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(54) Title: HIGH PERMEABILITY METAL CASTING PLASTER AND METHOD OF MAKING SAME**(57) Abstract**

A high permeability metal casting plaster is used for production of high accuracy simulated castings for prototypes and any other plastermold castings. Methods are provided that create the high permeability metal casting plaster and mold. Also, a high permeability metal casting plaster is disclosed that uses control ground and screened alpha-hemihydrate gypsum, control ground and screened beta-hemihydrate gypsum, sucrose for protection against thermal shock, and a foaming agent.

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DESCRIPTIONHigh Permeability Metal Casting Plaster
and Method of Making Same5 TECHNICAL FIELD

The present invention relates to a high permeability casting plaster and more particularly to a metal casting plaster of high permeability that allows any plaster mold castings and in particular the simulated die casting of parts used primarily for the creation of prototype and short run production parts which will substantially replicate the appearance and function of conventionally die cast parts.

It will be appreciated by those skilled in the art that the use of gypsum-type materials in the manufacture of molds used for casting of metals is well known. The need for inexpensive simulated die casting is particularly important for the creation of prototype or short run production parts which can be tested prior to the outlay of large sums of money to develop a permanent steel die. To this end, there have been several attempts to provide such a plaster for allowing the creation of prototype and short run production parts.

BACKGROUND ART

One such attempt is disclosed by R. Reingen in U.S. Patent No. 3,748,290. The Reingen patent briefly mentions the use of the addition of certain chemicals to a hemihydrate gypsum. The specific application of Reingen is directed toward ceramic molding. However, Reingen does mention that his method has had certain success with the manufacture of other molds, patterns, and pressed pieces. However, the Reingen patent does not create the thin wall casting that is required to develop prototypes.

U.S. Patent No. 4,749,431 issued to Fassle et al. on June 7, 1988, discloses the use of alpha and beta hemihydrates that are added to glass fibers. However, this disclosure, too, does not describe the simulated die casting that is required to cast a prototype piece.

Several problems have plagued the aluminum/zinc alloy

casting industry for many years. For example, the wall thickness of the metal castings vary due to irregularities in the surface of the mold. Also, turbulence in the molten metal caused by gases trapped in the mold cavity have caused 5 poor metal wall structure. Further, low strength mold walls separate and crack under high temperatures or pressure, resulting in flashings or fins on the metal walls of the casting. Conventional casting plasters, when cured, have also lacked the uniform permeability necessary to provide 10 uniform gas diffusion through and cooling of the molten metal during casting.

What is needed, then, is a high permeability metal casting plaster than can be used inexpensively to create simulated die castings. This needed plaster must produce a 15 harder and smoother skin on the plaster mold. This plaster must also hold the foam cells in the plaster mold in uniform suspension. To prevent large, irregular foam cells from forming directly behind the skin, which causes the collapse of the mold wall under the weight of the molten alloy, the 20 plaster must promote uniform density throughout the finished plaster mold. The plaster must also control cracking and micro-cracking of the mold surface that is caused by thermal expansion during drying and subsequent exposure to high 25 temperature by the molten alloy. A plaster having these qualities and characteristics is presently lacking in the art.

DISCLOSURE OF THE INVENTION

The present invention relates to the manufacture of simulated die castings using a mold formed of permeable 30 casting plaster. A master model is produced from blueprints supplied by the customer having the shape, dimensions, and finish qualities of the desired cast metal end-product. A cavity or negative is then made by investing rubber and plastic over the master model. From the negative of the 35 master model, a positive of the master model is then produced of rubber and plastic which is called a pattern tooling. The pattern tooling is then placed in a frame or box with novel highly permeable casting plaster of the present invention to

form the mold.

The casting plaster slurry disclosed herein uses alpha-hemihydrate plaster that is screened to increase the percentage of small gypsum particles in the plaster, thereby permitting more material to flow to the outside of the mold to form a tighter skin. Beta-hemihydrate plaster is added to control the amount of alpha material that flows to the skin, thereby creating greater uniformity of foam cellular structure throughout the mold. A foaming agent is added. Sucrose is added to the mixture to protect the formed crystalline structure against thermal shock. Talc, Type 1 Portland cement, and an accelerator are also added in the preferred embodiment to the dry mix that is added to water to create the slurry. During mixing and curing of the plaster, the water to plaster ratio and water temperature are controlled to achieve the desired mold skin thickness, skin strength, and uniformity of cellular structure.

BEST MODE FOR CARRYING OUT THE INVENTION

At the request of a customer, a master model of the desired part to be die cast is produced from wood, metal, or plastic. The dimensions of the master model are taken from a blueprint, drawing, or sketch provided by the customer. The master model must duplicate all of the important characteristics needed in the actual production die casting - appearance, dimensional accuracy, and mechanical and chemical properties. Because the simulated die castings are used for prototype purposes, the master model may go through many engineering changes and redesigns before final approval. The word "simulated" is used to differentiate between castings produced in a plastermold and those produced in a steel mold. Only a casting produced in a steel mold can be called a die casting.

Upon final approval by the customer, a duplicate of the master model is produced in conventional fashion using a variety of materials, primarily synthetic plastics and rubbers, to replicate the original master model. Rubber and plastic is invested over the master model in order to develop a cavity or negative of the master model. Additional rubber

and plastic is then introduced into the negative cavity to produce a positive of the original master model or "pattern tooling".

The pattern tooling is then placed in a frame or box of
5 wood, metal, or other suitable material capable of containing
a slurry of highly permeable plaster. Various types of
plaster (calcium sulphate) are blended with certain other
ingredients to form a dry material which is then combined
10 with heated free water. This mixture is allowed to become
saturated and is then mixed for a specific period of time
until a satisfactory slurry is produced. The water to
plaster ratio and water temperature are critical to achieve
the desired skin thickness, skin strength, and uniform
15 cellular structure of the mold. In the preferred embodiment,
the water to plaster ratio is substantially 1:1. The water
temperature is maintained at approximately 35°C to
43.3°C(95°F to 110°F).

The slurry is then poured over the pattern tooling and
allowed to harden. During this process, a heavier sediment
20 in the slurry settles to the face of the pattern tooling and
forms a skin which duplicates the exact detail and finish of
the pattern tooling. Directly behind the skin, cells are
created, much like those of a sponge. These cells give the
plaster mold its high permeability. The plaster of the
25 present invention promotes uniformity in the size and
distribution of foam cells, which improves the mechanical
properties, surface appearance and dimensional accuracy of
the final simulated casting. After the plaster slurry
hardens sufficiently, the plaster mold is then removed from
30 the pattern tooling and is placed in a drying oven to remove
the free water added during the original preparation of the
plaster slurry. The set, dry mold is a dihydrate (gypsum)
containing two molecules of water in the crystal. It is
surface calcined when the mold wall comes in contact with the
35 molten metal, and 1.5 to 2 molecules of water are released
and forced through the mold wall, into the cellular structure
of the mold body. This action maintains the smooth metal
surface by eliminating the gas (steam) in the direction of

least resistance.

The plaster mold, after having been thoroughly dried to less than one percent moisture content, is now prepared to receive the molten aluminum and/or zinc alloys. The molten 5 metal is conventionally introduced through a sprue or opening of the mold into the mold cavity, using either gravity, pressure, vacuum, or combinations thereof. The formation of the casting is complete upon solidification of the metal within the cavity. The casting is removed from the plaster 10 mold, at which time the casting is trimmed and ready for shipment or subsequent secondary machining operations.

The novel plaster of the present invention starts with an alpha-hemihydrate gypsum as part of the dry mix. This alpha-hemihydrate gypsum is a calcined gypsum material where 15 1.5 to 2 water molecules have been removed from the crystals during calcination. Examples of this alpha-hemihydrate gypsum are the conventional gypsum product sold by USG as "White Hydrocal®" and sold by Georgia Pacific as "Densecal WH®". This alpha-hemihydrate gypsum is screened to obtain 20 a finer product. The normal consistency of this alpha-hemihydrate gypsum as tested per ASTM 472-79, Methods 5 and 6, has 30 to 32 cc water per 100 gm of plaster. The plunger penetration of this alpha-hemihydrate gypsum is 30 mm, plus or minus 2 mm. In the preferred embodiment, the alpha- 25 hemihydrate gypsum yields the following alcohol wash sieve analysis as per the appendix to ASTM 472-79:

	<u>Sieve size (in microns)</u>	<u>Percent</u>
30	Through 30 mesh (-590 micron)	100% average
	Through 50 mesh (-297 micron)	99.99 average
	Through 100 mesh (-149 micron)	99.60 average
	Through 200 mesh (-74 micron)	97.60 average
	Through 325 mesh (-44 micron)	97.30 average

35 By screening and the controlled grinding of the alpha-hemihydrate gypsum, the percentage of small gypsum particles in the plaster is increased, thereby permitting more material to flow to the outside of the mold to form a tighter skin. Prepared as described, the alpha-hemihydrate should have a

particle size distribution that is 4 to 5% finer in the .5 to 44 micron range.

Beta-hemihydrate is then added to the dry mix to control the amount of alpha-hemihydrate that flows to the skin after 5 saturation. This beta-hemihydrate gives greater uniformity of foam cellular structure throughout the mold. The beta-hemihydrate gypsum is atmospherically calcined and reground to meet certain specifications. In the preferred embodiment, the water ratio as per ASTM 472-79, Methods 5 and 6, is 48 10 to 52 cc per 100 grams of plaster. The plunger penetration is 30 mm plus or minus 2 mm. An alcohol wash sieve analysis as per the appendix to ASTM 472-79 yields the following 15 results:

	<u>Sieve size (in microns)</u>	<u>Percent</u>
15	Through 50 mesh (-297 microns)	99.0% average
	Through 100 mesh (-149 microns)	99.0% average
	Through 200 mesh (-74 microns)	85.0% average
	Through 325 mesh (-44 microns)	70.0% average
20	A talc is also added to the premix. In the preferred embodiment, #2882 282 Tex-Ceram Talc® CAS No. 14807-96-6 is used.	

25 Type 1 Portland cement is added to the premix. When the tricalcium aluminate concentrate of the Portland Cement is 8% or less, the amount of sulphur trioxide should not exceed 2.5%. In the preferred embodiment, the product is to be free of all package lumps and screened through a 30 mesh screen.

30 An anionic biodegradable foaming agent, such as alkyl naphthalene suphonate, is added. In the preferred embodiment, Petro BAF® is used.

In the preferred embodiment, the premix that is produced

has 80% alpha-hemihydrate and 20% Petro BAF® foaming agent. This premix blend is kept in a closed container and should not be stored for more than 14 days.

5 Granulated sugar or sucrose is added as a colloidal retarder in the preferred embodiment to the mixture to protect the formed crystalline structure against thermal shock. This additive lowers the solubility rate of calcium sulphate by coating some of the grains of calcined gypsum.

10 Dihydrate gypsum which is freshly ground is used in the preferred embodiment of the plaster as an accelerator. The accelerator is screened through a 30 mesh. It is kept in a closed container. In the preferred embodiment, any Terra Alba-type gypsum may be used and is produced by mixing regular beta-hemihydrate plaster with water at a ratio of 70-15 80 parts water to 100 parts plaster by weight. The water/beta-hemihydrate plaster is then set and dried. The dry cast is then micropulverized to a powder passing through a 30 mesh screen.

20 A preferred powder mixture of these various materials in the preferred embodiment of the plaster is as follows:

	<u>Materials</u>	<u>Percent by Weight</u>
	Alpha-hemihydrate	51.450
25	Beta-hemihydrate	20.000
	Talc	25.000
	Portland cement Type 1	1.000
	Premix foaming agent	1.135
	Sucrose	0.050
30	Accelerator	1.125

30 The uniformly blended dry powder is added to free water heated to approximately 35°C to 43.3°C (95 to 105°F), at a mix of 1:1 (100 cc per 100 gm). The mixture is allowed to

soak for one minute, saturating the powder, and is then mixed for approximately one minute with a high speed mixer. The soaking time is to be measured from the moment the powder is added to the water.

5 When the dissolved plaster is prepared as described, the foam cells produced should have a diameter in the range of 2 to 4 mm. Also, the amorphous structure of the beta-hemihydrate particle will hold the cells in a more uniform suspension. It is desired that the slurry produced by
10 soaking and mixing the powder with heated water have a volume increase during mixing of approximately 90% to 100% in a Pat diameter. Also, the powder, when mixed with water at a ratio of 100 gm/56 cc should produce a Pat minimum diameter of 10.16 cm (4.0") with a maximum of 12.2 cm (5"). The Pat
15 diameter is measured by soaking the powder and water for 1 minute, hand mixing for 1 minute, and pouring the mixture from the container onto a clear plate glass from a height of 5.08 cm (2"). The preferred setting time for the preferred embodiment is approximately 12 to 15 minutes.

20 Thus, although there have been described particular embodiments of the present invention of a high permeability metal casting plaster, it is not intended that such references be construed as limitations upon the scope of this invention except as set forth in the following claims.

25 Further, although there have been described certain specifications used in the preferred embodiment, it is not intended that such be construed as limitations upon the scope of this invention, except as set forth in the following

claims.

CLAIMS

1. A high permeability metal casting plaster comprising a mixture of:

- (a) screened alpha-hemihydrate gypsum; and
- 5 (b) beta-hemihydrate gypsum.

2. The plaster of Claim 2 further comprising a foaming agent.

3. The plaster of Claim 2 further comprising a chemical additive means for protecting calcined gypsum grains 10 of said plaster against thermal shock.

4. The plaster of either of Claims 1 through 3 wherein said screened alpha-hemihydrate gypsum yields an average of 97.3% of particles passing through a sieve of 325 mesh.

5. The plaster of either of Claims 1 through 4 wherein 15 the ratio of said screened alpha-hemihydrate gypsum to said beta-hemihydrate gypsum in said mixture is approximately 2.5 to 1 by weight.

6. A permeable metal casting plaster comprising:

- (a) a mixture of screened alpha-hemihydrate 20 gypsum;
- (b) beta-hemihydrate gypsum; and
- (c) a foaming agent added to the means for producing foam cells in a calcined mold of said mixture having diameters in the range of 25 2 mm to 4 mm.

7. A high permeability metal casting plaster comprising a mixture of alpha-hemihydrate and beta-hemihydrate gypsum, talc, Portland cement, and a foaming

agent.

8. The plaster of Claim 7 further comprising a thermal shock additive.

9. The plaster of Claim 8 further comprising an
5 accelerator compound.

10. A method of producing a high permeability casting
plaster comprising the steps:

- (a) making a premix of screened alpha-hemihydrate gypsum and a foaming agent;
- 10 (b) blending said premix with beta-hemihydrate gypsum in a ratio of approximately 2.5 to 1 by weight of alpha- to beta-hemihydrate gypsums;
- 15 (c) adding talc, Portland cement, a thermal shock additive, and an accelerator to said blend, thereby forming a blended dry powder having a Pat diameter of approximately 10.16 cm to 12.20 cm; and
- 20 (d) combining said powder with heated water at a ratio of approximately 1 to 1, soaking said powder until saturated; and
- (e) mixing said combination of said powder and water until a slurry is formed which, during hardening, will have a volume increase of approximately 90% to 100% and a setting time of approximately 15 minutes.

25 11. The method of Claim 10 wherein the proportions by weight of each component of said powder is as follows:

substantially 51.45% of alpha-hemihydrate, substantially 20% of beta-hemihydrate, substantially 25% of talc, substantially 1% of Portland cement, substantially 1.135% of foaming agent, substantially .05% of thermal shock additive, and 5 substantially 1.25% of said accelerator.

12. A plaster metal casting mold made by the process of blending a powder of screened alpha-hemihydrate gypsum with beta-hemihydrate gypsum, talc, Portland cement, foaming agent, thermal shock additive, and an accelerator, mixing 10 said powder with heated water at an approximate ratio of 1 to 1 forming a slurry, and pouring said slurry over a pattern tooling.

13. A plaster metal casting mold made by the process of:

- 15 (a) making a premix of screened alpha-hemihydrate gypsum and a foaming agent;
- (b) blending said premix with beta-hemihydrate gypsum in a ratio of approximately 2.5 to 1 by weight of alpha- to beta-hemihydrate 20 gypsums;
- (c) adding talc, Portland cement, a thermal shock additive, and an accelerator to said blend, thereby forming a blended dry powder having a Pat diameter of approximately 10.16 cm to 25 12.20 cm;
- (d) combining said powder with heated water at a ratio of approximately 1 to 1, soaking said powder until saturated, and mixing said

combination of said powder and water until a slurry is formed which, during hardening, will have a volume increase of approximately 90% to 100% and a setting time of approximately 15 minutes; and

5

- (e) pouring said slurry over a pattern tooling and allowing it to harden.

14. A highly permeable metal casting plaster comprising in dry powder form:

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- (a) substantially 51.45% by weight of alpha-hemihydrate;
- (b) substantially 20% by weight of beta-hemihydrate;
- (c) substantially 25% by weight of talc;
- (d) substantially 1% of Type 1 Portland cement;
- (e) substantially 1.135% by weight of a premix foaming agent;
- (f) substantially .05% by weight of sucrose; and
- (g) substantially 1.25% by weight of an accelerator.

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15. A high permeability metal casting plaster comprising a mixture of:

- (a) control ground alpha-hemihydrate gypsum; and
- (b) control ground beta-hemihydrate gypsum.

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16. A permeable metal casting plaster comprising:

- (a) a mixture of control ground alpha-hemihydrate gypsum;
- (b) control ground beta-hemihydrate gypsum; and

(c) a foaming agent added to the means for producing foam cells in a calcined mold of said mixture having diameters in the range of 2 to 4 mm.

5 17. A method of producing a high permeability casting plaster comprising the steps of:

- (a) making a premix of control ground alpha-hemihydrate gypsum and a foaming agent;
- (b) blending said premix with beta-hemihydrate gypsum in the ratio of approximately 2.5 to 1 by weight of alpha- to beta-hemihydrate gypsum;
- (c) adding talc, Portland cement, a thermal shock additive, and an accelerator to said blend, thereby forming a blended dry powder having a Pat diameter of approximately 10.16 centimeters to 12.20 centimeters; and
- (d) combining said powder with heated water at a ratio of approximately 1 to 1, soaking said powder until saturated; and
- (e) mixing said combination of said powder and water until a slurry is formed which, during hardening, will have a volume increase of approximately 90% to 100% and a setting time of approximately 15 minutes.

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INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/07396

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (5): C04B 11/30; B28B 07/34, 36

U.S.CI.: 264/42 106/38.25, 38, 35

II. FIELDS SEARCHED

Minimum Documentation Searched ⁷

Classification System	Classification Symbols
IPC(5) U.S.CI.	C04B 7/04, 11/28, 11/30 106/38.35, 38.27, 38.35, 691, 726, 735, 782 264/42

Documentation Searched other than Minimum Documentation
to the Extent that such Documents are Included in the Fields Searched ⁸

III. DOCUMENTS CONSIDERED TO BE RELEVANT *

Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	US, A, 2,753,608 (NOLAN) 10 July 1956	1, 2, 5, 6, 15, 16
Y	See column 2, lines 3-9, 32-42. See column 2, lines 16, 20-25.	3-5, 7-9, 14
Y	US, A, 2,861,893 (BREWSTER) 25 November 1958 See column 2, lines 67-72.	3, 5, 8, 14
Y	US, A, 4,818,287 (RAVINS ET AL.) 04 April 1989 See column 3, lines 46-49.	7-9, 14
X	US, A, 4,127,628 (UCHIDA ET AL.) 28 November 1978	1, 2
Y	See column 2, lines 1-3 and column 4, lines 17-22, 54-59 and examples	3-6, 10-13, 15, 16
X	FR 2,058,727 TSENTRALNY NI In st Tekhnologii Mashinostroenia, 28 May 1971. Abstract.	1, 2, 15 4-7, 9-14, 16-17

* Special categories of cited documents: ¹⁰

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search

30 January 1992

Date of Mailing of this International Search Report

18 FEB 1992

International Searching Authority

ISA/US

Signature of Authorized Officer

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