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- [54] **PROCESS FOR PRODUCING SELF-DESTROYING SILICA MOLDS**
 8 Claims, No Drawings
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ABSTRACT: Self-destroying silica molds for casting molten metals are prepared by incorporating into amorphous silica-containing molds from 0.3 to 10 percent by weight based on the amorphous silica of a beta cristobalite-promoting catalyst selected from the group consisting of silicates, borates, phosphates, tungstates and molybdates of alkali and alkaline earth metals, zinc and lead and heating the resulting mold to at least 900°C. for a time sufficient to effect conversion of a major portion of said amorphous silica to beta cristobalite. After a molten metal is cast in the mold and solidified, the mold is cooled rapidly through the temperature range of from 300° to 200°C. to disrupt and fragment the mold.

PROCESS FOR PRODUCING SELF-DESTROYING SILICA MOLDS

BACKGROUND OF THE INVENTION

This invention relates to the art of amorphous silica-containing molds. Such molds are widely employed as precision investment casting molds and as cores for casting many different types of metals. One of the most expensive and time consuming aspects of precision investment casting operations is that of removing the mold from the solidified casting. Currently, this is accomplished through the use of jack hammers, sand blasting and finally soaking in hot caustic to dissolve the last traces of silica which cling to recessed regions of the casting. This invention is founded on the discovery of a method by which amorphous silica-containing molds can be prepared and treated such that they can be easily removed from metal castings.

SUMMARY OF THE INVENTION

In summary, this invention is directed to a process for producing a metal casting comprising:

- a. heating a mold having the shape of the desired metal casting and comprising at least 20 percent by weight of amorphous silica and from 0.3 to 10 percent by weight, based on said amorphous silica, of a beta cristobalite-promoting catalyst selected from the group consisting of silicates, borates, phosphates, tungstates and molybdates of alkali metals, alkaline earth metals, zinc and lead to a temperature of at least 900°C. for a time sufficient to effect conversion of at least 20 percent by weight of said mold to beta cristobalite;
- b. casting a molten metal in or around said mold; and
- c. rapidly cooling said mold through the temperature range of from 300° to 200°C., thereby disrupting and fragmenting said mold.

DETAILED DESCRIPTION OF THE INVENTION

This invention is based on the finding that amorphous silica-containing molds can be rendered self-destroying by incorporating therein a catalyst which promotes the devitrification of amorphous silica to beta cristobalite and heating the mold to at least 900°C., and preferably from 1,100° to 1,200°C., for a time sufficient to effect conversion of the amorphous silica to beta cristobalite. When the molds treated in this manner are rapidly cooled through the temperature range of from 300° to 200°C., the beta cristobalite converts to alpha cristobalite and the attendant large volume change is sufficient to disintegrate the mold. To assure that this volume change is sufficiently great to effect fragmentation, the mold in which or around which the metal is cast should contain at least 20 percent, and preferably at least 50 percent, by weight of beta cristobalite; this necessitates that the starting mold contain at least 20 percent, and preferably at least 50 percent by weight of amorphous silica.

The beta cristobalite-promoting catalysts utilized in the practice of this invention are the silicates, borates, phosphates, tungstates and molybdates of alkali metals, alkaline earth metals, zinc and lead. Preferred are the alkali and alkaline earth metal silicates and most preferred are the sodium, potassium and lithium silicates. These catalysts apparently function by furnishing, at temperatures above 900°C., a liquidus phase in which nuclei of cristobalite are formed. (See R. B. Sosman, *The Properties of Silica*, New York: The Chemical Catalog Co., Inc., 1927, Chapter XI.) In the absence of this liquid phase, as with pure silica, one must heat to temperatures at which the rates of diffusion of oxygen and silicon in pure silica become appreciable before the conversion occurs.

A variety of procedures known in the art can be employed to produce the original molds used in the practice of this invention. For example, the molds can be produced by the technique of multiple dipping wherein a wax pattern or other suitable expendable shaped structure is dipped into an

amorphous colloidal silica binder solution and is then dipped into a fluidized bed of refractory amorphous silica grain. The resulting coating is allowed to dry and the process is repeated until a coating sufficiently thick to withstand the weight and pressure of the molten metal is formed. Alternatively, the molded body can be prepared by dipping a wax pattern or other expendable shape to be duplicated into a solution of hydrolyzed ethyl orthosilicate and refractory amorphous silica grain in the presence of a substance to change the pH to within the range of from 5 to 9.5 and thus accelerate gel formation from the hydrolyzed ethyl orthosilicate solution.

The catalysts employed in the method of this invention are incorporated into the mold either during or following preparation. Thus, a mold which has been prepared by the dipping process can be dipped into a solution of one of the catalysts and then dried to deposit the catalyst uniformly throughout the structure. Alternatively, the catalyst can be present as one of the constituents in the solution to be gelled or to be deposited by drying. The catalyst can be distributed in a finely divided solid form, but this is not the preferred method because homogenous distribution is difficult to accomplish. The effectiveness of the catalysts is closely related to homogeneity of the distribution within the mold and the state of subdivision of the catalyst.

The larger the amount of catalyst incorporated into the mold, the more rapid will be the conversion of amorphous silica to beta cristobalite and the lower will be the temperature required to attain the desired degree of conversion. Use of too much catalyst, however, can have a deleterious effect on the refractory characteristics of the mold because all of the above-mentioned catalysts tend to reduce the melting point of silica. For this reason, from about 0.3 to about 10 percent, and preferably 0.5 to 3 percent, by weight of catalyst should be used.

The heating time required to produce sufficient beta cristobalite to cause an acceptable amount of mold fracture upon cooling will, of course, depend upon the temperature, the amount of catalyst in the mold and the rapidity of the eventual cooling through the 300° to 200°C. range. Typical heating times and temperatures, however, are from ½ to 1 hour at 1,100°C. and several minutes at 1,200°C.

After at least a major portion of the amorphous silica in the mold has been converted to beta cristobalite by heating, the mold should not be permitted to cool below 300°C. before being used to cast molten metal. The phase transformation temperature of beta cristobalite to alpha cristobalite is somewhat variable, depending on factors such as grain size, but is generally in the range of from 300° to 200°C. Therefore, after the molten metal has solidified, the mold can be cooled to about 300°C. at any desired rate, but then it should be cooled rapidly through the 300° to 200°C. range. This is most conveniently accomplished by blasting the surface of the mold with a jet of water or live steam. Any other procedure which will rapidly quench the mold can also be used. The more rapid the quenching, the more numerous are the cracks in the mold. By using a jet of cold water or steam, it is possible to completely pulverize the mold in one operation.

EXAMPLE 1

Five hundred grams of a 48 percent silica sol having an average particle diameter of 25 millimicrons is deionized to a pH of 2.3 using the hydrogen form of a strong acid ion exchange resin. Two hundred grams of this are mixed in a laboratory Waring Blender with 20 ml. of distilled water containing 4.2 ml. of 1 to 1 acetic acid in water. While this is stirred, 400 grams of refractory silica grain are added. The refractory silica grain is amorphous silica, 55 percent of which passes a 100 mesh screen and is retained on a 200 mesh, and 45 percent of which passes a 325 mesh screen. At this point, 20.4 grams of a solution of sodium silicate having 16.93 percent silica and a 4.66 mole ratio of SiO₂ to Na₂O are added, and the composition quickly cast around wax molds in a

polyethylene cup. This material gels and forms a strong replica of the mold.

After steaming to melt the wax from the interior of the mold and to reinforce the strength of the gel, this material is dried and fired to a temperature of 900°C. At 900°C., it is a strong, porous mold of amorphous silica which contains approximately 0.6 percent solid sodium silicate on the weight of the mold. One of these molds is heated to a temperature of 1,100°C. for an hour, then cooled to about 400°C. by air quenching and finally cooled rapidly through the temperature range of from 300 to 200°C. by quenching with live steam, whereupon a multiplicity of cracks appears throughout the structure and the mold disintegrates. X-ray examination shows that the major portion of the mold consists of cristobalite. The other three molds are employed after a similar one hour heat treatment at 1,100°C., as casting molds for molten iron, copper, and aluminum, respectively, and they perform very satisfactorily for this purpose. Upon being rapidly cooled between 300° and 200°C. after the metal has solidified, they disintegrate to liberate the metal casting, with only a minor amount of the mold material adhering to the metal.

I claim:

1. A process for producing a metal casting comprising:

- a. heating a shell mold having the shape of the desired metal casting and comprising at least 20 percent by weight of amorphous silica and from 0.3 to 10 percent by weight, based on said amorphous silica, of a beta cristobalite-promoting catalyst selected from the group consisting of silicates, borates, phosphates, tungstates and molybdates of alkali metals, alkaline earth metals, zinc and lead to a

temperature of at least 900°C. for a time sufficient to effect conversion of at least 20 percent by weight of said mold to beta cristobalite;

- b. casting a molten metal in or around said mold;
- c. cooling said mold to about 300°C. to solidify said metal; and
- d. cooling said mold through the temperature range of from about 300°C. to about 200°C. at such rapidity as to disrupt and fragment said mold.

2. The process of claim 1 wherein said beta cristobalite-promoting catalyst is a sodium, potassium or lithium silicate.

3. The process of claim 2 wherein said mold is heated to a temperature of from 1,100°C. to 1,200°C.

4. The process of claim 3 wherein said mold is rapidly cooled through said temperature range by blasting said mold with a jet of water or steam.

5. The process of claim 1 wherein said mold, prior to heating comprises at least 50 percent by weight of amorphous silica and wherein said mold is heated to a temperature of at least 900°C. for a time sufficient to effect conversion of at least 50 percent by weight of said mold to beta cristobalite.

6. The process of claim 5 wherein said beta cristobalite-promoting catalyst is a sodium, potassium or lithium silicate.

7. The process of claim 6 wherein said mold is heated to a temperature of from 1,100° to 1,200°C.

8. The process of claim 7 wherein said mold is rapidly cooled through said temperature range by blasting said mold with a jet of water or steam.

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