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PROCESS OF CASTING METALS BY USE OF WATER-SOLUBLE SALT CORES

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ABSTRACT OF THE DISCLOSURE

Production of metal castings containing cavities therein using as cavity-former a pressed and sintered core containing granular water soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting, with removal of the core after the casting has been cooled, for example, by flushing with water; and core usable as cavity-former in metal castings composed of granular particles up to about 1 mm. diameter of water soluble salt having the above-mentioned change of state critical temperature and having been pressed into the desired shape and volume at a pressure of about 1–10 kp/mm.^{2} and sintered at a temperature of about 500–750° C. for about ½–2 hours.

The present invention relates to the production of metal castings containing cavities therein, and more particularly to a process for the formation of cavities in metal castings, such as annular cavities which may carry a coolant as in the case of piston heads of internal combustion engines.

In accordance with prior art processes in this field of endeavor, a core is mounted in the usual case in a mold at the point where the desired cavity is to be formed in the casting, then the molten metal is introduced into the mold, and after the metal casting has cooled, the core is dissolved out.

In accordance with one particular prior art exemplification, it is known to use an insert ring as a core, which is inserted in the piston head area of a mold for producing a rough light metal casting, and upon producing the casting in the above-mentioned manner, the piston head is thereafter formed by a forging press. Such a piston head may be utilized in internal combustion engines, with the insert ring area forming an annular coolant cavity, for example, at the desired point behind those grooves provided in the piston head for carrying piston rings in the usual way. Such insert ring generally consists of a substance which can be removed from the casting by erosion using recognized chemical agents for this purpose. However, the process of forming such a coolant cavity in a piston head by dissolving away an insert ring core of the foregoing type is very time consuming and hence uneconomical.

In accordance with a further known technique in the casting of hard, high melting metal objects containing fine openings, holes or perforations therein, in order to produce the fine openings, etc., cores made of quartz, preferably hollow cores, are inserted in the mold used for the casting, whereupon once the casting has taken place, such cores are removed by chemical agents, so as not to harm or alter the cast metal piece itself. The core material in question is typically pressed or drawn quartz, although nickel also has been utilized for making cores in accordance with this technique. However, the difficulty of dissolving the particular core materials noted, once the casting has taken place, is apparently the main reason why such cores are generally utilized in the casting mold in the form of hollow inserts such as tubes or the like. In this way, the chemical agent used to dissolve the core may be introduced through such tubes or the hollow part of the core whereby access to all parts of the core will be attained and accordingly the chemical dissolution thereof will be carried out in the desired manner.

Also, similar proposals have been made with regard to the provision for cavities in metal objects formed by a casting technique, such as by the utilization of cores made from a mixture of hydrolyzed alkyl silicates and silicic acid as core material, inasmuch as such core materials may be dissolved out of the finished casting by the use of fused alkali, hot aqueous alkali solutions, or hydrofluoric acid.

Furthermore, it has been proposed to use as the core substance in molds for producing metal objects by casting, a salt such as sodium chloride or barium chloride, but only where the salt is preformed by casting while in the molten state to achieve the desired shape of the core to be used in the casting mold for the final casting of the metal object. This expedient, nevertheless, has not proved workable in casting practice, since molds made of fused substances like sodium chloride or barium chloride are very brittle and do not withstand the mechanical or thermal stresses to which the molded cores are subjected during the metal casting step.

Additionally, it has been proposed to utilize cores of water soluble salts in the metal casting step and then to dissolve such water soluble salts from the cast object. These salts are utilized in a precast core form and mainly comprise as core material either sodium metasilicate, Na_2SiO_3, or sodium meta-disilicate $Na_2Si_2O_5$. A main disadvantage of these salts when used as cores in the casting of aluminum alloys is that the aqueous solutions produced from the salts when flushing the metal casting to remove the core possess a highly alkaline reaction which attacks the aluminum alloy itself. As a result, such metal casting is often intolerably roughened during the dissolution step of the water soluble salt.

It is an object of the present invention to overcome the foregoing disadvantages, and to provide for the production of metal castings containing cavities therein utilizing a specific kind of core as cavity former in the casting which is readily removed after the formed casting has been cooled, without adversely affecting the casting.

It is another object of the present invention to provide for the production of such metal castings containing cavities therein utilizing a water soluble salt in a particular form, which salt is removed from the cavity within the metal casting in an extremely short period of time and without attacking the surface of the metal casting in question.

It is still another object of the present invention to provide for the production of such metal castings containing cavities therein utilizing such a water soluble salt in pre-pressed and pre-sintered predetermined shape corresponding to the shape of the cavity to be provided in the metal casting.

It is still another object of the present invention to provide for the production of such metal castings containing cavities therein, in accordance with the foregoing, and especially in connection with the provision for annular cavities in the metal casting by the use of annular cores of the foregoing type, particularly in the making of castings to be used as piston heads for internal combustion engines, wherein the piston head is to have an annular cavity for carrying a coolant in the vicinity of that portion of the piston head provided with piston rings.

Other and further objects of the present invention will become apparent from a study of the within specification and accompanying examples.

It has been found in accordance with the present invention that a process for the production of metal castings

containing cavities therein may be provided, which comprises carrying out the casting of a metal object which is to contain such a cavity therein, while using as cavity-former a pressed and sintered core containing granular water-soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting. Of course, the core in question will have a predetermined shape and volume corresponding to the shape and volume of the cavity in the metal object being cast therearound. The core may be removed after the formed casting has been cooled. In particular, the core is removed by flushing the same from the cavity of the formed casting, as for example with water.

Suitably, the core is composed of salt particles having a grain size of up to about 1 mm. diameter, which particles have been pressed into such predetermined shape and volume at a pressure of substantially between about 1 to 10 kp./mm.^{2}, and sintered in air at a temperature of substantially between about 500 to 750° C. for substantially between about ½ to 2 hours.

The water soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting may be typically an alkali metal halide, and especially a member selected from the group consisting of sodium chloride, potassium chloride, and mixtures thereof. If necessary because of specially high mechanical strength requirements, small additions of other salts (up to a total of 10%) such as borax, magnesium oxide, talcum powder and/or alkaline earth metal salts may be added.

The metal which may be used for the casting in accordance with the preferred embodiment may contain aluminum, such as for example where the metal used for the casting is composed of a member selected from the group consisting of aluminum and alloys of aluminum, such as Al-Si, Al-Si-Cu, Al-Cu-Ni-Mg. This is especially true where the salt used is sodium chloride and/or potassium chloride.

Accordingly, the present invention in particular contemplates a process for the production of metal castings containing cavities therein, which comprises positioning in a casting mold in a predetermined relation to the surrounding walls of such mold, as cavity-former in the metal object to be cast, a pressed and sintered core containing granular water-soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting, said core having a predetermined shape and volume corresponding to the shape and volume of the cavity in the metal object being cast therearound, introducing such molten metal into said casting mold, whereby to form the metal casting, and removing said core after the formed casting has been cooled. Such core is preferably removed by flushing with water and the same is composed preferably of salt particles having a grain size of 0–1 mm. diameter, which particles have been pressed into such predetermined shape and volume at a pressure substantially between about 1–10 kp./mm.^{2}, preferably 3–5 kp./mm.^{2}, and sintered in air at a temperature of substantially between about 500 to 750° C. for substantially between about ½ to 2 hours. Such salt particles are preferably dried at a temperature above about 110° C., i.e. substantially between about 115 to 150° C., prior to the pressing and sintering steps. As aforesaid, the salt is preferably an alkali metal halide such as sodium chloride and/or potassium chloride, while the metal used for the casting contains aluminum, i.e. aluminum per se and/or alloys of aluminum, including those aluminum metal materials typically utilized in the art for preparing metal castings, and especially metal castings to be used for making piston heads for internal combustion engines.

In accordance with a preferred embodiment, the present invention also contemplates an improvement in the process for the production of a rough casting to be used for making a piston head for an internal combustion engine, wherein an annular core as cavity former is positioned in the casting mold at a position corresponding to an annular coolant cavity to be provided within the casting at a position radially inwardly of the area at which peripheral grooves are to be provided correspondingly in the piston head to be produced therefrom for receiving piston rings thereat, which improvement comprises carrying out the casting with molten metal while using as such cavity former a pressed and sintered annular core containing granular water-soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting, and, after the formed casting has been cooled, removing such core by flushing said core with water. The core utilized, of course, is composed of salt particles of the foregoing type pressed and sintered in the noted manner, and preferably the metal used is aluminum or an aluminum alloy.

Furthermore, the present invention contemplates a core per se having a predetermined shape and volume, usable as cavity-former in metal castings, composed of granular particles having a grain size of up to about 1 mm. diameter of a water-soluble salt having a change of state critical temperature above the temperature of the particular molten metal used for the casting. The core, of course, is used in the form of a pre-pressed and pre-sintered article of predetermined shape and volume, wherein the pressing and sintering is carried out in accordance with the foregoing. The salt may be an alkali metal halide as aforesaid, and particularly a pre-dried sodium chloride or potassium chloride salt.

In connection with the foregoing, as the artisan will appreciate, a metal casting containing a cavity of predetermined shape and volume occupied substantially completely by a cavity-forming core of corresponding shape and volume containing granular particles of a salt of the foregoing type in pre-pressed and pre-sintered condition is also contemplated by the present invention, preferably where the metal casting is formed of a metal containing aluminum and where the salt is sodium chloride and/or potassium chloride.

Indeed, in accordance with the foregoing, the subject core can be made from readily water-soluble salts such as sodium chloride or potassium chloride in a simple and reliable manner, by the foregoing pressing and sintering steps. The choice of salt depends primarily upon the temperature of the metal being cast. For castings of aluminum and aluminum alloys, it has been found in accordance with the present invention that sodium chloride and potassium chloride, and mixtures thereof, are particularly suitable, and that inserts or cores produced therefrom by the above noted simple procedure have been found to be completely satisfactory as regards stability and freedom from gassing during the casting step with the molten metal. Unlike the previous efforts in this regard, the water-soluble salts used in accordance with the present invention are not highly alkaline in nature and therefore the metal casting, such as an aluminum alloy, is not attacked by the dissolving process, i.e. by the flushing with water of the salt core from the casting. It will be appreciated by the artisan that the instant water-soluble salts are substantially non-alkaline and non-acidic in aqueous solution as is true of sodium metasilicate and sodium meta-disilicate. The salts contemplated by the present invention therefore are for the most part considered neutral salts in aqueous solution, i.e. salts which in solution form do not attack metal surfaces.

As will be seen from the foregoing, in accordance with the present invention, it is now possible to create in the head of a cast internal combustion engine piston, made of aluminum alloy, an annular, enclosed cooling chamber, by including in the casting, i.e. in the casting mold, at the desired point, a core of the desired shape made from such water-soluble salt, for example sodium chloride or potassium chloride, whereupon after the casting has been formed and the molten metal solidified and cooled, the

core may be simply flushed from the casting with ordinary tap water.

Advantageously, the process of the present invention, and in particular the core in question, and even the finished casting, are distinguished from the state of the art by the important fact that the process and the core material are inexpensive, rendering the overall effort highly economical. Indeed, utilizing the instant process, the cores of the invention can be flushed out of the finished casting within a matter of minutes, i.e. 1 to 5 minutes for example, as compared with hours or days which are required, for instance, to eat out metal cores with chemical corrosives. Another important advantage of the present invention is the fact that the surface of the casting remains entirely free from attack by the core material, whereas a roughening of the metal surface, i.e. surrounding the cavity produced in the casting, cannot be avoided when inserts or cores are corroded out or eaten away with the aid of basic or acid substances used as dissolving agents.

The following examples are set forth for the purpose of illustration and not limitation of the present invention:

Example 1

Sodium chloride particles having an average grain size of about 0.5 mm. are poured into a pressing mold of predetermined shape and volume, i.e. an annular mold for producing a ring-shaped core, and a mold pressure of about 4 kp/mm.^{2} is applied for 2 minutes to form the core. The pressed core is then sintered in air at about 600° C. for about one hour.

The salt core formed in the foregoing manner is then placed in a casting mold for producing a piston head of 220 mm. diameter for an internal combustion engine. The core is placed at a position in the mold at which the annular coolant cavity is to be provided, i.e. adjacent the periphery where the piston rings are to be situated. Molten aluminum alloy of the type used for forming aluminum alloy piston heads for internal combustion engines is then added to the mold in the typical manner. Upon solidification and cooling, the rough casting is removed from the mold and tap water is used to flush the sodium chloride salt core therefrom. The flushing is completed within about five minutes and the cavity remaining in the casting is free from any evidence of attack to the surrounding surface by dint of salt used or the aqueous solution formed therefrom during the flushing. The salt used has a change of state critical temperature, i.e. a melting point of 801° C. which is above the temperature of the molten aluminum alloy used.

Example 2

Example 1 is repeated using granular potassium chloride salt having an average grain size of about 0.5 mm. diameter which has been pre-dried at a temperature of about 115° C. prior to the pressing step. The change of state critical temperature, i.e. a melting point of 776° C., is above the temperature of the molten aluminum alloy used in this example as well. The finished casting is flushed with water in the same manner and there is no evidence of attack of the metal surface surrounding the cavity formed in the piston head casting.

As the artisan will appreciate, various other neutral water-soluble salts may be utilized which possess change of state critical temperatures above the particular molten metal used for the casting, so long as such salts may be subjected to pressing and sintering in the foregoing manner whereby to form a solid core which may be inserted in the casting mold for the purposes in question.

As the artisan will also appreciate small additions (up to approximately 5%) of water-insoluble salts such as talcum powder or magnesium oxide may be added to the water-soluble bulk material such as sodium chloride. Such salt-mixtures are completely flushed out by the water stream without leaving any residue.

It will be appreciated that the instant specification and examples are set forth by way of illustration, and not limitation, and that various modifications and changes may be made without departing from the spirit and scope of the present invention which is to be limited only by the scope of the appended claims.

What is claimed is:

1. Process for the production of metal castings containing cavities therein, which comprises carrying out the casting of a metal object which is to contain a cavity therein, while using as cavity-former a solid unitary pressed and sintered core containing granular water-soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting, said core having a predetermined shape and volume corresponding to the shape and volume of the cavity in the metal object being cast therearound, and removing said core after the formed casting has been cooled.

2. Process according to claim **1** wherein said core is removed by flushing with water.

3. Process according to claim **2** wherein said core is composed of salt particles having a grain size of up to about 1 mm. diameter which have been pressed into such predetermined shape and volume at a pressure of substantially between about 1–10 kp/mm.^{2} and sintered at a temperature of substantially between about 500–750° C. for substantially between about ½–2 hours.

4. Process according to claim **3** wherein said salt is an alkali metal halide.

5. Process according to claim **4** wherein said salt is selected from the group consisting of sodium chloride and potassium chloride.

6. Process according to claim **4** wherein the metal used for the casting contains aluminum.

7. Process according to claim **6** wherein the metal used for the casting is composed of a member selected from the group consisting of aluminum and alloys of aluminum.

8. Process for the production of metal castings containing cavities therein, which comprises positioning in a casting mold in a predetermined relation to the surrounding walls of such mold, as cavity-former in the metal object to be cast, a solid unitary pressed and sintered core containing granular water-soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting, said core having a predetermined shape and volume corresponding to the shape and volume of the cavity in the metal object being cast therearound, introducing such molten metal into said casting mold, whereby to form the metal casting, and removing said core after the formed casting has been cooled.

9. Process according to claim **8** wherein said core is removed by flushing with water, and wherein said core is composed of salt particles having a grain size of up to about 1 mm. diameter which have been pressed into such predetermined shape and volume at a pressure of substantially between about 1–10 kp/mm.^{2} and sintered at a temperature of substantially between about 500–750° C. for substantially between about ½–2 hours, said salt particles having been dried at a temperature above about 110° C. prior to pressing and sintering.

10. Process according to claim **9** wherein said salt is an alkali metal halide.

11. Process according to claim **10** wherein said salt is selected from the group consisting of sodium chloride and potassium chloride.

12. Process according to claim **10** wherein the metal used for the casting contains aluminum.

13. In the process for the production of a rough casting to be used for making a piston head for an internal combustion engine, wherein an annular core as cavity-former is positioned in the casting mold at a position corresponding to an annular coolant cavity to be provided within the casting at a position radially inwardly of the area at which peripheral grooves are to be provided correspondingly in the piston head to be produced therefrom for receiving piston rings thereat, the improvement which

comprises carrying out the casting with molten metal while using as such cavity-former a solid unitary pressed and sintered annular core containing granular water-soluble salt having a change of state critical temperature above the temperature of the molten metal used for the casting, and, after the formed casting has been cooled, removing such core by flushing said core with water.

14. Improvement according to claim **13** wherein said core is composed of salt particles having a grain size of up to about 1 mm. diameter which have been pressed into such predetermined shape and volume at a pressure of substantially between about 1–10 kp/mm.^{2} and sintered at a temperature of substantially between about 500–750° C. for substantially between about ½–2 hours, said salt is an alkali metal halide, and said salt particles having been dried at a temperature above about 110° C. prior to pressing and sintering.

15. Process according to claim **14** wherein said salt is selected from the group consisting of sodium chloride and potassium chloride, and the metal used for the casting contains aluminum.

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