BINDER COMPOSITION AND METHOD OF FORMING FOUNDRY SAND CORES AND MOLDS

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ABSTRACT

A cost-effective starch/water-based binder composition and related method for forming silica sand cores and molds for foundries, wherein the sand grains are pre-coated with starch having additives making the coated sand effective for blowing said cores and molds. One or more additives are included with the starch; preferably sodium tripolyphosphate and silicon or Siles BS16. The preferred starch is a tapioca starch. The binder of the invention is highly competitive due to its low cost and effectiveness for forming silica-sand cores and molds, being particularly effective for use in aluminum foundries for the automotive industry.
BINDER COMPOSITION AND METHOD OF FORMING FOUNDRY SAND CORES AND MOLDS

FIELD OF THE INVENTION

[0001] The present invention refers to a binder and a method of forming foundry sand cores and molds, and more particularly to a water-based binder and a method of forming silica sand cores and molds with great economic and environmental advantages over the currently used organic-compound binders.

BACKGROUND OF THE INVENTION

[0002] The automotive industry is extremely competitive and demanding regarding manufacturing costs of automobile components. The manufacturers of cylinder engine blocks and heads, mainly made of aluminum alloys, are constantly looking for methods and systems that provide cost savings and simultaneously increase the quality of such engine parts.

[0003] One of the preferred processes for manufacturing engine blocks and heads utilizes silica sand molds and cores. Currently, the molds and cores are most typically made of silica sand grains bound by a heat-curable phenolic binder or a gas activated cold box binder. The heat-curable binders have the disadvantage of requiring heat to set the molds and cores, producing foul-smelling vapors, and requiring special anti-pollution equipment to prevent ambient contamination. Another disadvantage arises once the cast motor blocks or heads are solidified, since removal of such cores and molds needs additional heat to burn off the binder by contact with hot air (in order to combust the binder and thus loosen the sand to destroy the cores), thus adding further to the fuel cost of the process.

[0004] There is a long-felt and ongoing need for a low-cost, energy efficient, and effective water-soluble binder for the molds and cores, particularly useful in the aluminum-alloys foundries, in order to decrease operational costs in the manufacture of engine blocks and heads.

[0005] Several early attempts to meet this need, going back many years, are mentioned below. [0006] U.S. Pat. No. 2,508,359 discloses a starch-containing product for use as a core binder, and more particularly to such a binder made from dextrinized corn flour.

[0007] U.S. Pat. No. 5,582,231 discloses a foundry mold member made from a plurality of sand particles bound together with a binder which consists essentially of gelatin (animal protein). The sand particles are coated with a film of a binder of gelatin having Bloom ratings of less than about 175 Bloom grams.

[0008] While a number of earlier patents teach the utilization of starch as an ingredient of water-soluble binders in different proportions for forming sand cores, the starch in such patents is used combined with binders like alkaline silicates and organic resins with which starch cooperates for providing the main binding effect. No reference has been found that addresses the problem of using starch as the main constituent of a binder composition which when mixed with the sand provides sand with good flow characteristics so that it can be effectively utilized to be air-blown into core forming boxes. The present invention provides a starch-based binder composition employable in the widely-used core forming process of blow boxes where it is desired to have a strong setting sand bonding agent and at the same time a sand mix that easily flows into the core molds and fills all the spaces in the geometries of even complex sand molds, such as for automotive parts. The binder composition of the invention comprises specific additives which mixed with starch and sand are specially suited for such core making process.

[0009] The following patents are of general background interest which are not directly related with the invention.

[0010] U.S. Pat. No. 4,070,196 “Binder compositions” discloses a binder composition consisting essentially of an aqueous solution of an alkali metal silicate and a stabilized starch hydrolysate having a dextrose equivalent of below 5. The components being present in the weight ratios, calculated as solids, of 0.4 to 35 parts of stabilized starch hydrolysate per 20 to 49.5 parts alkali metal silicate. The mixture is hardened either by gassing with carbon dioxide or by incorporating chemical hardening agents such as esters of polyhydric alcohols.

[0011] U.S. Pat. No. 4,158,574 “Hydrolyzed amylaceous product and process of making same” relates to a foundry binder system employing glyoxal, a polyhydroxyl compound and a unique catalyst comprised of inorganic alkali halides. The polyols used are those that react rigidly with glyoxal including sugars, starch, starch hydrolysates, gums and dextrins. The general object of the invention is to make it possible for glyoxal to be used as a low-cost resin-forming binder system with control over the rate of setting.

[0012] U.S. Pat. No. 3,642,503 “Process for bonding particulate materials” teaches the use of an aqueous alkali metal silicate, silicon, dicaleium silicate and lime. An organic additive may be added to retard the setting of the binder, for example glucose or dextrose. No starch is mentioned.

[0013] Documents cited in this text (including the foregoing patents), and all documents cited or referenced in the documents cited in this text, are incorporated herein by reference. Documents incorporated by reference into this text or any teachings therein may be used in the practice of this invention.

[0014] Applicants have found suitable additives for providing starch-based binder with sufficient fluidity for using the standard method of blowing sand cores while at then same time obtaining cores of sufficient strength and shape definition with the combination of additives in a predefined proportion thus providing a suitable core and mold making process at a competitive cost.

OBJECTS AND SUMMARY OF THE INVENTION

[0015] It is therefore an object of the present invention to provide a competitively effective water-soluble binder composition for forming sand cores and molds for foundries with several cost and technical advantages plus environmental benefits, as well as the method of making such cores and molds and the cores and molds made with such composition.

[0016] It is another object of the present invention to provide a method of forming sand cores and molds for foundries at a lower cost.

[0017] It is a further object of the invention to provide such a binder for forming sand cores and molds for foundries that do not require enclosed installations for control of foul smelling vapors in foundries.

[0018] It is still another object of the invention to provide a method, a binder composition, and sand cores and molds
for foundries for producing castings with dimensional precision that advantageously avoids the need to use higher-cost zircon sand to obtain comparable results.

[0019] It is yet a further object of the invention to achieve all the foregoing objectives using a starch-based binder and its starch derivatives (dextrines for example) that is demonstratively more effective than any starch-containing binder taught in the prior art.

[0020] The objects of the invention are generally met according to one aspect of the present invention by a binder made from starch having additives to improve flowability, to improve water repellency, and optionally to improve as needed the coating of the sand by the other additives by use of wetting agents.

[0021] Applicants have determined that the mix of silica sand with any kind starch can be used to make sand cores for some limited foundry purposes. Even insoluble amylopectin can be used when a proper temperature is applied. The sand mix can be dumped into any core box with most any geometry and compacted to make the desired cores.

[0022] However, to be commercially and competitively useful, the sand mix must be able to be blown into, and thereby be compacted in, the mold forms. In practice, the coated sand typically is pushed through blow pipes of about 1 inch or less in diameter, using air pressure. The applicants have been able to achieve this goal of using low cost water soluble starch as a core binder capable of being effectively blown by use of selective additives.

[0023] Such additives that have been found to effectively increase flowability are: sodium tripolyphosphate, sodium hexametaphosphate, dicalcium phosphate dihydrate, sodium chloride, dimethylpolysiloxane and ethyl alcohol. All these additives match very well with the water repellency additives described below.

[0024] Such additives that have been found to effectively control water repellency are: Alkyl silicone (Silres BS69050), triethoxo (2,4,4 trimethylpentil) silane, oleyl triethoxi silane plus alkyl silicone Silres BS 16, Wax emulsions, paraffin waxes, wax polymers, natural and paraffin wax combinations under different trade names were tested with acceptable results.

[0025] Such water repellency additives that have been found to be particularly useful in this invention are: triethoxi (2,4,4 trimethylpentil) silane, oleyl triethoxi silane plus alkyl silicone Silres BS 16. Wax emulsions, paraffin waxes, wax polymers, natural and paraffin wax combinations under different trade names were tested with acceptable results.

[0026] In addition, the applicants have determined that some starches are better than others when used in commercial applications. As part of their ongoing research, tapioca starch has been found to be superior to corn and potato starch with regard to the amount needed to achieve the same mechanical strength in the core.

[0027] The amyllose/amyllopectin ratio for tapioca is given as 0.22. Although the amyllose is a linear chain of 500 to 2000 glucose units, the amyllopectin is more massive and branched with linear chain lengths of 25-30 glucose units.

[0028] Preferred embodiments of a binder according to the present invention comprise about 70%-95% starch (or more preferably 70%-90%, or still more preferably 70%-85%) plus additive(s) (such as, for example, preferably sodium tripolyphosphate and silicon or Silres BS 16, or their functional equivalents).

[0029] Silres BS®16 is the tradename of Wacker Chemie, AG for a concentrated water solution of 1-5% potassium hydroxide and 40-70% potassium methyl silicate (per the list of ingredients in that company’s Material Safety Data Sheet for the U.S.); more specifically, that company’s product brochure for Silres BS®16 gives the solids content as 54 wt. % and the approximate active ingredients as 34%.

[0030] A preferred method for making a binder coated sand according to the present invention is by forming silica sand cores and molds for foundries utilizing a starch-water-based binder comprising mixing silica sand grains with starch in a suitable mixer, adding water to said sand and starch mixture and continue mixing said sand, starch, and water so that the sand grains are coated with starch (typically in about one minute); drying the starch-coated sand grains and treating them in a mill to break down lumps which might have been formed during the starch-coating step and screening the sand to separate said lumps; adding water to said coated sand grains and screening said sand grains for homogenizing and loosening said grains; adding sodium tripolyphosphate and silicon or Silres® BS 16; optionally adding dispersing additives; and blowing said cores and molds utilizing said starch-coated sand grains.

[0031] Alternatively, applicants have determined that such binder coated sand can also be made by direct mixing of sand and binder from starch and additives before blowing.

[0032] The objects of the invention are also met by providing a core or mold made from the starch/water based binder composition of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. 1 shows a process block diagram illustrating the main steps of a method illustrating one preferred embodiment of the invention for the manufacture of sand molds and cores utilizing an artificially-modified tapioca type starch.

[0034] FIG. 2 shows a second preferred embodiment: being a process, similar to that in FIG. 1, modified to utilize native tapioca type starch.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0035] The present invention will be better understood with reference to the following detailed description of certain specific embodiments thereof.

[0036] Silica sand cores are made from sand grains bound by a suitable binder which provides a strong bond between such sand grains in such a manner and with a sufficient capacity to withstand the handling of the cores and the assembled molds without losing the precise dimensions and form needed for impressing the desired geometry and surface quality to the casting under the temperature and pressure of the molten metal used to form said casting.

[0037] Currently, sand cores are shaped by mixing sand and a binder, blowing the binder-sand mixture into a mold having the desired shape, and curing or hardening the binder in the mold so that the mold geometry is fixed in the cores after their removal from said mold.

[0038] There are a variety of synthetic resins used as binders as is known in the art. According to the present invention, a water-based binder and a method for forming the sand cores provide a number of advantages over the current state-of-the-art binders regarding manufacturing costs and core qualities.

[0039] The binder of the invention is mainly composed of starch. Though starch has been utilized as an additive to
prior-art binders, mostly in proportions of less than 20% of the binder composition, to the best of applicants’ knowledge it has not previously been effectively used as the main constituent of a sand core-making binder in mass production foundries. According to a preferred embodiment of the present invention, two additives are added to the starch, in the proportions and in the form explained below, which in combination with the starch, provide the desired qualities to the formed cores. These additives are sodium tripolyphosphate and silicon or Silres BS 16. More broadly, the separate functions of the two additives with certain starches may be found in only one single additive.

[0040] There are several types of starch suitable to be utilized as the basis of the binder composition of the invention. One difference among them is the amount of starch needed to achieve the same mechanical strength. For example potato requires more than 2% weight (based on sand) and for maize close to 2% weight. However, when using Tapioca starch, the core needs significantly less starch content to achieve the same strength.

[0041] Tapioca starch is thus preferably used but other varieties of starch can also be utilized according to broader aspects of the invention. There are two types of tapioca starch: (a) native (i.e. unmodified) starch and (b) artificially-modified starch. Both types have proven effective as binders for the particular application of core making. The method of the invention may have some differences depending on which type of tapioca starch is utilized.

[0042] The core-making method of this embodiment of the invention will be described first as applied to the utilization of artificially-modified tapioca starch. With reference to FIG. 1 showing a diagram of the method steps for forming such cores, silica sand 10 is mixed with the artificially-modified starch 12 in a proportion of from about 0.5% to 3.0% by weight on the basis of the sand weight, in a paddle mixer 14 for a period of time from about 30 seconds to about 120 seconds. This period of time must be sufficient for achieving a good dispersion of the starch over the surface of the sand particles. After this first mixing step, water 16 is slowly added to the sand-starch mixture preferably in a proportion from about 5% to 10% by weight on the basis of the sand weight and the sand-starch-water mixture is mixed in said mixer 14 for at least 1 minute, producing starch-coated sand grains 18 which are then allowed to dry naturally (indicated by dotted line 19) or optionally in a suitable drying furnace 20 for accelerating the drying process and thereby increasing the process productivity. The furnace 20 can be of the type having forced air 17. The dry starch-coated sand 18 is then treated in a suitable mill 22 (for example, a ball mill or a vibrating shaker) for destroying the sand lumps which may have been formed during the previous step. Thereafter, the milled coated sand 23 is screened on a screen 24, for example utilizing a sieve # 30 for assuring that all the sand grains have a homogeneous particle size. Sand lumps 25, separated from the coated loose sand grains, are recycled to mill 22. After screening, the starch-coated sand 23 undergoes a second mixing step in a mixer 28 where water 35 is added in a proportion preferably of at least 2% by weight on the basis of the sand weight, also sodium tripolyphosphate 32 is added in a proportion of from 0.1% to about 0.2% by weight on the basis of the sand weight, and silicon 34 from about 0.1% to 0.2% or Silres DS 16 from about 0.02% to 0.06%, resulting in sand ready for core blowing in blower 36 where the final core 38 is formed.

[0043] Referring now to FIG. 2, wherein same numerals designate the same elements, the method therein described is the method followed when native-type tapioca starch is used for binding the sand grains in cores and molds. Silica sand 10 is pre-heated to a temperature in the range from about 110° C. to about 130° C. in a furnace 13. The preheated sand is then transferred to the mixer 14 to follow the rest of the method in the same manner as above-described for the artificially modified starch.

[0044] Water 16 is also preferably heated to a temperature of about 70° C. in order to preserve as much as possible the temperature of the sand above about 70° C. The amount of water 16 added at this mixing step should be sufficient to reach a humidity level in the range from about 2% to about 4% of the humid sand weight.

[0045] The rest of the method illustrated in FIG. 2 is the same as in FIG. 1.

[0046] It is of course to be understood that in the above specification, only certain specific embodiments have been included for purposes of illustrating the principles of the invention and that the invention is not intended to be limited thereto. It will also be evident that numerous changes may be made to the embodiments herein described without departing from the spirit and scope of the invention which is limited only to the extent set forth in the appended claims.

What is claimed is:

1. A method of forming silica sand cores and molds for foundries utilizing a starch-water-based binder comprising mixing silica sand grains with starch in a suitable mixer, adding water to said sand and starch mixture and continuously mixing said sand, starch and water so that the sand grains are coated with starch; drying the starch-coated sand grains and treating them in a mill for destroying lumps formed during the starch-coating step; adding water to said coated sand grains and screening said sand grains for homogenizing and loosening said grains; adding at least one additive selected from the group consisting of sodium tripolyphosphate, silicon and a concentrated water solution of 1-5% potassium hydroxide plus 40-70% potassium methyl silicate; and blowing said cores and molds utilizing said starch-coated sand grains.

2. The method according to claim 1, wherein said silica sand is mixed with starch in a proportion of from about 0.5% to 2% by weight on the basis of the sand weight.

3. The method according to claim 1, wherein said sand grains and starch are mixed in a paddle mixer for a period of time from about 30 seconds to about 120 seconds.

4. The method according to claim 1, wherein water is added to the sand-starch mixture in a proportion from about 5% to 10% by weight on the basis of the sand weight.

5. The method of forming silica sand cores and molds according to claim 1, wherein said starch-coated sand grains are allowed to dry naturally.

6. The method of forming silica sand cores and molds according to claim 5, wherein said starch-coated sand grains are dried in a drying furnace for increasing productivity.

7. The method of forming silica sand cores and molds according to claim 1, wherein the dry starch-coated sand is treated in a ball mill or a vibratory shaker.

8. The method of forming silica sand cores and molds according to claim 1, further comprising screening the starch-coated sand and thereafter mixing said starch-coated sand with water in a proportion of at least 2% by weight on the basis of the sand weight.
9. The method of forming silica sand cores and molds according to claim 1, wherein said additive is sodium tripolyphosphate, which is added in a proportion of from about 0.1% to about 0.2% by weight on the basis of the sand weight; and a further additive is silicon being also added in the same proportion.

10. The method of forming silica sand cores and molds according to claim 1, wherein said additive is sodium tripolyphosphate, which is added in a proportion of from about 0.1% to about 0.2% by weight on the basis of the sand weight; and a further additive is iron oxide is also added in the same proportion.

11. The method of forming silica sand cores and molds according to claim 1, further comprising heating said sand to a temperature in the range from about 110° C. to about 130° C. prior to mixing said sand with water and starch.

12. The method of forming silica sand cores and molds according to claim 1, wherein said starch is artificially modified tapioca starch.

13. The method of forming silica sand cores and molds according to claim 1, wherein said starch is native tapioca starch.

14. The method of forming silica sand cores and molds according to claim 11, wherein said starch is native tapioca starch.

15. A starch-water-based binder composition suitable for forming silica sand cores and molds for foundries, comprising from about 1.0% to about 1.5% by weight of starch; and from about 0.1% to about 0.2% by weight of sodium tripolyphosphate; and from about 0.1% to about 0.2% by weight of silicon; all on the basis of the sand weight.

16. A starch-water-based binder composition suitable for forming silica sand cores and molds for foundries, comprising from about 1.0% to about 1.5% by weight of starch; and from about 0.1% to about 0.2% by weight of sodium tripolyphosphate; and from about 0.1% to about 0.2% by weight of silicon; all on the basis of the sand weight.

17. A starch-water-based binder composition according to claim 15, suitable for forming silica sand cores and molds for foundries, wherein said starch is tapioca starch.

18. A starch-water-based binder composition according to claim 15, suitable for forming silica sand cores and molds for foundries, wherein said starch is artificially modified tapioca starch.

19. A starch-water-based binder composition according to claim 15, suitable for forming silica sand cores and molds for foundries, wherein said starch is artificially modified tapioca starch.

20. A starch-water-based binder composition according to claim 15, suitable for forming silica sand cores and molds for foundries, wherein said starch is native tapioca starch.