Molding sand comprising biodegradable polymeric binder

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ABSTRACT

Molding sand containing (i) 100 parts by weight of refractory quartz or olivine matrix and (ii) 1 to 5 parts by weight of organic binder. The organic binder contains a mixture of (a) 40-50% w/w aqueous solution of sodium poly(acrylate) in the amount of 30-70% by weight and (b) 40-50% w/w aqueous solution of dextrin in the amount of 30-70% by weight.

CLAIMS (3)

The invention claimed is:

1. Molding sand, comprising:

(i) 100 parts by weight of refractory quartz or olivine matrix, and

(ii) between 1 and 5 parts by weight of an organic binder, wherein

the organic binder comprises a mixture of:

(ii-a) 30-70% by weight with respect to the weight of the organic binder of a 40-50% w/w aqueous solution of sodium poly(acrylate), and

(ii-b) 30-70% by weight with respect to the weight of the organic binder of a 40-50% w/w aqueous solution of dextrin.

2. The molding sand of claim 1, wherein the sodium poly(acrylate) has a weight average molecular weight Mw of 4,000-250,000 g/mol, pH of 7-9, and Brookfield viscosity of 400-5000 mPas.

3. The molding sand of claim 1, wherein the dextrin has a molar mass Mw of 4,000-8,000 g/mol, pH of 6.5-7.5, and a Brookfield viscosity of 4000 mPas.

DESCRIPTION

CROSS-REFERENCE TO RELATED APPLICATIONS

No foreign or domestic priority claims are being made at the present time. Inquiries from the public to applicants or assignees concerning this document should be directed to: Matthias Scholl P.C., Attn.: Dr. Matthias Scholl Esq., 14781 Memorial Drive, Suite 1319, Houston, Tex. 77079.

BACKGROUND OF THE INVENTION

1. Field of the invention

The invention relates to molding sand comprising biodegradable polymeric binder, for foundry use.

2. Description of the Related Art

Molding sand, also known as foundry sand, is sand that tends to pack well and hold its shape. It is used in the process of sand casting.

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. The term “sand casting” can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 70% of all metal castings are produced via a sand casting process.

Sand casting is relatively cheap and sufficiently refractory even for steel foundry use. In addition to the sand, a suitable binder is mixed or occurs with the sand. The mixture is moistened, typically with water, but sometimes with other substances, to develop strength and plasticity of the clay and to make the aggregate suitable for molding. The sand is typically contained in a system of frames or mold boxes known as a flask. The mold cavities and gate system are created by compacting the sand around models, or patterns, or carved directly into the sand.

There are four main components for making a sand casting mold: base sand, a binder, additives, and a parting compound.

Binders are added to a base sand to bond the sand particles together (i.e. it is the “glue” that holds the mold together).

A mixture of clay and water is the most commonly used binder. There are two types of clay commonly used: bentonite and kaolinite, with the former being the most common.

Oils, such as linseed oil, other vegetable oils and marine oils, used to be used as a binder, however due to their increasing cost, they have been mostly phased out. The oil also required careful baking at 100 to 200° C. (212 to 392° F.) to cure (if overheated the oil becomes brittle, wasting the mold).

Resin binders are natural or synthetic high melting point gums. The two common types used are urea formaldehyde (UF) and phenol formaldehyde (PF) resins. PF resins have a higher heat resistance than UF resins and cost less. There are also cold-set resins, which use a catalyst instead of a heat to cure the binder. Resin binders are quite popular because different properties can be achieved by mixing with various additives. Other advantages include good collapsibility, low gassing, and they leave a good surface finish on the casting. MDI (methylene diphenyl diisocyanate) is also a commonly used binder resin in the foundry core process.

Sodium silicate [Na_2SiO_3 or $(Na_2O)(SiO_2)$] is a high strength binder used with silica molding sand. To cure the binder carbon dioxide gas is used.

The advantage to this binder is that it occurs at room temperature and quickly. The disadvantage is that its high strength leads to shakeout difficulties and possibly hot tears in the casting.

Although much progress in the area of molding sand binders has been made over the years, much opportunity remains. Particularly, binders are needed that have better biodegradability, are easier to cross-link, and are easier to regenerate, all while providing molds and cores that have high microstructural homogeneity.

SUMMARY OF THE INVENTION

In one aspect, this invention provides molding sand comprising based on weight of the molding sand: (i) 100 parts by weight of refractory quartz or olivine matrix and (ii) 1 to 5 parts by weight of an organic binder, the binder comprising a mixture of: (ii-a) an aqueous solution of sodium poly(acrylate), in an amount of 30-70% by weight with respect to the weight of the binder, and (ii-b) an aqueous solution of dextrin, in an amount of 30-70% by weight with respect to the weight of the binder.

When using the mixture of sodium poly(acrylate) and dextrin as a binder, it has been observed that the binder features much better adhesion properties, allowing for a formulation of molding sand with much higher strength compared to existing formulations. It is significant also that the binder more readily distributes in the binder-matrix compound. Moreover, the binder shows much higher biodegradability compared to existing formulations.

The first component of the binder is sodium poly(acrylate) having polar properties. It is very highly soluble in water and, as a salt of a strong base, it maintains the pH within a range of 8-9, which affects the basic reaction of the binder and does not prevent its biodegradability. It is used as a 40-50% aqueous solution. Sodium poly(acrylate) has good adhesive properties, viscosity and wettability of the matrix grains (relatively low wettability angle). Furthermore, an active contribution of carboxylate groups (—COONa) present in sodium poly(acrylate) to the process of physical hardening of the molding sand, influences the achievement of highly cross-linked form. Molds and cores having higher strength are thus achieved in the hardening process.

The average weighted molar mass of sodium poly(acrylate) as used herein is about: 4,000, 10,000, 56,000, 60,000, 94,000, 123,000, 132,000, 156,000, 166,000, or 250,000 g/mol.

The second component is a modified biopolymer in the form of dextrin, which is well soluble in water (e.g., much better than carboxymethyl starch). Dextrin is used as a 40-50% aqueous solution. It has good viscosity and adhesion in relation to the binder-matrix compound. In addition, dextrin is fully biodegradable.

The average weighted molar mass of dextrin as used herein is about: 4,000, 6,000, or 8,000 g/mol.

In certain embodiments of the invention, a molding sand binder was prepared

Molds or cores made of the above compound are subjected to cross-linking reaction by microwaves or heat.

The sand of the invention is easy to break, and the water-soluble biopolymer contained in it causes the binder biodegradability, which is important for the storage of used sand and binder reactivity while hardening, and allows cross-linking with a physical factor. Furthermore, the used sand not fully burnt, can be subjected to a refreshing process, which allows easy recycling thereof. The compounds are also easier to regenerate thermally or mechanically. Moreover, the molds and cores allow high microstructural homogeneity and, thus, the mechanical, usability and corrosion properties across the entire cast, and good surface quality is achieved. The casts are free from such defects as: pits, roughness, gas porosity or graphite deformation at the subsurface layer. The compound causes minimum hazards to the workers and environment.

Whenever the term “molding sand” is used herein, it encompasses “molding sand”, i.e., sand that is used as the mold material to fill the casting flask, and “core sand,” i.e., sand that is used to make cores to be placed into the mold to create the interior contours of the casting.

DETAILED DESCRIPTION OF THE INVENTION Examples

The following general procedures were applicable to all examples.

A 250 g sample of polymer binder was formulated by mixing 40-50% aqueous solution of sodium poly(acrylate) with 40-50% aqueous solution of dextrin in a weight ratio of 1:1.

The process of mixing polymer components of the binder was performed using: (a) mechanical mixing with a mechanical mixer, PX-SR 90D laboratory mixer at 1000 rpm, mixing time 40 min., with the general binder preparation time of 60 min., (b) ultrasonic mixing using an ultrasonic device, Polsonic, Sonic 3 model, frequency 40 kHz, ultrasonic exposure of 40 minutes, the total preparation time of the polymer binder 60 minutes, or (c) hand mixing at an elevated temperature in a heating jacket, water temperature in the heating jacket was 60-80° C., total preparation time of the binder of 60 minutes.

Molding compounds were prepared as follows. To the Ms-017A vane mixer, 100 parts by weight of mineral matrix of quartz molding sand obtained from Jaworzno Szczakowa mine were added (sand type: 1K-0,2/0,16/0,32, PN-85/H-11001). Then, the specified amount of binder of 1 to 3 parts by weight, were added and the parts were mixed for 3 minutes.

LUZ-1 WADAP vibration device was a part of the densification system. The device was provided with a control module allowing for adjustment of vibration time and amplitude. The vibration frequency was a constant 50 Hz. The device was also provided with an execution module which enabled preparation of up to nine slabs having an equal compaction degree.

Molds or cores made of the above compound are subjected to cross-linking reaction by microwaves or heat.

Bending strength (for slabs) and compression strength (for rolls) were measured after hardening of the molding compounds. Measurements were made periodically at specified intervals of 1 h, 2 h, 3 h, and 24 h using the LRu-2e device for testing molding sand strength according to norm PN-83H-11073/EN. Strength values are averages of at least 6 measurement results.

All experiments and measurements were conducted at 20° C. (±2° C.) and relative air humidity of 45-50%.

Example 1

Molding sand comprising 100 parts by weight of quartz sand and 2.5 parts by weight of binder containing: 45% aqueous solution of sodium poly(acrylate) of 50% by weight and 40% aqueous solution of dextrin of 50% by weight.

Sodium poly(acrylate) was purchased from BASF (catalog number NJTS-50163-NVE, polymer in water, 45%-aqueous solution) and had the following properties: average weighted molar mass Mw=4,000 g/mol, pH=9, and Brookfield viscosity=500 mPas. Dextrin was purchased from SIGMA-ALDRICH® (ID 24858939, product number 31405 Fluka, dextrin from potato starch) and had the following properties: average weighted molar mass Mw=4,000 g/mol, pH=8.5, and Brookfield viscosity=400 mPas.

A mold was made of the sand, which was placed in a heating system at 150° C. for 120 minutes. After hardening, compound with compression strength after 24 hours storage=2 MPa, and bending strength after 24 hours storage=1.3 MPa was obtained.

Example 2

Core sand comprising 100 parts by weight of olivine sand and 2.5 parts by weight of binder containing 40% aqueous solution of sodium poly(acrylate) of 50% by weight and 40% aqueous solution of dextrin of 50% by weight.

Sodium poly(acrylate) was purchased from DWORY SA (polymer in water, 35% aqueous solution) and had the following properties: average weighted molar mass Mw=250,000 g/mol, pH=8.5, and Brookfield viscosity=5,000 mPas. Dextrin was purchased from SIGMA-ALDRICH® (ID 24858939, product number 31405 Fluka, dextrin from potato starch) and and had the following properties: average weighted molar mass Mw=4,000 g/mol, pH=7, and Brookfield viscosity=400 mPas.

A core was made of the compound, which was then exposed to microwave radiation from a source having a power of 800 W for 90 seconds. After hardening, compound with compression strength after 24 hours storage=2.5 MPa, and bending strength after 24 hours storage=1.5 MPa was obtained.

Example 3

Core sand comprising 100 parts by weight of quartz sand and 3 parts by weight of binder containing 40% aqueous solution of sodium poly(acrylate) of 50% by weight and 40% aqueous solution of dextrin of 50% by weight.

Sodium poly(acrylate) had the following properties: average weighted molar mass Mw=4,000 g/mol, pH=8.5, and Brookfield viscosity=400 mPas. Dextrin was purchased from SIGMA-ALDRICH® (ID 24858939, product number 31405 Fluka, dextrin from potato starch) and and had the following properties: average weighted molar mass Mw=4,000 g/mol, pH=7, and Brookfield viscosity=400 mPas.

A core was made of the compound, which was then exposed to microwave radiation from a source having a power of 800 W for 90 seconds. After hardening, compound with compression strength after 24 hours storage=2.7 MPa, and bending strength after 24 hours storage=1.5 MPa was obtained.

This invention is not to be limited to the specific embodiments disclosed herein and modifications for various applications and other embodiments are intended to be included within the scope of the appended claims. While this invention has been described in connection with particular examples thereof, the true scope of the invention should not be so limited since other modifications will become apparent to the skilled practitioner upon a study of the drawings, specification, and following claims.

CLASSIFICATIONS

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LEGAL EVENTS

Date	Code	Event	Description
Mar 3, 2013	AS	Assignment	**Owner name:** AKADEMIA GORNICZO-HUTNICZA IM. STANISLAWA STASZICA **Free format text:** ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNORS:GRABOWSKA, BEATA;HOLTZER, MARIUSZ;REEL/FRAME:029911/0176 **Effective date:** 20130219