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(54) Divisible slip-casting molds.

(57) A divisible slip-casting mold including novel fluid-flowing conduits in filter layers (4,5) is provided, the fluid-flowing conduits of which comprise minor portions of porous ropes (16,17) arranged in a curved line and major portions of blind holes (10,11) installed in a straight line. The porous ropes (16,17) are essentially installed in the portions of the filter layer (4,5) where the mechanical strength of the portion is lower than other portions of the filter layer, and the blind holes (10,11) are essentially installed in other portions of the filter layer. Thus, sufficient mechanical strength and substantially uniform fluid-flowing properties are provided in the filter layers (4,5) of the mold.

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DIVISIBLE SLIP-CASTING MOLDS

This invention relates to a divisible slip-casting mold and a method for producing the mold. More particularly, this invention relates to improvements in a casting mold for molding green articles of sanitary ware, ceramic ware and the like.

It is known in the art to install fluid-flowing conduits composed of either blind holes or porous ropes alone in the filter layers of a slip-casting mold. Such filter layers of the mold have had problems such as non-uniform fluid-flowing properties and weak strength of the mold. It has been considered in the art that such problems are unavoidable. Such problems and improvements therein provided by the present invention are explained in detail in the comparative example and working example of the present specification.

The present inventors have tried to employ effective combinations of both the blind holes and porous ropes for the fluid-flowing conduits, and have found that the conventional problems can be unexpectedly eliminated by installing specific combination of the blind holes and porous ropes in the filter layers of the mold.

Thus there is provided according to the present invention, a mold for cast-molding a slip which comprises a divisible .casting mold including at least two mold portions to form a mold cavity when mated together; each mold portion comprising a housing and a filter layer of continuously porous structure adjacent to the housing, said filter layer including fluid-flowing conduits; a slip supply duct connected with said mold cavity and communicating with the outside of the housing; a fluid-flowing duct connected with said fluid-flowing conduits and communicating with the outside of the housing; characterized in that

the fluid-flowing conduits comprise major portions of blind holes installed in the filter layers in a substantially straight line and minor portions of porous ropes arranged along the filter layers in a curved line;

the porous ropes are essentially installed instead of the blind holes in the portions of the filter layer where the mechanical strength of the portion is lower than other portions of the filter layer for preventing the weak portion from further decrease in the strength due to installation of blind holes therein; and

the blind holes are essentially installed in other portions of the filter layers where the mechanical strength is substantially sufficient;

whereby sufficient mechanical strength and substantially uniform fluid-flowing properties are provided in the filter layers of the mold.

Incidentally, the porous rope can also be installed in the portion where uniform installation of the blind holes are difficult in the filter layer, although the blind holes are useful for controlling fluid-flowing properties in the filter layer by adjusting the length of the blind holes.

The above-mentioned divisible casting mold can be produced by the following steps which comprise;

(1) preparing a model for a filter layer having the shape of an article to be molded, (2) placing over the model a supporting wire such as net having necessary porous ropes arranged and fixed thereonto, (3) placing divided housing over the model and ropes, (4) filling the space composed by the housing and the model for the filter layer with a flowable filter material and allowing the material to solidify, and (5) forming blind holes by drilling or the like from the housing towards the filter surfaces of the filter layer. The mold including supporting layers for the filter layers can be produced by using divided housing including the supporting layer inside of the housing in the step (3).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG.1 is a vertical cross-sectional view of the mold of Example 2. FIG.2 is a vertical cross-sectional view of the conventional mold of comparative Example 1.

EMBODIMENTS OF THE INVENTION

The filter layer of the present mold can contain a supporting layer between the filter layer and housing, in view of reinforcement of and material cost for the filer layer as well as preventing the filter layer from deformation. In other words, the air-tight housing of the mold comprises housing for the mold and supporting layers for the filter layers installed between the housing and the filter layers.

The materials for the filter layer can be any material which can form a continuously porous solid layer, and include porous synthetic resins and gypsum. In view of performances and durability of the mold, it is generally preferred that the filter layer comprises a continuously porous synthetic resin. The materials for the supporting layer can be a substantially non-porous solid material.

The housing can be a rigid case or frame supporting the filter layer or the supporting layer. When the mold comprises a frame and a filter layer , the exposed portions of the filter layer are nor-

mally coated with air-tight paint.

The porous ropes include for example fibrous cords and fibrous tubes, and fibrous tubes (e.g. knitted cotton tubes) are normally employed. The outer diameter of the porous rope is generally in the range of about 2 to about 20 mm. The porous ropes are generally arranged along the filter layers at an interval of about 5 to 60 mm and at a depth of about 10~ 40 mm from the surfaces of the filter layers.

The term "blind hole" means a long narrow hole installed at an interval of ,e.g., about 10 to 100 mm from the housing towards the surfaces of the filter layers, the top of which reaches near the filter surfaces at a distance of about 10 to 40 mm from the filter surfaces. The diameter of the blind hole is generally in the range of about 5 to 30 mm. Incidentally, the blind holes can contain some fillers such as fibers to store some water therein for providing water films.

Example 1 (Comparative)

A cross-sectional view of a conventional casting mold is shown in FIG.2. This mold is a divisible casting mold including an upper mold portion 1 and a lower mold portion 2. The mold portion comprises a filter layer 4 or 5 composed of a porous solid material (which forms a mold cavity 3 when mated together), a housing, and as necessary a supporting layer 6 or 7 composed of a non-porous material which supports the filter layer 4 or 5. The filter layer 4 (or filter layer 5) and the supporting layer 6 (or supporting layer 7) are supported by a reinforcing frame 8 (or reinforcing frame 9), i.e. a housing.

Numeral numbers 10~ 10 and 11~ 11 represent blind holes which are installed parallel to each other upwardly or downwardly in the upper mold portion 1 and lower mold portion 2, respectively. The blind holes 10~ 10 are closed at their lower ends within the filter layer 4, and the upper ends thereof extend to crossing conduits 12 located between the lower surface 8a of the reinforcing frame 8 and the supporting layer 6. The blind holes 10~ 10 are communicated with one another via the conduits 12. Similarly, the blind holes 11~ 11 are closed at their upper ends within the filter layer 5, and the lower ends thereof extend to crossing conduits 13 located between the upper surface 9a of the reinforcing frame 9 and the supporting layer 7. The blind holes 11~ 11 are communicated with one another via the conduits 13. The conduits 12 and 13 are communicated with the outside via fluid-flowing ducts (not shown in drawings).

In such a casting mold, slip is supplied to the mold cavity 3 via a slip supply duct 14 and pressurized to drive out water contained in the slip into the filter layers 4 and 5, whereby the slip is deposited onto the inner surfaces of the filter layers, while the fluid-flowing ducts can be depressurized to drain the water driven into the filter layers 4 and 5 via the blind holes 10~ 10 and 11~ 11, respectively. In the production of a hollow molded article, the slip supply duct 14 is set to a gravitationally low position when the deposited layer reaches predetermined thickness, and the slip remaining in the mold cavity is drained via the slip supply duct.

The materials themselves of such filter layers 4 and 5, however, are weak in mechanical strength, and the strength thereof is further decreased by installing blind holes 10~ 10 and 11~ 11 therein. Such mold have defects in that, when slip was supplied and pressurized, cracks (e.g. C, D in FIG.2) are generated owing to concentrated stress at the weak portions of the filter layers where the layers are relatively thin and receive the pressure substantially from one side, for example, at the portions which are thin, receive pressure from one side and curved in an L-shape such as parts A and B shown in FIG.2. Such cracked filter layers are not feasible. When the slip in the mold was pressurized to 1.5 MPa which was practically used for molding, cracks of about 2 mm in width were generated in 5 cycles of the molding.

Example 2 (Working Example)

FIG.1 shows a cross-sectional view of a casting mold according to the present invention, the construction of which is basically the same as the mold in Comparative Example 1. Thus, similar members are represented by the same numbers to simplify the description.

The reinforcing frame 8 (i.e. housing) consists essentially of a plate-like upper frame 8A which form an upper surface of the mold and side frames 8B which cover a supporting layer 6. The interface between the lower surface 8a of the reinforcing frame 8 (i.e. the lower surface of the upper frame 8A) and the upper surface of the supporting layer 6 (excluding the parts of the surface wherein crossing conduits 12 are located) can be sealed by means of resin putty. The reinforcing frame 9 consists essentially of a plate-like lower frame 9A which forms the lower surface of the mold and side frames 9B which cover a supporting layer 7. The interface between the upper surface 9a of the reinforcing frame 9 (i.e. the upper surface of the lower frame 9A) and the lower surface of the supporting layer 7 (excluding the parts of the surface wherein crossing conduits 13 are located) is sealed by means of resin putty. The casting mold is designed to provide gaps 15 between the lower

end of the side frame 8B of the reinforcing frame 8 and the upper end of the side frame 9B of the reinforcing frame 9, when the mold is closed as shown in FIG.1. Thus, both the supporting layer 6 and filter layer 4 of the upper mold portion 1 and the supporting layer 7 and filter layer 5 of the lower mold portion 2 are intimately mated with each other without a gap. (Incidentally, the interface between them may also be sealed by means of resin putty when the mold is in a closed state.) The supporting layer can be avoided by replacing the supporting layers with the filter layers.

This working example is characterized in that porous tubes 16~ 16 and 17~ 17 are installed instead of the blind holes 10~ 10 and 11~ 11 in the part A of the filter layer 4 and the part B of the filter layer 5, respectively (these parts are weak in mechanical strength as explained in the comparative example 1). The porous tubes 16~ 16 and 17~ 17 are made from air-permeable, water-permeable materials such as woven fabrics (e.g. cotton fabrics) or glass fibers, and form continuous tubular conduits running in a curved fashion throughout the part A and the part B, respectively. The tubular conduits consisting of porous tubes 16~ 16 and 17~ 17 are connected to the outside fluid-flowing ducts via the corresponding conduits 12 or 13 through the supporting layer 6 or 7 to conduct supply and drainage actions, similarly as the blind holes 10~ 10 and 11~ 11. The numbers 18 and 19 represent supporting nets which support the porous tubes 16~ 16 and 17~ 17, respectively, and are embedded integrally in the corresponding filter layers 4 and 5 in the course of producing said layers.

Along the backside of the part A which has very weak strength (this part is long in the vertical direction} is provided with a stainless steel bar 20. The reinforcing bar 20 has an n-shaped configuration similar to the shape of a part 3a of the casting cavity 3, and is generally installed at such a position between the supporting layer 6 and filter layer 4 that does not adversely affect the supply and drainage action of water.

In this example, porous tubes 16~ 16 and 17~ 17 (similarly as blind holes 10~ 10 and 11~ 11) serve to lead the water entered into the filter layers 4 and 5 to the outside fluid-flowing ducts during deposition of slip. After deposition of the slip, an appropriate amount of water is supplied via the porous tubes 16~ 16 and 17~ 17 and the blind holes 10~ 10 and 11~ 11 by pressurizing the fluid-flowing ducts. This water exudes onto the surfaces of the filter layers 4 and 5 to form thin water films between the filter layers and a molded article, whereby removal of the mold is facilitated.

Since porous tubes 16~ 16 and 17~ 17 are installed in the parts A and B of the filter layers 4 and 5 in this example, the strength of the parts A and B are increased by means of the ropes and wire installed, in comparison with the case where blind holes 10~ 10 and 11~ 11 are installed therein. Thus, generation of cracks can be prevented. Incidentally, the part A is reinforced from the backside thereof by providing the stainless steel bar 20 around the part A, and such generation of cracks can be further improved.

Although the porous tubes 16~ 16 and 17~ 17 are installed only in the parts A and B which are weak in strength, it is also possible to employ such porous tubes in other suitable parts instead of the blind holes (for example, such parts where a blind hole is too deep to be readily installed).

A explained above, porous ropes (e.g. porous tubes) can be successfully used instead of blind holes according to the present invention, in the portions of the filter layer where the mechanical strength is weak such as the portions A and B as shown in FIGS. 1~ 2 and Examples 1~ 2 (for example, the portions of the filter layer which is relatively thin, i.e. thinner than other portions and receive pressure of slip substantially from one side).

Such weak portions of the filter layer are further decreased in mechanical strength, when blind holes are installed therein. The porous ropes installed therein instead of the blind holes do not substantially decrease the mechanical strength of the filter layer; and often serve to reinforce the portions where the ropes are installed, because of the ropes arranged along the filter layer. As necessary, the weak portions of the filter layer can be further reinforced by embedding a supporting bar therein.

Claims

1. A mold for cast-molding a slip which comprises a divisible casting mold including at least two mold portions (1,2) to form a mold cavity (3) when mated together; each mold portion (1,2) comprising a housing (8,9) and a filter layer (4,5) of continuously porous structure adjacent to the housing (8,9), said filter layer (4,5) including fluid-flowing conduits (10,11,16,17); a slip supply duct (14) connected with said mold cavity (3) and communicating with the outside of the housing (8,9); a fluid-flowing duct connected with said fluid-flowing conduits and communicating with the outside of the housing (8,9); characterized in that
a majority of the fluid-flowing conduits comprise substantially straight blind holes (10,11) extending into the filter layers (4,5) and a minority of the fluid-flowing conduits comprise porous ropes (16,17) arranged in curved pathways through at least one of the filter layers (4,5);

the porous ropes (16,17) being located in a portion or portions of at least one filter layer (4,5) of inherently low mechanical strength, where the formation of blind holes (10,11) would cause further weakening of the filter layer (4,5);
the blind holes (10,11) being formed in other portions of the filter layers (4,5).

2. The mold according to Claim 1, in which the housing (6,7,8,9) comprises a housing (8,9) for the mold and a supporting layer (6,7) for the filter layer (4,5) installed between the housing (8,9) and the filter layer (4,5).

3. The mold according to Claim 2, in which the supporting layer (6,7) comprises substantially non-porous materials.

4. The mold according to Claim 1, 2 or 3, in which the filter layer (4,5) comprises a continuously porous synthetic resin.

5. The mold according to any one of Claims 1-4, in which the blind holes (10,11) are installed from the housing (8,9) towards the filter surfaces of the filter layers (4,5) and reach near the filter surfaces.

6. The mold according to any one of Claims 1-4, in which the porous rope (16,17) serves to reinforce the portion of the filter layer (4,5) where the rope (16,17) is installed.

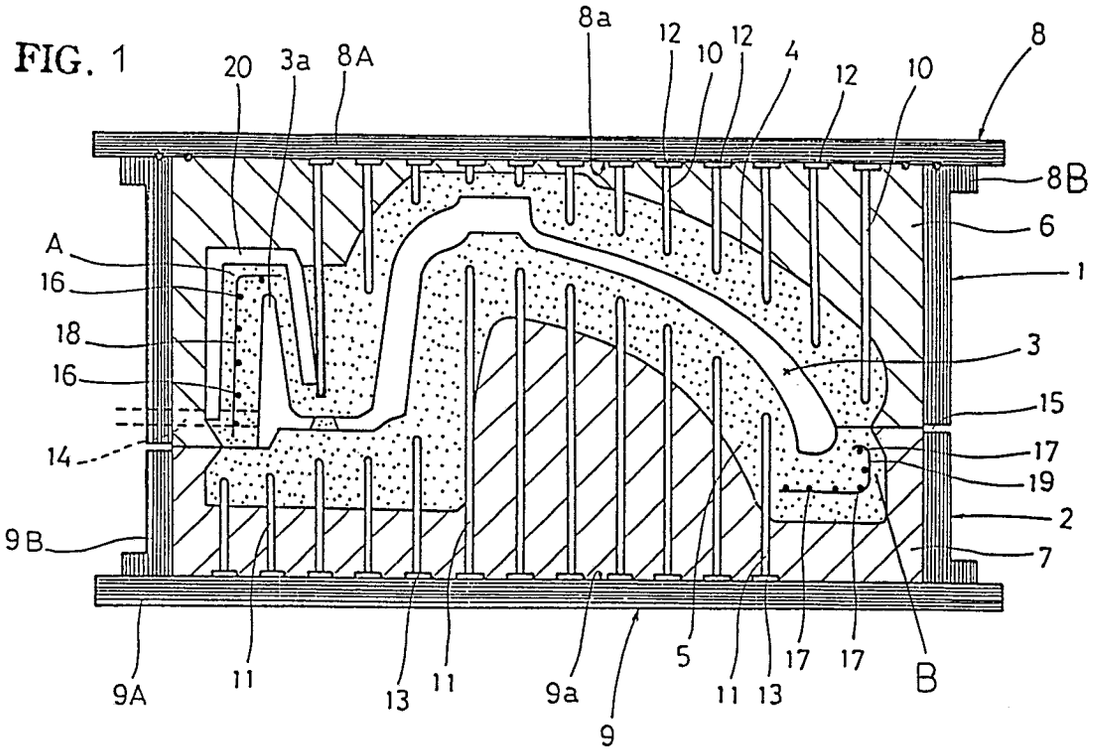
7. The mold according to any one of Claims 1-6, in which the blind holes (10,11) contain some filters such as fibers to store some water therein.

8. A method for producing the mold of Claim 1, which comprises (1) preparing a model for a filter layer having the shape of an article to be molded, (2) placing over the model a supporting wire having necessary porous ropes arranged and fixed thereonto, (3) placing divided housing over the model and ropes, (4) filling the space composed by the housing and the model for the filter layer with a flowable filter material and allowing the material to solidify, and (5) forming blind holes from the housing towards the filter surfaces of the filter layer.

9. The method according to Claim 8, which uses divided housing including a supporting layer inside of the housing in the step (3) to provide a supporting layer between the filter layer and housing.

10. The method according to Claim 9, in which the supporting layer comprises substantially non-porous materials.

FIG. 1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12
4
12
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3a
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8B
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16
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9a
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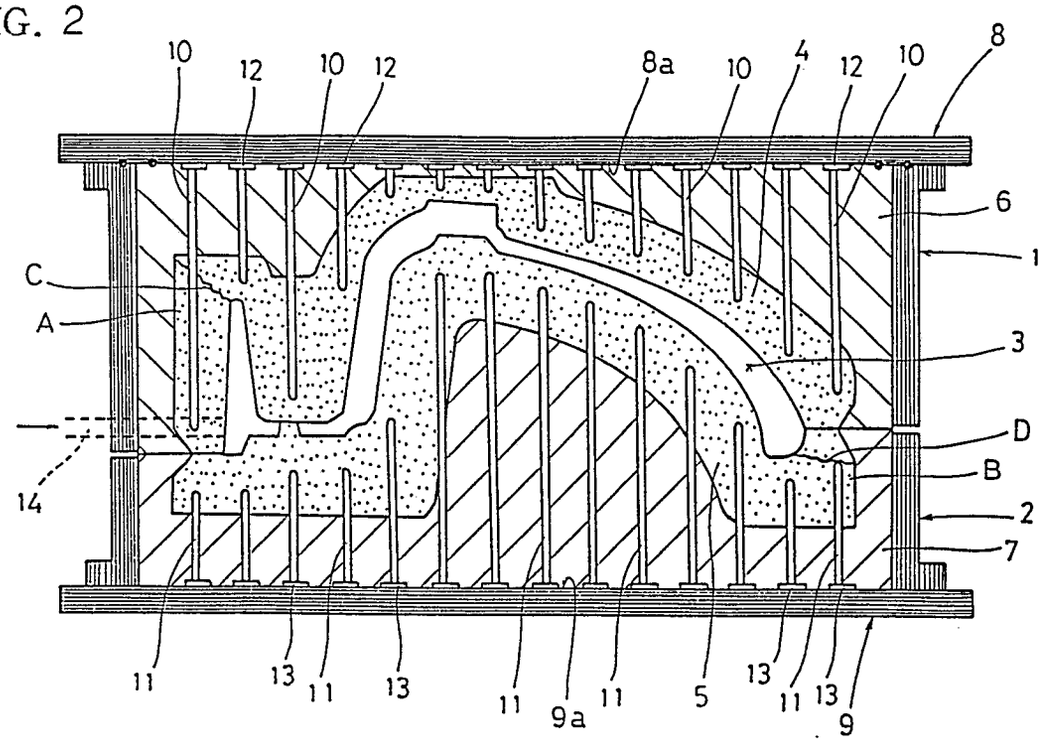
FIG. 2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