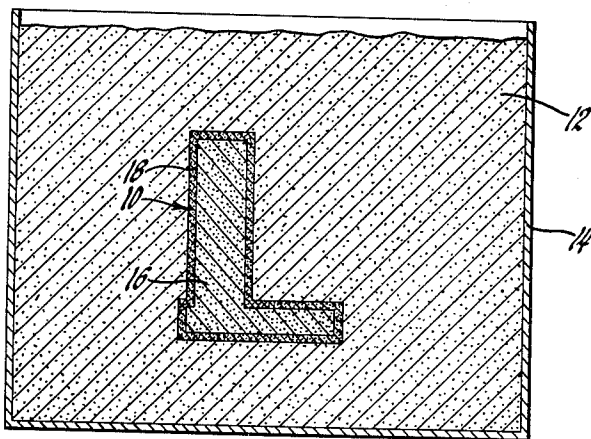


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SAND CORES HAVING HIGH-TEMPERATURE STRENGTH AND METHOD OF PRODUCING SAME

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This invention relates to sand cores having high-temperature strength and particularly to a method of forming such cores.

To produce certain precision cast parts, such as hollow precision cast turbine buckets, it is necessary to use cores which have high strength at both room temperature and elevated temperatures. Typical sand cores heretofore used in normal foundry practice have been unable to adequately meet these strength requirements. The untreated oil binders of common sand cores burn and volatilize at elevated temperatures, thereby precluding the satisfactory use of such cores in the production of precision castings employing hot molds.

The principal object of our invention, therefore, is to overcome the aforementioned difficulties by providing a process which produces a core having not only the required permeability and collapsing characteristics but also possessing unusual high-temperature strength and resistance to "burn in" by the casting metal.

Other objects and advantages of this invention will more fully appear from the following description of a preferred process for forming such sand cores having the aforementioned desirable properties, reference being made to the accompanying drawing showing a sectional view of the resultant core structure.

In accordance with our invention, a new and useful core possessing the above characteristics may be made from common foundry materials by a process wherein a green core is initially baked, subsequently immersed first in an ethyl silicate solution and later in a waterglass solution, and finally dried and sintered.

More specifically, superior results have been obtained in accordance with a procedure embodying the invention in which a suitable mixture of sand and binder, usually core oils, is first rammed or blown into a core box. The uncured core thus formed is preferably next dried by heating in a circulating air oven at a temperature in the range between approximately 300° F. and 500° F. The core should remain in the oven until it is thoroughly dry, a baking period of at least two hours producing best results in most instances.

The baked core is then immersed in a hydrolyzed or condensed ethyl silicate solution, preferably for a period of time sufficient to soak completely through the core. We have found an immersion period of from three to fifteen minutes to be appropriate for cores of conventional sizes. A typical example of the ethyl silicate solution preferably used is the commercially available condensed ethyl silicate which contains, by volume, approximately 50% ethyl silicate, 0.5% hydrochloric acid, and the balance methyl alcohol and water. It will be appreciated, however, that any hydrolyzed or condensed ethyl silicate solution may be satisfactorily used in this process so long as the ethyl silicate content is sufficient to provide the proper bonding of the interior of the core upon the subsequent baking and sintering operations.

In order to obtain this result, we have found it advantageous in most instances to employ a solution which

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contains at least 10% by volume of ethyl silicate. With respect to the permissible upper limits of the concentration of the ethyl silicate solution, it is desirable that condensing conditions exist. Accordingly, to insure these conditions, we have found it feasible to use a solution which contains only enough water to provide a sufficient amount of hydrolysis to obtain the above desirable bonding and strengthening effects upon sintering or to otherwise use ethyl silicate under hydrolyzing conditions.

Apart from other consideration, however, it should be noted that it is preferable not to use a solution having too high an ethyl silicate content because the increased viscosity of such a solution prevents the proper rapid permeation of the core. On the other hand, if the concentration of the ethyl silicate solution is too low, the resultant core will not possess the requisite high temperature strength. Accordingly, we have obtained best results by the use of a hydrolyzed or condensed ethyl silicate solution having an ethyl silicate content between 25% and 75% by volume.

Following the ethyl silicate treatment the core should again be dried, preferably in air, until all the volatile constituents have disappeared. In most instances this will require at least twenty minutes, and we have found that thirty minutes is a typical drying period for a core having a cross-sectional thickness of approximately 1/4". After the core has been thus dried, it is immersed in a waterglass solution and again dried, preferably in air, for a minimum of one hour. The length of time the core should remain immersed in the waterglass solution is determined, of course, by the amount of penetration desired, the latter in turn being governed by the size of the bore and the concentration of the waterglass solution. We have found, for example, that most applications require an immersion period of approximately five minutes to one-half hour.

Although we prefer to use sodium silicate, which is very inexpensive, it should be understood that our invention is not limited to that particular silicate. By the term "waterglass" we wish to include not only sodium silicate and its water solutions, but also potassium silicate and mixtures of these two silicates, the latter generally being referred to as "double waterglass." Moreover, the use of sodium tetrasilicate, if the silicate is to be introduced in that form, is also meant to be included within the scope of this invention. Accordingly, statements hereinafter made with reference to "waterglass" or "sodium silicate" compositions are intended to also encompass the use of the above other silicates.

As is the case with the ethyl silicate solution, it is usually desirable not to use an extremely concentrated waterglass solution because the high viscosity of such a solution prevents it from properly and rapidly penetrating the core. Hence, it is frequently advantageous to add water to commercial waterglass solutions. On the other hand, the lower limits of the sodium silicate content, for example, are governed by the amount required to provide an outer layer which may be appreciably hardened by the sintering operation. Moreover, if the sodium silicate content is too low, the waterglass solution will penetrate the core too rapidly, thus making it difficult to control this immersion operation and to obtain an outer layer having a fairly uniform thickness. To provide satisfactory results, therefore, the concentration of the waterglass solution should be between 3.5% and 40%, optimum properties being obtained in the core through the use of an aqueous sodium silicate solution containing between 20% and 30% by weight of sodium silicate. Hence, we have found it convenient to employ commercially available waterglass having a sodium silicate content ranging from 30% to 40%.

It will be appreciated that the water content in the

above examples is the sum of the water of hydration and any additional water which may be present in commercial waterglass, together with any other water which it may be desirable to add to satisfactorily wet the sand and binder materials in the core. Accordingly, either the pure or commercially pure solid silicates may be employed in conjunction with the amount of water necessary to bring the water content to the above percentages, or commercial waterglass solutions may be used with water being added, if it is found advantageous to do so, in order to provide sufficient wetting properties.

The core is necessarily subjected to the ethyl silicate soak prior to the treatment with waterglass in order to permit the saturation of the entire interior portions of the core with the ethyl silicate solution. This sequence permits the ethyl silicate to "set" during the intermediate drying period, and thus prevents dissolution of the ethyl silicate in the subsequent waterglass soak.

The treated green core, which is indicated generally by the reference numeral 10 in the drawing and which is shown as being an L-shaped core for use in forming a hollow turbine bucket, is sintered subsequent to the last drying operation. This sintering operation may be conveniently carried out by burying the core in silica sand 12 contained in a suitable receptacle 14 and sintering the core while buried in the silica sand. Inasmuch as sodium silicate melts at approximately 1700° F. to sinter the core sand particles together, the sintering temperature must be above this point. At the same time, however, the temperature should not be permitted to exceed the melting temperature of the sand particles, which is approximately 2500° F., in order to prevent loss of green core strength. Accordingly, we have found that a sintering temperature within the range between 1900° F. and 2300° F. is desirable in most instances. Normally the core should be sintered for at least thirty minutes to provide the proper high-temperature strength.

Fairly coarse silica sand is preferably employed as the supporting sand 12 in order to prevent the sintering of this sand to the tacky core. Coarse sand also provides less contact surface between the core and the supporting sand, thereby further reducing the aforementioned danger of sintering the sand to the core.

Following the sintering process, the core is cooled, preferably in still air, while within the sand support to eliminate differential cooling in various parts of the core. The treated core is then removed from the sand support at room temperature and is immediately ready for use in high temperature casting operations.

Inasmuch as the initial steps of ramming or blowing the sand core and of baking in a circulating oven are standard foundry core-making practices, the desired high-temperature permeability and collapsibility properties required for the types of cores under consideration must be acquired through further conditioning. This is accomplished by the subsequent immersion, baking and sintering steps described in the above process. As a result of this further conditioning, the core 10 is formed with a bonded, relatively soft center portion 16 containing sintered ethyl silicate. This center portion is surrounded by a hard outer shell 18 containing both sintered sodium silicate, if that is the type of "waterglass" used, and sintered ethyl silicate.

The relatively soft interior 16 of the core permits the necessary collapsibility, thus preventing upsetting of the casting. The ethyl silicate penetration also contributes to the strength of the core, while a deeper waterglass or sodium silicate penetration, to the exclusion of ethyl silicate, would result in a core which is excessively brittle. At the same time, the hard exterior layer 18 of the core provides adequate strength to prevent distortion by warpage, cracking and thermal shock, and yet retains sufficient permeability to permit the escape of the formed gases and to prevent the formation of gas pockets in the casting.

The duration of the final immersion of the core in the waterglass solution may be adjusted to produce any desired degree of penetration of the core, of course, the depth of this penetration thus predetermining the thickness of the final hard outer shell produced during the high-temperature sintering. Inasmuch as the soaking time and the depth of penetration are related, it is evident that an excessive soaking period produces a thick outer shell which is so rigid that the necessary collapsing characteristics are lost. The desired thickness of this hard outer shell can be varied, however, to give comparable results between cores of different cross-sectional dimensions. For example, we have determined that excellent results may be produced by this process when the combined thicknesses of two oppositely disposed portions of the hard outer layer 18 are not more than approximately one-fourth the average thickness of the interjacent softer interior portion 16 in cores which are approximately ¼" thick. Cores of greater thickness require an adjustment of this ratio in favor of deeper waterglass penetration in order to obtain optimum strength for many precision casting operations at high temperatures.

Inasmuch as the binder solutions do not provide the cores with adequate green strength before and during the baking operation, support for the cores is required during this period. The lack of green strength of the cores is intensified with increasing temperatures until the curing and sintering temperature is reached and the operation completed. It has been observed that the adhesive properties of the binder material are very poor at intermediate temperatures and that the high strength characteristics of the final sintered core are almost totally dependent upon extremely high curing and sintering temperatures.

In order to provide for adequate support of the core during the sintering operation without affecting the shape of the core because of differential expansion of the adjacent parts, therefore, the support should be self-adjusting without core interference. As hereinbefore indicated, we have found that this may be accomplished by embedding the impregnated core in the silica sand 12 contained in the receptacle 14. Upon heating, movement of the sand particles is permitted and the core is not completely restrained at any location, thus providing for self-adjustment of the core support.

It will be understood that the term "core," as used herein, is generally meant to define a casting form which includes certain "molds" requiring high strength at elevated temperatures, this invention not being limited to conventional "cores" as such.

While our invention has been described by means of certain specific examples, the scope of the invention is not to be limited thereby except as defined in the appended claims.

We claim:

1. A method of treating a sand core to increase its high-temperature strength which comprises immersing a sand core in an ethyl silicate solution for a period of time sufficient to soak substantially through said core, and subsequently immersing said core in a waterglass solution for a time sufficient to form a hard outer supporting layer.

2. A method of treating a sand core to increase its high-temperature strength which comprises immersing a sand core in an ethyl silicate solution containing at least 10% by volume of ethyl silicate for a period of time sufficient to substantially permeate said core, subsequently drying said core, and thereafter immersing the dry core in a 3.5% to 40% waterglass solution for a time sufficient to produce a hard outer waterglass-impregnated layer.

3. A method of treating a sand core having approximately the same refractory composition throughout its cross section to increase its high-temperature strength, said method comprising immersing a sand core in condensed ethyl silicate for a period of time sufficient to soak substantially through the core, subsequently immersing

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said core in a waterglass solution, and thereafter sintering said core.

4. In foundry operations, a method of treating a sand core having approximately the same refractory composition throughout its cross section to increase its high temperature strength, said method comprising immersing a sand core in condensed ethyl silicate for a period of time sufficient to substantially permeate the core, drying said core until most of the volatile constituents have been removed, immersing the dry core in a waterglass solution, again drying the treated core for a period of time sufficient to drive off substantially all the volatile constituents, and thereafter sintering the core.

5. A process for treating a sand core to increase its high-temperature strength which comprises immersing a baked sand core in condensed ethyl silicate for a period of time sufficient to soak substantially through said core, thereafter drying said core, immersing said core in a waterglass solution for a time sufficient to form an outer layer, subsequently burying the core in silica sand contained in a suitable receptacle, and finally sintering the impregnated core at a temperature between 1700° F. and 2500° F. while buried in the silica sand.

6. A method of treating a sand core to increase its high-temperature strength which comprises immersing a sand core in an ethyl silicate solution having a concentration of at least 10% for a period of time sufficient to substantially permeate said core, drying said core until most of the volatile constituents have been removed, immersing the dried core in a 3.5% to 40% aqueous solution of sodium silicate, again drying the treated core for a period of time sufficient to drive off substantially all the volatile constituents, subsequently burying the dry core in silica sand and thereafter sintering said core.

7. A process for treating a sand core to increase its high-temperature strength which consists of immersing a sand core in hydrolyzed ethyl silicate for three to fifteen minutes, air drying said core for at least twenty minutes, subsequently soaking the dry core in an aqueous sodium silicate solution containing 3.5% to 40% by weight of sodium silicate, subsequently again air drying the treated core for at least one hour, and thereafter sintering said core at a temperature between approximately 1700° F. and 2500° F.

8. In foundry operations, a method of treating a sand core to increase its high-temperature strength which consists of soaking a baked sand core in an ethyl silicate solution containing at least 10% by volume of ethyl silicate for at least three minutes, air drying said core for at least twenty minutes, subsequently immersing the dried core in a 3.5% to 40% aqueous solution of sodium silicate for at least five minutes, again air drying the treated core for at least one hour, thereafter burying the dried core in coarse silica sand, and finally sintering the core at a temperature within the range of approximately 1900° F. to 2300° F. for a time sufficient to produce the required high-temperature strength.

9. A process for forming sand cores characterized by high-temperature strength which comprises forming a sand core of suitable proportions of sand and binder materials, baking the formed core at a temperature between 300° F. and 500° F. for at least two hours, immersing the baked core in hydrolyzed ethyl silicate for at least three minutes, drying the treated core to remove substantially all the volatile constituents, subsequently immersing the dried core in a waterglass solu-

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tion for a period of time sufficient to provide an outer supporting layer, and thereafter sintering the impregnated core at a temperature between 1700° F. and 2500° F.

10. A process for forming a sand core characterized by high gas permeability, collapsibility and high-temperature strength, said process comprising forming a sand core of suitable proportions of sand and binder materials, baking the formed core in a circulating oven at a temperature between 300° F. and 500° F. for at least two hours, immersing the baked core for three to fifteen minutes in a hydrolyzed ethyl silicate solution having an ethyl silicate concentration between 25% and 75%, air drying the treated core until substantially all the volatile constituents have been driven off, subsequently immersing the dried core in an aqueous sodium silicate solution containing between 3.5% to 40% by weight of sodium silicate for five minutes to one-half hour, again air drying the treated core to remove substantially all the volatile constituents, burying the core in a silica sand support, thereafter sintering the impregnated core by heating within the temperature range of 1900° F. to 2300° F. for at least thirty minutes, and finally cooling the core within the sand support.

11. A unitary sand core characterized by high-temperature strength and having an interior portion impregnated with ethyl silicate and an outer layer impregnated with waterglass and ethyl silicate.

12. A unitary sand core for use in casting operations at elevated temperatures, said core having approximately the same refractory composition throughout its cross section, said core being provided with a bonded interior portion impregnated with sintered ethyl silicate and a harder outer layer impregnated with both sintered ethyl silicate and sintered waterglass.

13. A one-piece sand core for use in metal casting operations and characterized by high gas permeability, collapsibility and high-temperature strength, the interior portion of said core being impregnated with a binder of sintered ethyl silicate, the outer portions of said core being formed into a hard layer impregnated with both sintered ethyl silicate and sintered sodium silicate, said layer having approximately the same refractory composition as the interior portion of said core.

14. A unitary core for use in metal casting operations and characterized by high-temperature strength, said core being formed principally of sand having approximately the same refractory composition throughout its cross-sectional area, said core being provided with an interior portion bonded with sintered ethyl silicate and a harder outer layer impregnated with both sintered ethyl silicate and sintered sodium silicate, the combined thicknesses of two oppositely disposed portions of the harder outer layer being at least one-fourth the average thickness of the interjacent softer interior portion of the core.

References Cited in the file of this patent

UNITED STATES PATENTS

921,002	Roberts	May 11, 1909
1,193,416	Owen	Aug. 1, 1916
2,195,452	Erdle	Apr. 2, 1940
2,391,855	Bean	Dec. 25, 1945
2,441,695	Feagin et al.	May 18, 1948

FOREIGN PATENTS

466,904	Great Britain	June 8, 1937
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