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FERROUS CASTINGS WITH SILICONIZED INSERTS

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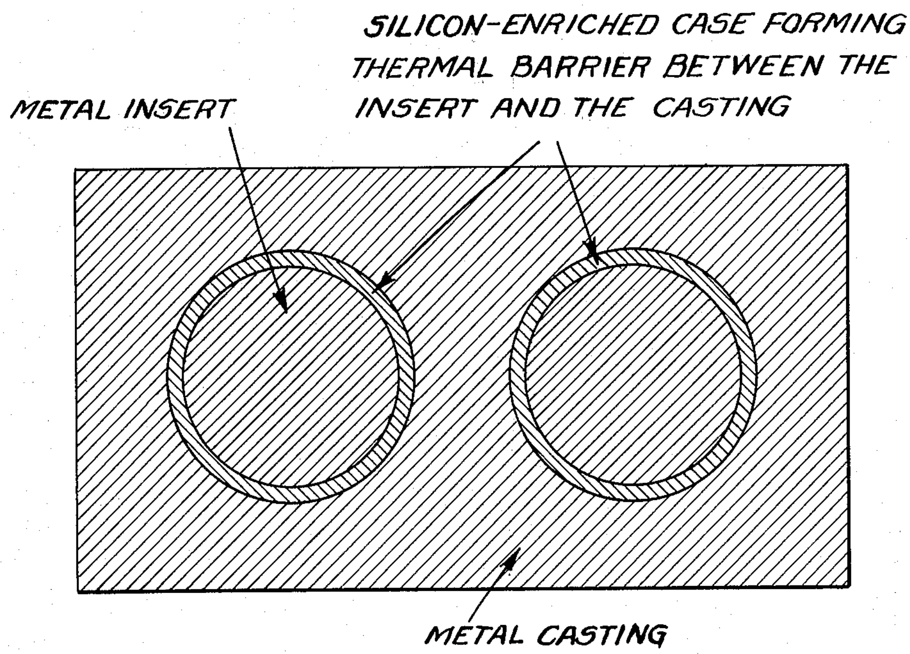

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FERROUS CASTINGS WITH SILICONIZED INSERTS

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This invention relates to ferrous castings with silicon impregnated inserts, and more particularly to cast ferrous base metal articles comprising a cast body portion having imbedded therein a metal insert with a silicon-enriched case.

The art of making castings around metal inserts of various kinds is quite old and has been used for many different purposes. As early as 1722, Réamur described cast iron articles with wrought iron inserts. Obtaining a good bond was considered a problem and various coatings were designed to promote bonding. Perhaps the most common and well-known such bonding medium is the tin coatings, commonly used on chaplets for "casting-in" ferrous articles to promote chill and/or strengthening for core placement. The United States Patent to Ihrig 2,163,753 is directed to casting a body around an insert having a silicon-rich surface coating. The silicon present at the surface coating, or case, of the insert is at least incipiently fused and effects satisfactory bonding with the cast metal. According to the foregoing Ihrig patent, the silicon-rich case is well bonded to the underlying metal insert, and when the cast metals are poured into the mold, a silicon-rich surface is fused to an extent such as to insure excellent bonding of the cast body and the insert (Ihrig patent, page 2, column 1, lines 30–38). One of the benefits of the bond produced between the cast metal body in the insert in the Ihrig process is a reduction of the thermal barrier between the insert and the cast body (Ihrig patent, page 2, column 2, lines 29–38). In consequence, good heat transfer is afforded between a fluid passed through the tube of the insert and the surface of the article, and at the same time uniformity of surface temperature is achieved (Ihrig patent, page 1, column 2, lines 24–28).

There exists "casting-in" problems, even of the type insert described in the Ihrig patent, in which the surface coating, or case, is fused with the consequent good heat transfer properties, particularly in the casting of a thin body section against a relatively thick cold metal insert. Because of the good heat transfer between the cast body portion, and the cold metal insert, the iron must be poured on the "cold side" to avoid melting the insert with resulting "cold iron scrap losses." In addition, considerable difficulty has been encountered with peripheral cracking of the cast iron, due to the chilling of the cast body adjacent the insert due to the good heat transfer to the cold metal insert. As to the latter difficulty, a partial solution of cracking has been achieved by setting the cold metal insert so that its end is encased by the cast iron, which is later machined away. The chilled cast metal body portion at the end of the insert, however, presents an additional machining problem.

It is, therefore, an object of this invention to provide cast metal articles having metal inserts imbedded therein which are characterized by a sound structure. It is a further object of the invention to provide cast metal articles with metallic inserts imbedded therein in which the tendency to melt the insert is reduced. It is a still further object of the invention to provide cast metal articles having metallic inserts imbedded therein in which cracking of the body portion is reduced. Further objects and advantages of the invention will be apparent from a study of the following description and appended claims.

The accompanying drawing illustrates diagrammatically in cross-section a product prepared in accordance with the present invention in which a metal insert with a siliconized case is imbedded in a cast metal article.

Briefly stated, the present invention is directed to a cast metal article comprising a cast metal body portion and a metal insert having a silicon-enriched case integral therewith, the silicon-enriched case forming a thermal barrier between said cast metal body portion and said metal insert. The silicon-enriched case by virtue of its low thermal conductivity and intimate contact with the cold insert is protected against fusion. The present invention also relates to processes for manufacturing the foregoing article.

It is a discovery of the present invention that the problem of obtaining cast metal articles having metallic inserts imbedded therein, may be reduced by providing a thermal barrier between the cast body portion and the metal insert. The thermal barrier may be produced on the metallic insert by forming a siliconized case, surface, or layer, at least partially insulative to heat transfer from the cast body. The insulative case may be made by siliconizing in the presence of a reagent which reduces the free chlorine present during the siliconizing reaction. The siliconized case thus formed, remains intact during the pouring of the cast body portion, has a fusion point above the pouring temperature of the cast ferrous base metal, and produces a thermal barrier which produces unexpected advantages.

In this connection, it is noted that the United States patent to Ihrig 2,163,753 states that the silicon-rich case is at least incipiently fused. By contrast, cases formed by siliconizing in the presence of a reagent for reducing the presence of free chlorine has a fusion point above the pouring temperature of the cast body and remains intact as a thermal barrier between the cast body and the insert.

The insulative siliconized cases formed on the inserts in the present invention are obtained by the following illustrative procedure. The inserts receiving the siliconizing treatment are placed in a horizontal drum or retort. The retort is connected to a source of substantially dry inert gas to provide a non-oxidizing atmosphere for example a noble gas such as nitrogen, helium, or argon, which is introduced to displace the air. After the preliminary flushing, the flow of nitrogen, for instance, is reduced so as to be sufficient to make up for losses that may occur due to leakage. Then the retort is rotated and heat is applied, for example, by electric heating elements on the sides, to raise the temperature to proper siliconizing levels. The temperatures are not critical, but generally best results are obtained in the range from about 1300° F. to about 2000° F., more particularly from about 1500° F. to about 1900° F., and in most instances at around 1850° F.

After the siliconizing temperatures are attained, the flow of inert gas is shut off and silicon tetrachloride is introduced into the retort. This gas is generated by applying heat to a receptacle containing liquid silicon tetrachloride. Alternatively, the silicon tetrachloride may be introduced by a carrier gas, which is bubbled through the silicon tetrachloride liquid and then conducted into the retort. After the retort has filled with the siliconizing reagent with, or without, the presence of the carrier, the flow of the reagent is reduced to a slow, continuous ingress for this siliconizing process.

The treatment of the articles with the silicon tetrachloride is accomplished in the presence of a reagent which reduces the presence of free chlorine. For example, silicon carbide is added to the retort, so that the reaction between the siliconized article and the silicon tetrachloride takes place in the presence of silicon carbide, as more particularly described in United States patent to Eckman No. 2,897,093. Although the foregoing silicon carbide reagent is preferred, other reagents may be utilized, for instance, hydrogen may be employed in lieu of the silicon carbide, as more particularly described in the United States Patent to Henderson No. 2,501,051.

Ordinarily the exposure time of the treated articles to the siliconizing atmosphere is from about 0.5 to about 5 hours. Satisfactory results are obtained usually within one to three hours.

By controlling the time of exposure to the siliconizing atmosphere, and the temperature, the depth of the silicon impregnation and concentration of the silicon in the case may be controlled according to need.

After receiving the siliconizing treatment, the articles may be allowed to cool in the retort to room temperature, or may be removed to separate containers to lower temperatures for handling.

The silicon-enriched cases thus produced on the insert are insulative and form a thermal barrier so that when the cast metal is poured into the mold, the silicon-enriched surface maintains a thermal barrier between the metal insert and the cast body portion. The thermal barrier prevents chill occurring in the cast body portion, and thus reduces cracking problems. It further prevents melting, or fusion, of the metal insert.

The inserts provided with the insulative silicon-enriched cases in the foregoing, or any other suitable manner, are placed in the mold and the molten metal, such as molten iron or steel, is then poured about them. The inserts are located in positions in which they are to be arranged in the finished casting.

The inserts may be of ferrous or non-ferrous metals. For some applications, preference may be given to the alloys having a stable body centered cubic crystal structure throughout the solid phase. In the case of ferrous base metal articles this is represented by the stable alpha-delta alloys, as set forth in the co-pending application by the same inventor, Serial No. 197,702, filed May 25, 1962 and assigned to the same assignee. Alloys possessing the preferred crystal structure reduces the tendency for the case to spall, caused by allotropic transformations. This is particularly important if the insert is to be subjected to wide changes in temperature. Various alloying constituents may be added to ferrous base metals to close the gamma loop and form a stable alpha-delta alloy, for example, at least about two percent silicon, 0.75 percent titanium, six percent tungsten, one percent aluminum, 1.5 percent vanadium, three percent molybdenum, two percent nobium, and thirteen percent chromium. Combinations of the foregoing alloying constituents in ferrous base metal alpha-delta alloys are contemplated. Various other non-ferrous metal alloys have been demonstrated to develop silicon-enriched cases which serve as thermal barriers on inserts of these alloys, for example the cobalt base, or nickel base, alloys.

In order to further illustrate the invention the following examples are given. These examples, however, are not intended to limit the scope of protection afforded, except as defined by the appended claims.

Example I

Two tubular glands were placed in a mold. One gland had been siliconized with silicon tetrachloride in the presence of silicon carbide at about 1850° F. The other gland was untreated. The mold was filled with nodular iron at about 2700° F. Examination of the casting after cooling showed marked differences. As to the cast iron within the glands, the iron which had entered the gland without the siliconized case had solidified in a convex meniscus, while the iron which had entered the gland with the siliconized case solidified with a flat to slightly concave meniscus. As to the cast iron outside the glands, the iron had failed to cover the gland without the siliconized case, while the iron had substantially coated the gland with the siliconized case.

Example II

Four nodular austenitic nickel chromium cast iron inserts were mounted on disc cores in a position that allows the ends to protrude beyond the cast iron. Two inserts had been provided with a siliconized case by treating with silicon tetrachloride in the presence of silicon carbide at about 1850° F. The treated inserts developed a case of about $\frac{1}{32}$ inch over a one hour treatment cycle. The other two inserts were untreated. The molds were filled with gray iron. The two inserts without siliconized cases cracked around the insert. The two inserts with the siliconized case remained sound, and resisted cracking.

Example III

An experiment was performed on austenitic nickel-chromium cast iron inserts imbedded in stainless steel (25–12). One of the inserts was provided with a siliconized case by treatment with the silicon tetrachloride in the presence of silicon carbide at a temperature of about 1850° F. in a non-oxidized atmosphere. The other insert was untreated. After pouring the stainless steel and cooling, the inserts were observed. The insert without the siliconized case melted into the steel, while the insert with the siliconized case remained intact. This experiment demonstrates the effect of the thermal barrier in establishing the feasibility of "cast-in" material in a higher melting point metal.

One of the advantages of forming the case by siliconizing in the presence of a reagent that removes the free chlorine is a refractory case that resists spalling and disintegration when subject to severe thermal shock. The refractory case remains intact during the pouring and solidification of the cast metal and maintains an insulative, or thermal barrier, between the case and cast metal. Another advantage is that the case is substantially free from chlorides. Chlorides are undesirable since they sublimate at the pouring temperature of the cast metal and produce unsound castings.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such be employed.

I claim:

1. A cast ferrous metal article comprising, a cast body portion consisting essentially of a ferrous base metal, a metal insert embedded in said cast body portion consisting essentially of a ferrous base metal, and a non-fusible, insulative silicon-rich case surrounding and integral to said metal insert which is non-fusible at the pouring temperature of said cast body portion and which is of sufficient thickness to form a thermal barrier between said cast body portion and said metal insert at the pouring temperature of said cast body portion.

2. The cast ferrous metal article of claim 1 in which said silicon-rich case is substantially free from iron chlorides and prepared by treating said metal insert with silicon tetrachloride at temperatures in the range of about 1300° F. to about 2000° F. for a period of time from about 0.5 to about 5 hours in the presence of a reagent that removes free chlorine.

3. A cast ferrous metal article comprising, a cast body portion, a metal insert embedded in said cast body portion, and a non-fusible, insulative silicon-enriched case which is non-fusible at the pouring temperature of said cast body portion and which surrounds and is integral to said metal insert in a layer of sufficient thickness to form a thermal barrier between said cast body portion and said metal insert at the pouring temperature of said cast body portion.

4. A cast article comprising, a cast body portion, a metal insert embedded in said cast body portion, and an insulative, non-fusible siliconized case which is non-fusible at the pouring temperature of said cast body portion and which is of a thickness sufficient to form a thermal barrier between said cast body portion and

said metal insert at the pouring temperature of said cast body portion, said siliconized case formed by treating said metal insert with silicon tetrachloride at temperatures in the range from about 1300° F. to about 2000° F. for a period of time from about 0.5 to about 5 hours in the presence of a reagent that removes the free chlorine during the reaction and prevents the formation of iron chlorides.

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