature adjusting passages 19 and 25, the heat conductive distance is increased, and the cooling capacity is lowered. As a result, the temperature on surfaces 3A and 3B of product cavity 3 can be uniformized.

Moreover, since temperature adjusting passages 19 and 25 are formed by grooves, and the above distances A, B, A' and B' are set as the distances between the bottom surfaces of groove-shaped temperature adjusting passages 19 and 25 and surfaces 3A and 3B of product cavity 3, distances A, B, A' and B' can easily be set from the surface

on the opposite side of product cavity 3 by cutting apparatus 35.

In addition, together with a plurality of temperature adjusting passages 19 and 25 being formed concentrically with product cavity 3, as a result of increasing distances B and B' in communicating passage portions 19D, 19E, 25D and 25E that connect inside temperature adjusting passage portions 19A, 19B and 19C with outside temperature adjusting passage portions 25A, 25B and 25C, precise optical discs can be formed as a result of uniformizing the surface temperature by lowering the cooling capacity and raising the temperature of surfaces 3A and 3B of product cavity 3 in communicating passage portions 19D, 19E, 25D and 25E.

Next, an explanation is provided of a second embodiment of the present invention with reference to FIGS. 4 and 5. Furthermore, the same reference symbols are used to indicate those portions of the second embodiment that are the same as those of the first embodiment, and a detailed explanation of those portions is omitted. A groove-shaped temperature adjusting passage 41 provided in cavity block 15 is provided with first through third temperature adjusting passage portions 41A, 41B and 41C that respectively form a semicircular arc and are formed to as to form a concentric circle with product cavity 3 in one of the surfaces of cavity block 15. On the other hand, fourth through sixth temperature adjusting passage portions 41D, 41E and 41F that respectively form a semicircular arc are provided in the other surface of cavity block 15 and form a concentric circle with product cavity 3. A coolant supply inlet 42 is connected to the starting end of first temperature adjusting passage portion 41A, and a communicating passage portion 43 is respectively connected between the terminal end of first temperature adjusting passage portion 41A and the starting end of second temperature adjusting passage portion 41B, the terminal end of second temperature adjusting passage portion 41B and the starting end of third temperature adjusting passage portion 41C, the terminal end of third temperature adjusting passage portion 41C and the starting end of fourth temperature adjusting passage portion 41D, the terminal end of fourth temperature adjusting passage portion 41D and the starting end of fifth temperature adjusting passage portion 41E, and the terminal end of fifth temperature adjusting passage portion 41E and the starting end of sixth temperature

adjusting passage portion 41F. In addition, a coolant discharge outlet 44 is connected to the terminal end of sixth temperature adjusting passage portion 41F.

The outermost third temperature adjusting passage portion 41C and sixth temperature adjusting passage portion 41F are provided so as to oppose the outer periphery of product cavity 3, and distance C between the bottom surfaces of the grooves that form third and sixth temperature adjusting passage portions 41C and 41F and surface 3A of product cavity 3 is shorter than distance D between the bottom surfaces of the grooves that form the other first, second, fourth and fifth temperature adjusting passage portions 41A, 41B, 41D and 41E and surface 3A of product cavity 3.

Similarly, temperature adjusting passage 45 is formed in core block 24 as well by first through sixth temperature adjusting passage portions 45A, 45B, 45C, 45D, 45E and 45F. The outermost third temperature adjusting passage portion 45C and sixth temperature adjusting passage portion 45F are provided so as to oppose the outer periphery of product cavity 3, and distance E between the ends of the grooves that form these third and sixth temperature adjusting passage portions 45C and 45F and surface 3B of product cavity 3 is shorter than distance F between the ends of the grooves in the other first, second, fourth and fifth temperature adjusting passage portions 45A, 45B, 45D and 45E and surface 3B of product cavity 3.

In this second embodiment, resin inside product cavity 3 that has been filled into product cavity 3 is cooled as a result of coolant passing through temperature adjusting passages 41 and 45. At this time, since the amount of radiated heat is typically large at the outer periphery of product cavity 3, it is necessary to increase cooling capacity by coolant. In contrast, distances C and E between outermost third and sixth temperature adjusting passage portions 41C, 41F, 45C and 45F and surfaces 3A and 3B of product cavity 3 are formed to be shorter than distances D and F of the other temperature adjusting passage portions 41A, 41B, 41D, 41E, 45A, 45B, 45D and 45E.

According to this second embodiment, the distance from the surface of product cavity 3 is made to shorter at the outer periphery of product cavity 3. As a result, since the heat conductive distance of coolant at the outer periphery of product cavity 3 becomes shorter, the cooling capacity at the outer periphery of product cavity 3 where

the amount of radiated heat is large is relatively increased, thereby making it possible to uniformly set the temperature distribution of product cavity 3.

Furthermore, the present invention is not limited to the embodiments described above, but rather various other variations can be carried out within the scope of the gist of the present invention.

CLAIMS

1. A metal mold device for forming an optical disc having a mold body provided with a fixed mold and a movable mold provided in opposition to the fixed mold, and together with a product cavity being formed between the fixed mold and movable mold, a temperature adjusting passage is provided in the mold body through which a coolant flows; wherein, the distance from the surface of the product cavity to the temperature adjusting passage is lengthened at those locations where the cooling capacity per unit surface area of the product cavity is lowered by the temperature adjusting passage, and the distance from the surface of the product cavity to the temperature adjusting passage is shortened at those locations where the cooling capacity per unit surface area of the product cavity is increased by the temperature adjusting passage.
2. A metal mold device for forming an optical disc according to claim 1, wherein the temperature adjusting passage is formed in the shape of a groove, and the distance is the distance between the bottom of the groove-shaped temperature adjusting passage and the surface of the product cavity.
3. A metal mold device for forming an optical disc according to claim 1, wherein together with a plurality of temperature adjusting passages being formed so as to be concentric with the product cavity, the distance is increased in a communicating passage portion that connects a temperature adjusting passage portion located on the inside with a temperature adjusting passage portion located on the outside.
4. A metal mold device for forming an optical disc according to claim 2, wherein together with a plurality of temperature adjusting passages being formed so as to be concentric with the product cavity, the distance is increased in a communicating passage portion that connects a temperature adjusting passage portion located on the inside with a temperature adjusting passage portion located on the outside.
5. A metal mold device for forming an optical disc according to claim 1, wherein the distance is shortened at the outer peripheral side of the product cavity.
6. A metal mold device for forming an optical disc according to claim 2, wherein the distance is shortened at the outer peripheral side of the product cavity.
7. A metal mold device for forming an optical disc according to claim 3, wherein the

distance is shortened at the outer peripheral side of the product cavity.

8. A metal mold device for forming an optical disc according to claim 4, wherein the distance is shortened at the outer peripheral side of the product cavity.