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CAST IRON AND A METHOD OF PRODUCING CHILLED SURFACES THEREON

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Our invention relates to cast iron and a method of producing chilled surfaces thereon. It has to do, more particularly, with a method of producing a hard chilled surface on gray iron castings.

In the art of providing chilled surfaces on gray iron castings, it is general knowledge that one of the oldest and still widely used methods is to embed a metal chill in the mold corresponding in location to the area or surface desired to be hardened. A hard surface is thus produced by casting the metal against the chill, in which case, the metal chill extracts heat from the contacting metal at a rate which causes it to solidify at the surface and to some depth beneath the surface as white iron. The carbon in the iron which normally is present as soft graphite in gray iron castings exists as inter-dendritic masses of carbide in the area adjacent to the metal chill.

Still another method for producing chilled surfaces on gray iron castings has been to adjust the composition of the iron very closely with regard to silicon, carbon and sulfur contents and to use certain carbide stabilizing elements such as chromium and vanadium. With precise control of composition, chilled, wear-resistant surfaces have been formed on castings without the aid of metal chills. This practice, however, has had limited application because of difficulty in regulating iron compositions and has thus been suitable for a few types of castings only. Even when production conditions are favorable to the use of this practice, the resultant chilled surfaces are frequently mottled, that is, they consist of gray and white areas and are, therefore, not fully hardened.

There are also certain limitations in the use of metal chills for producing chilled surfaces on gray iron castings. It is difficult, for example, to use such chills when the section of the casting is light. Furthermore, metal chills can be used only where it is possible to remove them from the solidified castings; otherwise they are lost. The making of metal chills is expensive, and unless they can be used over and over again a large number of times, it is not economical and feasible to use them. The high cost of metal chills is particularly evident in the making of a single casting or only a few castings from a pattern. The full cost of the metal chill or chills must be borne in the casting price, and in this case it becomes an item of considerable expense. Metal chills also require frequent attention in order to keep them in good condition and to keep their surfaces from oxidizing and rusting. Finally, the depth of chill obtained in this manner is largely determined by the composition of the iron used. Depth of chill cannot be varied without altering the metal composition.

One of the objects of our invention is to provide an improved chilled gray iron, the chilled surface being very hard and having a high resistance to wear and to corrosion.

Another object of our invention is to provide a simple and effective though inexpensive method for producing chilled surface areas on gray iron castings.

Another object of our invention is to provide a method of producing localized hard chilled surface areas on gray iron castings without the use of metal chills.

Another object of our invention is to provide a method of producing chilled surfaces on cast iron wherein the depth of chill can be controlled without altering the basic composition of the iron.

Another object of our invention is to provide an improved chilled gray iron which is particularly suitable for use in the manufacture of wear-resistant objects.

Other objects and advantages of our invention will become apparent from the following description and claims.

We have found a novel and inexpensive method for producing a hard, chilled surface on gray iron castings that overcomes the limitations of the prior art. By using small quantities of tellurium either in the iron composition or on the mold surface, or by introducing minute amounts of tellurium into the iron at the point where chill is desired, we have found it possible to effect strong general and local chilling tendencies in iron castings. In its effect, tellurium is extremely potent, and in such instances where it is not introduced directly to the iron but is placed in the mold for localized chilling, its sphere of influence extends a substantial though limited distance beyond the point where it contacts the iron. Chilled surfaces not only can be localized if desired, but the depth of chill can be varied merely by varying the amount of tellurium used. While the amount of tellurium required to effect various chill depths depends upon the composition of the iron and the size of the casting, our invention makes possible the control of chill depth for any gray iron composition or for any size of casting by the use of varying amounts of tellurium.

The effectiveness of tellurium in forming white iron was demonstrated by adding small quantities to a gray iron melt containing 2.65 per cent carbon, 2.00 per cent silicon, 0.40 per cent manganese, 0.15 per cent phosphorus, and 0.036 per cent sulfur. The iron cast into sections of different thicknesses gave chill results as follows:

Tellurium addition	Structure of metal in section			Thicknesses of 1 in.
	1/8 in.	1/4 in.	1/2 in.	
None	Mottled	All gray	All gray	All gray.
0.025%	All white	All white	All white	All white.
0.05%	do	do	do	Do.

In these tests, with an iron of low carbon content, the potency of 0.025 per cent tellurium was indicated by the stabilizing of cementite in sections as large as 1 inch. If insufficient tellurium is added to iron to produce an entirely white iron, we have found that a casting is obtained having a white shell or chill of uniform thickness with a gray iron interior. This was illustrated with wedges cast in sand from heats whose base composition was 3.30 per cent carbon, 1.70 per cent silicon, 0.50 per cent chromium, 0.60 per cent manganese, and 0.07 per cent sulfur. The cross-section of the wedges was triangular with two sides 1¾ inches long and the third side ⅞ inch long. A wedge from metal containing no tellurium showed no chill. On adding 0.02 per cent tellurium, a chill approximately 1/32 inch in depth surrounded the wedge, while with 0.028 per cent tellurium the chill depth was increased to approximately 3/32 inch. With 0.045 per cent tellurium the entire section was white.

Chilled surfaces produced by adding tellurium to the molten iron are uniform in depth and are usually distinguished from chills obtained by other practices by the fact that they rarely show a mottled zone between the chill and the gray interior. The transition from white to gray structure is usually quite sharp. In spite of this sharpness of contact between the chill and gray interior, the chills so formed resist spalling against thermal and mechanical shock to a marked degree.

The depth of chill formed in accordance with our invention is determined largely by the size of the casting, by the composition of the iron, by the duration of time between the introduction of the tellurium in the iron and the pouring of the casting, and by the amount of tellurium used. The size of the casting affects the rate of the cooling and consequently a decrease in the size of sections of the casting decreases the amount of tellurium required for a given depth of chill. If the cast iron has other elements therein which help to stabilize the cementite, less tellurium will be required for a given depth of chill, while with more strongly graphitizing cast iron, more tellurium will be required. The effect of tellurium diminishes as the time, from the moment it is added to the melt to the time of pouring the casting, increases. Thus, the time factor must be given consideration. Vaporization of the tellurium from the melt is probably responsible for its diminishing effect with time. Proper chill depths are obtainable by control of these various factors. Even though the castings are large, the iron strongly graphitizing, and the time before pouring after the introduction of tellurium long, we have found that it requires substantially less than 1 per cent tellurium to produce chilled surfaces on sand castings. We prefer to add from 0.001 per cent to 0.5 per cent tellurium to the iron to produce the desired chill adjacent the surface of the casting.

Another effective method for producing chill either over the entire surface or at localized areas on a gray iron casting is to coat the mold surface with powdered tellurium or tellurium alloy, or with compounds of tellurium. The effectiveness of the individual tellurium-bearing materials or the mixtures made from them is determined almost exclusively by the concentration of the tellurium. Tellurium-containing coatings have been applied as mold washes which can be sprayed or painted on the mold, as dry powder which can be dusted on the mold, and as a material applied to the pattern which subsequently can be transferred to the mold when it is being made. Another method of application not as effective as these above mentioned, but nevertheless practical, is to add the tellurium or tellurium-containing substance to facing sand used to cover such portions of the pattern where chilled surfaces are to be formed on the castings.

In producing chilled areas by application to the mold surface, the most satisfactory method found for controlling the depth of chill was to vary the tellurium concentration on the mold surface.

Our preferred method of coating mold surfaces with tellurium-bearing material is to incorporate the tellurium in a sprayable mold wash. Various washes have been prepared and used successfully. Typical compositions of such mold washes as were used are:

#1

	Per cent
Water	8
Soluble mineral oil	12
Kerosene	52
Silica flour	18
Tellurium (powdered)	10

#2

	Per cent
Water	8
Soluble mineral oil	12
Kerosene	52
Silica flour	18
Iron tellurium (powdered)	10

#3

	Per cent
Absolute alcohol	60
Orange shellac	30
Tellurium (powdered)	10

#4

	Per cent
Kerosene	50
Sulfonated castor oil	15
Sodium tellurate solution	35

We employed kerosene in many wash mixtures to decrease the water content and to provide a kerosene water emulsion for suspending the tellurium, tellurides, tellurates or other tellurium compounds which normally settle rapidly in water. Furthermore, by decreasing the water content, danger from porosity in the metal which may arise from excessive moisture in the sand beneath the sprayed wash, should high water concentration be used, is lessened. Inert material, such as silica flour, was employed in some cases to decrease the rate of absorption of the tellurium by the iron and to restrict the sphere of influence of the tellurium, an important factor when the chill is to be localized. Such material proved effective in momentarily protecting the tellurium and retarding its penetration into the iron, permitting the metal to flow and fill the mold before the tellurium became thoroughly active.

A measure of the quantity of tellurium, deposited on the mold surface, that has been employed successfully for the production of local chilled areas on castings can be gained from some tests conducted on automotive cam shafts. The tips and surfaces of cams were chilled by spraying the surface of the cam cavities in the mold with a light coating of tellurium-bearing wash. The amount of tellurium used per square inch of surface covered varied from about 0.01 gram to about 0.05 gram. The amounts gave chills approximating 1/16 inch and 3/16 inch in depth, respectively, for an iron analyzing 3.20 per cent carbon, 1.70 per cent silicon, 0.50 per cent chromium, 0.20 per cent phosphorus, 0.50 per cent manganese, 0.07 per cent sulfur. By altering the amount of tellurium in the mold wash or the amount of wash sprayed on the mold surface, it is possible to produce either a heavier or a lighter chill.

Chilled surfaces formed in the above-described manner have hardness similar to those of chilled surfaces produced with metal chills.

The production of localized chilled areas on gray iron castings can also be effected by using tellurium-coated inserts in the mold made up from wire, nails, or other ferrous materials, and casting the iron about the inserts. These coated inserts may be prepared by hot-dipping in molten tellurium or tellurium alloys. Light inserts of this kind in the molds melt and disappear in the hot iron and permit the tellurium to act upon the iron, forming chilled areas in the vicinity. Very satisfactory localized chilled areas are obtained in this manner with small quantities of tellurium. For chilling the tip and surface of a cam on a cast iron cam shaft, it was found that 0.02 to 0.06 gram per square inch of tellurium on an insert was sufficient.

When the chill is produced by applying tellurium to the mold surface or to the insert, the resultant chilled layer immediately adjacent the surface of the casting will be characterized by the presence of tellurium in an amount ranging from 0.001 per cent to 0.5 per cent.

An inexpensive method for producing hard, chilled surfaces on gray iron castings is thus provided by our invention. Chills can be localized with ease, if necessary. Because the quantity of tellurium used is small, the cost of the tellurium itself is negligible. The various methods used in applying tellurium or its compounds in accordance with our invention are also inexpensive. Besides being very simple and inexpensive, our process is flexible and is readily adapted to castings having surface contours that prohibit obtaining desired results with metal chills.

Further economies over present practices prevail in surface chilling castings where only one or a few are made from a pattern. The preparation of metal chills is dispensed with so that the cost of making the castings, whether the iron is alloyed with tellurium or whether tellurium is applied to the mold, is relatively no more than if the castings were made without the chill. Considerable savings in time are also involved.

Our invention provides a practical way to improve the resistance of gray iron castings to atmospheric corrosion and to corrosion in some acids. Chilled cast iron is usually more resistant to atmospheric and acid corrosion than gray iron, so that improved resistance is obtained by surfacing gray iron castings with a chill. The effect of the chilled surface was determined as follows: Specimens 1 inch x 3 inches x 3/8 inch of gray iron whose surfaces were and were not chilled by tellurium were totally immersed in 2 per cent sulfuric acid and 2 per cent hydrochloric acid for 26 hours, the acids being renewed every 4 hours. Weight losses in grams in these two acids after immersion were:

Surface treatment	2% H_2SO_4	2% HCl
None	4.16	5.51
With tellurium	3.08	2.29

Similar irons, with and without chilled surfaces, when exposed to the weather for a year lost 0.37 gram and 0.61 gram per square inch of surface, respectively, showing that a marked decrease in corrosion loss obtains as a result of providing the castings with chilled surfaces.

Our invention of utilizing tellurium and tellurium-bearing materials to provide chilled surfaces and localized chilled areas on gray iron castings is suitable for a wide range of applications. Articles such as cams on cast iron camshafts, teeth on cast iron gears, various castings on agricultural equipment, cast iron paving blocks, sections of cast iron roofing, and other cast iron articles requiring resistance to wear, abrasion, or corrosion are examples where our invention is applicable.

It is to be understood that when the term "tellurium" is used in the following claims, alloys of tellurium and compounds and other materials containing tellurium are also included.

Having thus described our invention, what we claim is:

1. A method of forming chilled surfaces on a gray iron casting which comprises applying tellurium to the surface of a mold cavity and then pouring the iron into such mold cavity, the tellurium being applied to the surface of the mold cavity in an amount sufficient to produce a chilled iron layer adjacent the surface of the casting characterized by the presence of tellurium in an amount ranging from 0.001 to 0.5 per cent.

2. A method of forming chilled surfaces on a gray iron casting comprising the application of a mold wash containing tellurium to the surface of a mold cavity and then pouring the iron therein, the mold wash containing tellurium in an amount sufficient to produce a chilled iron layer adjacent the surface of the casting characterized by the presence of tellurium in an amount ranging from 0.001 to 0.5 per cent.

3. A method of forming chilled surfaces on a gray iron casting which comprises the application of from 0.005 gram to 0.3 gram of tellurium to each square inch of surface of a mold cavity and then pouring the iron therein.

4. A method of forming localized chilled surface areas on a gray iron casting, said method comprising the coating of the surface of the mold cavity with tellurium at such locations corresponding to the areas of localized chill on the casting, then pouring the iron therein, the tellurium being applied to the surface of the mold cavity in an amount sufficient to produce a chilled iron layer adjacent the surface of the casting characterized by the presence of tellu-

rium in an amount ranging from 0.001 to 0.5 per cent.

5. A wear-resistant cast iron article comprising a layer of chilled iron on a gray iron casting, said chilled iron layer being characterized by the presence of tellurium in an amount ranging from 0.001 per cent to 0.5 per cent.

6. As a new article of manufacture, a cast iron the basic composition of which without a tellurium content would normally be from gray to mottled if cast without chilling, said cast iron having a hard wear-resistant surface and containing tellurium in effective amount in said surface causing it to be hard and white and greater in percentage as compared with the interior of the same.

7. A method of forming chilled surfaces on a gray iron casting which comprises applying tellurium to the surface of a mold cavity and then pouring the iron into such mold cavity, the tellurium being applied to the surface of the mold cavity in an amount sufficient to produce a chilled iron layer adjacent the surface of the casting.

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