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(54) MANUFACTURE OF FOUNDRY MOULDS AND CORES

(71) We, THE WHITE SEA & BALTIC COMPANY LIMITED, a British Company of Patman House, George Lane, South Woodford, London, E18 2SA, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 In making foundry moulds and cores the particles of the foundry sand or other inorganic aggregate used must be bound together. A variety of binder systems have been proposed for this purpose, the binders sometimes being organic, sometimes inorganic and sometimes organic/inorganic mixtures. In some cases heating is necessary to make the binder systems effective whilst others are designed to be effective at room temperature. In some cases a distinct catalyst or hardening agent is present in the binder system and, often, the binder systems are aqueous-based.

25 Normally a mixture of the aggregate and binder system is put in a mould or core box, caused or allowed to set and the mould or core then removed from the box. In cases where heating has been necessary this has been achieved by use of external heating means e.g. external gas burners or electrical heating elements in the walls of the core or mould box or outside the box.

35 In accordance with the present invention a foundry core or mould is made by a process comprising putting a mixture, containing water and electrolyte, of the aggregate and binder into a core or mould box, and causing or allowing the mixture to set, in which the setting is caused or assisted by passing an electric current through the mixture. In the process there may be used a foundry core or mould box that has at least two internal electrodes and means for passing an electric current between them.

45 Naturally the current can only pass be-

tween the electrodes when there is a suitable mixture of aggregate and binder system in the box. By passing the current, heating of the mixture can be effected and setting thereby caused or assisted.

50 In known processes where the mixture in the core or mould box has been heated to cause setting, the conversion of energy consumed by the heating means to useful thermal energy has been low since much of the heat generated has been wasted by external conduction and radiation and has therefore not been of use in heating the mixture of the aggregate and binder system. Also the known processes have all involved indirect heating in the sense that they have been entirely dependent on the applied heat being conducted through the mixture; this is unsatisfactory, particularly for large cores or moulds, since the thermal conductivity of the mixture is low and thus, in the first place, a considerable time is needed for the mixture to be heated and, in the second place, it is very difficult to achieve uniform setting throughout the core or mould.

75 So that core and mould boxes can be used at as frequent intervals as possible it is of great economic importance in foundries that the setting time of the mixtures should be as short as possible. Admittedly a variety of ways of obtaining short setting times are known but there comes a point when shorter setting times are only obtained at the expense of cores or moulds of lower strength. For example, in the case of binder systems comprising an acid-hardenable resin and an acidic catalyst, although the setting time can be decreased to a certain extent by using higher proportions of catalyst, if this is done the strength of the core or moulds tends to suffer.

85 The present invention enables shorter setting times to be obtained in a satisfactory way without loss of core or mould 90

strength in the case of binder systems which which will cause setting at room temperature. In fact, as a result of the heating, the strength of the cores or moulds may be increased since, for example with resin-based binder systems a higher degree of condensation can be achieved than at room temperature. Also, the invention is advantageous in the case of binder systems where heating is essential since, as will be described hereinafter, the way in which the heating is effected is quite generally advantageous compared with the known indirect heating methods.

15 In the process of the present invention the heating of the mixture that can be effected is direct as a result of the electric current passing through the mixture, this being possible because of the use of the mixture comprising water and an electrolyte. The electric current passing through the electrolyte is converted substantially quantitatively into thermal energy and the present process also has the advantages that external heat losses are minimized and non-uniform setting arising from low thermal conductivity of the mixture is avoided as the entire bulk of the mixture has the same temperature throughout at any moment. The current may cause electrochemical changes as well as heating and, depending on the nature of the electrolyte and binder, such changes may also assist setting.

35 The fact that the process of the present invention is only applicable in the case of mixtures comprising water and an electrolyte does not in practice restrict the area of use of the process to any great extent because binder systems often contain both water and an electrolyte. One widely used type of binder system comprises an aqueous resin composition, suitable resins being, for example, urea/formaldehyde, furfuryl alcohol/formaldehyde and phenol/formaldehyde condensates and co-condensates of formaldehyde with more than one of urea, furfuryl alcohol and phenol. The condensates are usually lowly condensed materials i.e. oligomers having, for example, a molecular weight in the range of 200 to 300 and it may be advantageous for the compositions, which are usually solutions, also to contain free furfuryl alcohol. The aqueous resin composition of these binder systems contains water but not any significant amount of an electrolyte. However, such systems are suitable for use in the process according to the present invention since they are normally used with catalysts which are electrolytes e.g. acids such as 80% phosphoric acid, 67% para-toluenesulphonic acid, sulphuric acid and hydrochloric acid. Suitable proportions, based on the aggregate, for these and other types of binder

systems are known as are suitable relative proportions of the binders and catalyst. It is also known that such binder systems can be improved by inclusion of small proportions of certain silanes.

70 The resin-based binder systems described above are often termed "No Bake" or cold-setting systems since they are normally such that the catalyst causes setting at room temperature. However, the process of the invention is of value with systems of this type since it provides a satisfactory and economical way of shortening setting times. A quite general advantage of the process of the present invention is that it provides a means for controlling the setting process in quite a precise fashion whereas generally the setting time is dependent on a number of factors, not all of which are readily controllable e.g. the ambient temperature in the case of a cold-setting process or, in the case of an indirect heating process, the rate at which the applied heat is conducted through the mixture.

85 Another class of binder system to which the present invention is applicable is that comprising aqueous solutions of sodium or potassium silicate. Such systems are aqueous electrolytes and may contain further inorganic materials and may be used in conjunction with resin-based binder systems. The manner in which these and other inorganic-based binder systems may be used is known.

100 Irrespective of the chemical nature of the binder systems, the present invention is applicable both to aggregate/binder system mixtures which behave physically like normal particulate solids and to such mixtures which behave as fluids by virtue of the aqueous phase including a foaming agent and being foamed. The latter type of mixtures have the advantage that they can easily be poured into mould or core boxes and all the cavities filled without any need for ramming or otherwise mechanically forcing the mixture into the boxes. In the present invention such mixtures are advantageous in that the presence of an effectively continuous aqueous, electrolyte-containing phase makes for low resistance to the current and thus highly efficient heating.

105 The present invention is particularly useful with the fluid mixtures. In this case, as in others, the heating enables the amount of catalyst to be reduced and with fluid mixtures that will set at room temperature this is particularly advantageous since it permits improved fluidity to be obtained. With cold-setting fluid mixtures there has normally been a dilemma since, although short setting times are favoured by use of relatively large proportions of catalyst, the use of a catalyst which causes rather rapid setting is undesirable in that it results in 130

appreciably diminished fluidity of the mixture before it can be put in the box.

It is desirable that foundry cores or moulds should have an appreciable degree of permeability. The permeability of the fluid mixtures is initially low because they behave generally as liquids but, as the mixture sets the foam bubbles break up and permeability develops. By use of the process according to the present invention permeability of the fluid mixtures can be developed more rapidly but without reducing the bench life and fluidity of the initial mixtures.

By suitable choice of the current used the order in which foam collapse and setting of the fluid mixtures occur can be controlled. Thus, with high currents, and therefore rapid heating, the mixture can be set before any substantial degree of foam collapse, and therefore shrinkage occur. Conversely, with lower currents some degree of foam collapse may occur before setting and denser products thereby result. Either outcome may be advantageous depending on the intended use for the mould or core.

With moulds and cores made using binder systems containing water, some drying occurs during and after setting and this is desirable. However, the drying generally occurs in an uncontrolled fashion whereas in the present process, controlled drying can be effected by heating, this being particularly useful with fluid mixtures.

Either direct or alternating current is used. Mould or core boxes having suitable electrodes can easily be made or the electrodes fitted in existing boxes. For maximum uniformity of temperature throughout the mixture the electrodes are preferably parallel and of equal surface area. There are a number of controllable variables e.g. voltage, electrode spacing, duration of current and composition of the electrolyte and suitable values can be found by simple experiment. Desirably the variables are so chosen that the resulting temperature is not greater than 100°C, temperatures in the range 30 to 75°C especially 30 to 50°C, often being preferred. The voltage must be sufficient for the current to pass and is preferably not greater than 440 volts. Different electrode surface areas may be desirable in different circumstances and suitable areas for a particular case can be found by simple experiment. In some cases may be advantageous to use more than two electrodes e.g. for large moulds or cores or for shapes where parallel and equal area electrodes cannot conveniently be used.

If the temperature produced is relatively high and/or is reached rather rapidly e.g. by the use of a high voltage, a steam pressure may develop in the mould or core that will tend to distort the setting mixture.

Such distortion can be inhibited by use of one or more permeable inserts suitably placed in the mixture and/or in the walls of the box. When steam pressure is liable to develop it may be desirable to close the box more tightly than usual. In the case of direct current some anti-polarising agent may be desirable on either or both of the electrodes in order to prevent insulating gases developing on the electrodes. For example, a cloth soaked in 50% sodium bichromate solution may be put on the cathode and a cloth soaked in 40% sodium nitrite solution on the anode.

The invention is illustrated by the following examples.

Example 1

A foundry sand/binder system mixture in which the aqueous phase was foamed, was poured into a box fitted with electrodes spaced six inches apart. The weight of sand was 3.4 kilograms and, based on this, 2% by weight of a nitrogen-containing binder comprising a furfuryl alcohol-based resin was used. A catalyst system comprising para-toluene-sulphonic acid as catalyst together with water and a wetting agent to permit the foaming was used in an amount of 2.5% by weight based on the sand.

An alternating current of 190 volts at 2.4 amps was then passed between the electrodes for 3 minutes thus causing the temperature of the mixture to rise to 65°C. It was found that the set mixture could then readily be removed from the box and that its characteristics were satisfactory. The permeability at this stage was relatively low but was still increasing.

Example 2

The procedure of Example 1 was repeated except that the current was passed for 9 minutes, the temperature of the mixture then being 100°C. Again the set mixture could easily be stripped from the box and had satisfactory characteristics.

Example 3

The procedure of Example 1 was repeated except that the weight of sand was 1.1 kilogram, the electrodes were spaced 2 inches apart, the voltage was 140, the current was 4 amps and the current was passed for only 1 minute. The final temperature was again 65°C. Again, the set mixture could easily be stripped from the box and its characteristics were satisfactory.

Example 4

The procedure of Example 1 was generally repeated but in this case the binder comprised a nitrogen-free furfuryl alcohol-based resin. The weight of sand was 2.2 kilograms, the electrode spacing was 4

inches, the voltage was 160, the current was 6 amps and was passed for 1.5 minutes. The final temperature was again 65°C and the set mixture was then easily removed from the box and had satisfactory characteristics.

Example 5

The procedure of Example 1 was modified by using sodium silicate as the binder in an amount of 5% by weight based on the sand and by using a mixture of diacetin, water, wetting agent and ethylene glycol diacetate in an amount of 1.5% by weight based on the sand as the catalyst system. The initial voltage was 216 but was reduced to 200 during the time of current flow (3.5 minutes) and during this period the initial current of 1.2 amps rose to 2.0 amps. The final temperature was 40°C. The mixture was left in the box for 5.5 minutes after the current was switched off and the set mixture was then easily removed from the box and had satisfactory characteristics.

Example 6

The procedure of Example 5 was repeated but using only 4.0% by weight of the binder based on the sand. In this case the current was passed for 4 minutes and the voltage decreased during this period from 220 to 204 whilst the current increased from 1.05 to 1.57 amps. The final temperature was again 40°C. The mixture was left in the box for 9 minutes after the current had been switched off and the set mixture was then readily stripped from the box and found to have satisfactory characteristics.

Example 7

The procedure of Example 1 was modified by using an unfoamed binder system, the catalyst system in this case containing no wetting agent and being used in an amount of only 2.25% by weight based on the weight of the foundry sand, 3.8 kilograms. The initial voltage was 240 and the current was passed for 11 minutes during which time the current increased from 1.4 to 2.0 amps. The final temperature was 97°C. The set mixture could then easily be stripped from the box and had good permeability and other characteristics.

Example 8

The procedure of Example 7 was modified by using a nitrogen-free binder comprising a furfuryl alcohol-based resin and in this case the amount of catalyst system used based on the sand was only 2.0% by weight. The current was passed for 8 minutes during which period the current increased from 0.95 to 1.57 amps. The final temperature was 73°C and the set mixture

could then be removed readily from the box and had good permeability and characteristics.

Example 9

The procedure of Example 5 was modified by using an unfoamed binder system, the catalyst system being used in an amount of only 1% by weight based on the weight of the sand (3.8 kilograms) and not containing any wetting agent but containing ethylene glycol rather than ethylene glycol diacetate. The initial voltage was 240 and the current increased from 0.52 to 1.0 amps during the time (8 minutes) that it was passed. The final temperature was 77°C and the set mixture was then easily stripped from the box and found to have good permeability and other characteristics.

WHAT WE CLAIM IS:—

1. A method for making a foundry mould or core by putting a mixture, containing water and an electrolyte, of aggregate and binder into a mould or core box and causing or allowing the mixture to set, in which the setting is caused or assisted by passing an electric current through the mixture.
2. A method according to claim 1 in which the binder is an aqueous composition containing a resin condensate of formaldehyde with one or more of urea, furfuryl alcohol and phenol and the mixture also contains a catalyst, which is an electrolyte, for the condensate.
3. A method according to claim 1 in which the binder is an aqueous composition containing sodium or potassium silicate.
4. A method according to any preceding claim in which the mixture of aggregate and binder is poured into the mould or core box, the mixture being fluid by virtue of the presence of a foamed aqueous phase.
5. A method according to claim 4 in which the mixture in the mould or core box is caused to set before any substantial degree of foam collapse has occurred.
6. A method according to any preceding claim in which the current through the mixture is passed between internal electrodes.
7. A method according to claim 6 in which the current through the mixture is passed between two internal, equal area and parallel electrodes.
8. A method according to claim 1 substantially as hereinbefore described with reference to any of the Examples.
9. A foundry mould or core made by a method according to any preceding claim.

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The procedure of Example 1 was modified by using sodium silicate as the binder in an amount of 5% by weight based on the sand and by using a mixture of diacetin, water, wetting agent and ethylene glycol diacetate in an amount of 1.5% by weight based on the sand as the catalyst system. The initial voltage was 216 but was reduced to 200 during the time of current flow (3.5 minutes) and during this period the initial current of 1.2 amps rose to 2.0 amps. The final temperature was 40°C. The mixture was left in the box for 5.5 minutes after the current was switched off and the set mixture was then easily removed from the box and had satisfactory characteristics.

Example 6

The procedure of Example 5 was repeated but using only 4.0% by weight of the binder based on the sand. In this case the current was passed for 4 minutes and the voltage decreased during this period from 220 to 204 whilst the current increased from 1.05 to 1.57 amps. The final temperature was again 40°C. The mixture was left in the box for 9 minutes after the current had been switched off and the set mixture was then readily stripped from the box and found to have satisfactory characteristics.

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The procedure of Example 1 was modified by using an unfoamed binder system, the catalyst system in this case containing no wetting agent and being used in an amount of only 2.25% by weight based on the weight of the foundry sand, 3.8 kilograms. The initial voltage was 240 and the current was passed for 11 minutes during which time the current increased from 1.4 to 2.0 amps. The final temperature was 97°C. The set mixture could then easily be stripped from the box and had good permeability and other characteristics.

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The procedure of Example 7 was modified by using a nitrogen-free binder comprising a furfuryl alcohol-based resin and in this case the amount of catalyst system used based on the sand was only 2.0% by weight. The current was passed for 8 minutes during which period the current increased from 0.95 to 1.57 amps. The final temperature was 73°C and the set mixture

could then be removed readily from the box and had good permeability and characteristics.

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2. A method according to claim 1 in which the binder is an aqueous composition containing a resin condensate of formaldehyde with one or more of urea, furfuryl alcohol and phenol and the mixture also contains a catalyst, which is an electrolyte, for the condensate.
3. A method according to claim 1 in which the binder is an aqueous composition containing sodium or potassium silicate.
4. A method according to any preceding claim in which the mixture of aggregate and binder is poured into the mould or core box, the mixture being fluid by virtue of the presence of a foamed aqueous phase.
5. A method according to claim 4 in which the mixture in the mould or core box is caused to set before any substantial degree of foam collapse has occurred.
6. A method according to any preceding claim in which the current through the mixture is passed between internal electrodes.
7. A method according to claim 6 in which the current through the mixture is passed between two internal, equal area and parallel electrodes.
8. A method according to claim 1 substantially as hereinbefore described with reference to any of the Examples.
9. A foundry mould or core made by a method according to any preceding claim.

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