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[54] **METHOD FOR CASTING GRAY CAST IRON COMPOSITION**

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[52] **U.S. Cl.**..... **75/130 R,** 75/123 CB, 75/123 AA, 75/123 E, 75/123 M

[51] **Int. Cl.**..... **C22c 37/04**

[58] **Field of Search** ..... 75/130 A, 130 AB, 75/130 R, 123 CB

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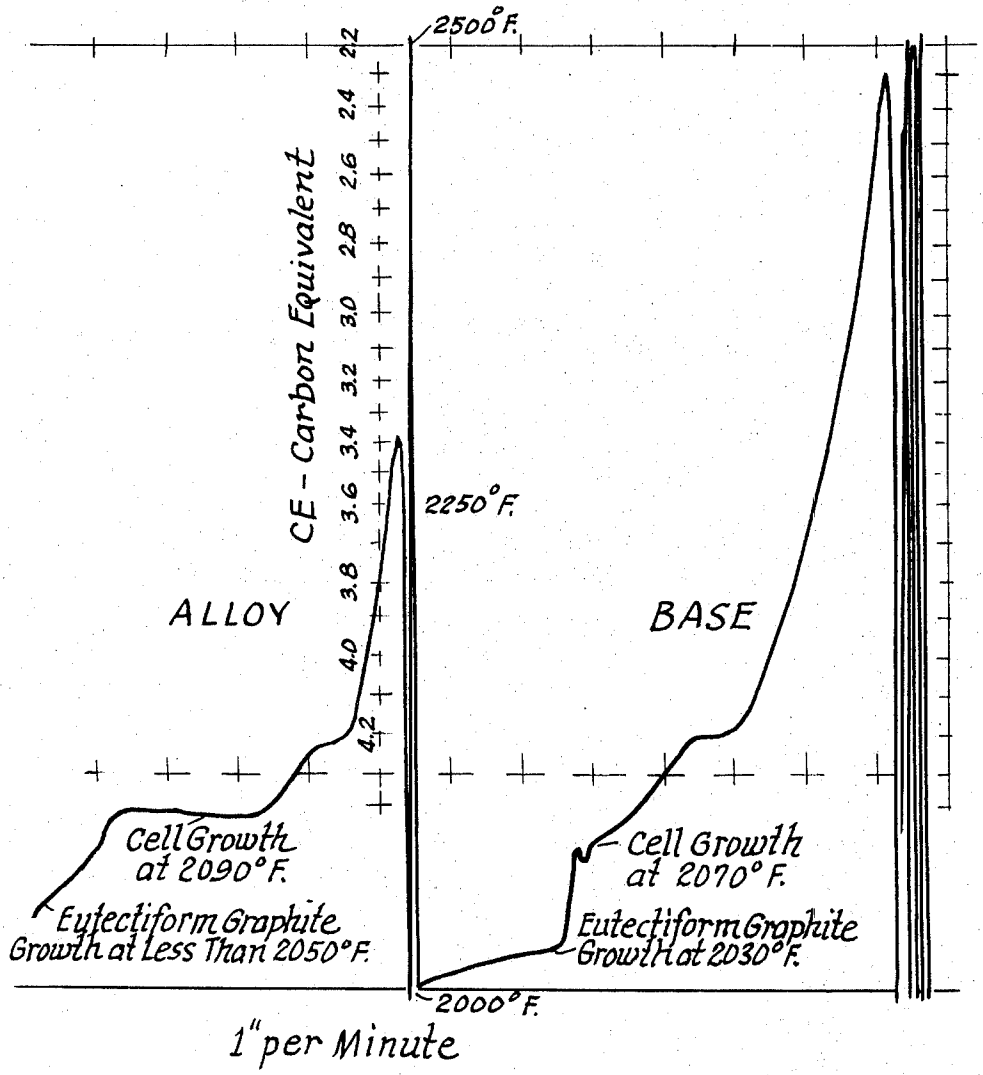
[57] **ABSTRACT**

The preparation of castings of gray cast iron having reduced chill and hard spots without increased shrinkage holes in which the composition is formulated to contain a metal component such as tellurium, selenium, bismuth or Misch-metal, preferably in combination with titanium, to carry the metal to a liquid portion below the eutectic arrest.

4 Claims, 1 Drawing Figure



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METHOD FOR CASTING GRAY CAST IRON COMPOSITION

This invention relates to gray cast irons and to compositions thereof intended to minimize shirnkage during solidification, and to produce castings having improved physical and mechanical properties.

It has been recognized that there is a tendency for the carbon that is present in gray cast iron to form iron carbides. This is generally referred to in the trade as "chill."The iron carbides that form are hard and brittle and tend to produce hard and brittle castings when present in excessive amounts.

This tendency to form iron carbides has been offset somewhat, in foundry practice, by the addition of ingredients which tend to increase the cell count in the cast metal, such as by the addition of ferro-silicons, titanium and the like.

In gray cast irons which are not inoculated with ferro-silicon, 4.05 to 4.20 percent carbon equivalent (CE) being typical, the eutectic cell count is normally about 1000 per square inch when the titanium content is about 0.10 to 0.02 percent. After ferro-silicon inoculation, the cell count may be raised to 1200 to 1600 per square inch, or even higher. Higher cell count, in the range of 1400 to 2000 per square inch, can be obtained when a titanium addition is made or residual introduced so that the titanium content is in the range of 0.025 to 0.05 percent. At about 3.6 to 3.9 percent CE, the cell count is about 700 to 850 in low titanium inoculated gray cast irons with the result that chilled edges and hard spots are secured in the products cast thereof. This can be alleviated somewhat by raising the titanium to 0.03 to 0.05 percent and inoculating with ferro-silicon to increase the cell count.

While the chill tendency is reduced, the higher cell count induced by the presence of titanium and/or the inoculation with ferro-silicon, the amount of shrinkage in casting is undesirably increased. When the freezing process of the cast metal ends up with shrinkage, holes form in the portions of the castings last to solidify and unacceptable castings result. Thus the measures which have been taken to reduce chill and hard spots tend to increase the amount of shrinkage that takes place at the end of the freezing process thereby to raise other problems heretofore sought to be overcome by the use of risers and other procedures.

It is an object of this invention to produce gray cast iron castings and compositions for use in same which minimize chill and the formation of hard spots in the cast product, which provides for expansion in amounts substantially to offset or compensate for shrinkage during the freezing process so that, at the end of the freezing process, the cast product will continue to fill out the mold cavity without the need for risers or other means to fill the mold and without the development of holes in the cast product due to shrinkage in the portions last to solidify,

It has been found that the desired results can be achieved when the gray cast iron is formulated with an amount of titanium, ferro-silicon or other component to increase cell count sufficiently to minimize solidification as carbides or phosphides thereby to reduce chill and formation of hard spots in the cast product and other components which insure the presence of a liquid state below the temperature for eutectic arrest so that some of the metal will solidify below the critical temperature of eutectic arrest for the particular composition. Such liquid phase which remains for solidification below the critical temperature will freeze by a type D eutectiform graphite mechanism instead of cell growth mechanism. The type D eutectiform graphite structure expands upon freezing and operates in the system to offset the shrinkage which usually accumulates at the end of the freezing process and thus prevents the formation of shrinkage cavities. The eutectiform graphite will tend to form mostly in the areas last to solidify and therefore in higher concentrations in areas where maximum shrinkage would otherwise occur. When the metal solidifies, the expansion of the type D eutectiform graphite fills out the areas to compensate for the shrinkage of the type A and B cells formed during freezing at or above the eutectic arrest.

The amount of eutectiform graphite formed in the liquid phase remaining for freezing below the eutectic arrest should ideally be related to the amount of type A and B cells formed so that the amount of expansion will more or less compensate for the amount of shrinkage in the final stages of cooling. This will depend somewhat on the composition of the gray cast iron from the standpoint of carbon, titanium, silicon and other ingredients present to reduce chill and hard spots. As a general principle, the desired results can be achieved when the amount of type D eutectiform graphite structure that is formed is above 0.1 percent but not more than 20 percent by volume of the gray cast iron with best results being secured within the range of 0.3 to 5 percent by volume of type D eutectiform graphite structure, especially in the critical areas which are the last to solidify. The eutectic arrest for gray cast iron of normal composition occurs within the temperature range of 2070°–2115° F. Freezing of the eutectic will begin upon cooling down through 2115° F. and will form type A and B cells. The cells that are formed during freezing in the upper portion of the described temperature range at and above the eutectic arrest, will contain coarser graphite flake while the cells formed during the lower portion of the range will contain finer graphite flake. The cells all form with type A and B graphite, not eutectiform graphite.

Eutectiform graphite structure is formed at temperatures lower than 2070° F., usually lower than 2055° F., by a second eutectic arrest. The attached cooling curve shows an alloy treated to have two arrests, one with cell growth at a higher temperature and one with eutectiform graphite at a lower temperature. The attached cooling curves are for a base metal containing 3.36 percent carbon, 2.06 percent silicon, 0.09 percent manganese, 0.12 percent phosphorus, 0.11 percent sulphur, with the remainder iron plus impurities. The alloy represents the base metal after treatment with ferro-silicon in which the amounts of elements are the same with the exception of silicon which is increased to 2.23 percent.

Inoculants which increase the number of sites for cell formation generally raise the temperature for eutectic arrest. Thus, titanium, ferro-silicons and other metals which are added to reduce chill, such as titanium and ferro-silicon combinations marketed under the trade name "Graphidox,"generally raise the temperature for eutectic arrest with corresponding increase in the number of cells and the amount of shrinkage that takes place during final stages of freezing.

An important concept of this invention resides in the formulation of the gray cast iron with one or more com-

ponents that will cause the metal to sustain some liquid below the temperature of normal type A cell eutectic arrest so that this metal, in the liquid stage, will solidify to form eutectiform graphite structure in an amount within the range of 0.1 to 20 percent by volume of the metal.

This can best be achieved by the formulation of the gray cast iron with tellurium and/or bismuth, rare earths, and copper. The desired results can be achieved when tellurium is present in the gray cast iron in an amount within the range of 0.00001 to 0.01 percent by weight and preferably in an amount within the range of 0.0005 to 0.001 percent by weight.

Representative of other materials which are effective to carry the metal to provide a liquid phase below the critical temperature for formation of eutectiform graphite include bismuth, Misch-metal, selenium, sulphur, rare earths and copper. When use is made of selenium the amount may vary from a maximum of 0.1 percent ot a minimum of 0.001 percent and preferably an amount within the range of 0.005 to 0.05 percent by weight. With bismuth, the amount may vary within the range of 0.0005 to 0.02 percent and preferably within the rangeof 0.005 to 0.05 percent by weight.

An important technological advance in the art of gray cast iron resides in the ability to reduce chill and the formation of hard spots by the addition of titaniuj, thereby to obtain the desirable effects from titanium additions, without the need also to accept the undesirable effects previously experienced from the additions of such titanium, such as marked increase in the numbeof sites for cell formation with corresponding increase in the amount of shrinkage. For this purpose, it is effective to make use of tellurium with titanium in the cast iron in the ratio of onepart by weight of tellurium to 50 to 1000 parts by weighof titanium, depending somewhat upon the desired cell count reduction desired and in which the tellurium is present in the amount described above. Others of the metals such as bismuth, Misch-metal, copper and selenium may be used instead of tellurium in corresponding amounts to enable the desirable effects to be secured with titanium without being faced with the undesirable effects achieved when the desired proportion of the cast metal remains in the liquid phase below the critical temperature for formation of eutectiform graphite during the final stages of solidification.

Thus, in the preferred practice of this invention, use is made of the combination of both titanium and tellurium, or other metal component, which results in the presence of 0.1 to 15 percent by volume of a liquid phase below the critical temperature for eutectic arrest. The amount of titanium should be at least 0.001 percent by weight but not more than 0.15 percent by weight of the gray cast iron andpreferably within the range of 0.003 to 0.05 percent by weight. When the amount of titanium exceeds 0.15 percent by weight, poor graphite shapes results and the castings are characterized by insufficient hardness, low tensile strength and poor machinability. When titanium is present in an amount less than 0.001 percent by weight, it has little noticeable effect.

In practice, the tellurium can be added to the melt any time prior to pouring but it is preferred to add the tellurium immediately prior to pouring, as by addition to the melt in the ladle from which the metal is poured.

Titanium can be added as a residual element in the pig iron making up the melt, as an inoculant, such as in a titanium-bearing ferro-silicon, represented by the material marked by Vanadium Corporation as "Graphidox" containing 10–12 percent titanium along with silicon, manganese and iron, or a similar material marketed by Foote Minerals. The titanium can be added to the ladle with the tellurium or it can be added as a ferro-titanium alloy, or it can be incorporated as part of the steel scrap.

The amounts of silicon, aluminum and calcium, when employed, are within the conventional amounts generally formulated into gray cast irons.

An important concept of this invention resides in the production of a master alloy for use in addition of the titanium and tellurium in the desired ratios and amounts to gray cast iron. Such master alloy, in addition to containing titanium and tellurium in the ratio described, can advantageously be formulated to contain substantial amounts of silicon or silicon and aluminum and/or calcium. The silicon is an effective inoculant for producing graphite and the aluminum and calcium also have beneficial effects. In formulating the master alloy, iron can be used as a diluent.

The following is representative of a master alloy embodying the features of this invention and which may be used for introducing titanium and tellurium into gray cast iron melts in accordance with the principles of this invention.

Example 1

Master alloy:	Broad range parts by weight	Narrow range parts by weight
Aluminum		6 –12
Titanium	10 –40	12 –23
Silicon	60 –90	63 –81
Calcium		.5 –2
Sodium		.5 –2
Tellurium	1 part by weight tellurium per 25–100 parts by weight of titanium	

The master alloy of Example 1 can be diluted with iron in amounts up to 50 percent by weight and preferably in amounts up to 15 percent by weight.

The following are specific examples of master alloys embodying the features of this invention:

Example 2

12 parts by weight aluminum
23 parts by weight titanium
63 parts by weight silicon
1 part by weight calcium
1 part by weight sodium
.3 part by weight tellurium

Example 3

6 parts by weight aluminum
12 parts by weight titanium
81 parts by weight silicon
.5 part by weight calcium
.5 part by weight sodium
.2 part by weight tellurium

Example 4

12 parts by weight aluminum
23 parts by weight titanium
63 parts by weight silicon
.46 part by weight tellurium
15 parts by weight iron

EXAMPLE 5

Gray cast iron of convention composition is reduced to a molten state for casting by heating to a temperature of about 2600°–2800° F. The molten cast iron is

tapped from the melting furnace into a ladle and before the metal is poured from the ladle, an amount of master alloy of Examples 1–4 is introduced into the molten metal to provide 20 parts per million tellurium and 0.1 percent by weight titanium.

When the added master alloy has been reduced to the molten state and mixed with the molten gray cast iron, the metal is poured from the ladle into the molds for casting. A casting is produced which is characterized by the presence of carbon as flake graphite and in which the casting is relatively free of shrinkage porosity.

It will be understood that changes may be made in the details of formulation and operation without departing from the spirit of the invention, especially as defined in the following claims.

We claim:

1. The method of casting gray cast iron with reduced chill andhard spots and reduced shrinkage holes comprising casting molten gray cast iron containing titanium and a metal component which carries the metal to a liquid phase in an amount within the range of 0.1 to 20 percent by volume below the temperature of eutectic arrest and cooling the cast metal through the temperature of 2115° F. to below solidification temperature whereby the portions first to solidify above the eutectic arrest form into type A and B cells and the liquid portions below the eutectic arrest solidify as type Deutectiform graphite structure concentrated in the portions last to solidify.

2. The method as claimed in claim **1** in which the metal component for carrying the gray cast iron to a liquid phase below eutectic arrest is selected from the group consisting of tellurium, bismuth, selenium, Misch-metal, sulphur, rare earths and copper.

3. The method as claimed in claim **1** in which the metal component is tellurium present in an amount within the rangeof 0.00001 to 0.01 percent by weight and in which the titanium is present in the ratio of one part by weight of tellurium to 50 to 21000 parts by weight of titanium.

4. The method as claimed in claim **1** in which the metallic component is tellurium present in an amount within the range of 0.005 to 0.001 percent and in which titanium is present in an amount within the range of more than 0.001 percent but less than 0.15 percent by weight.

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