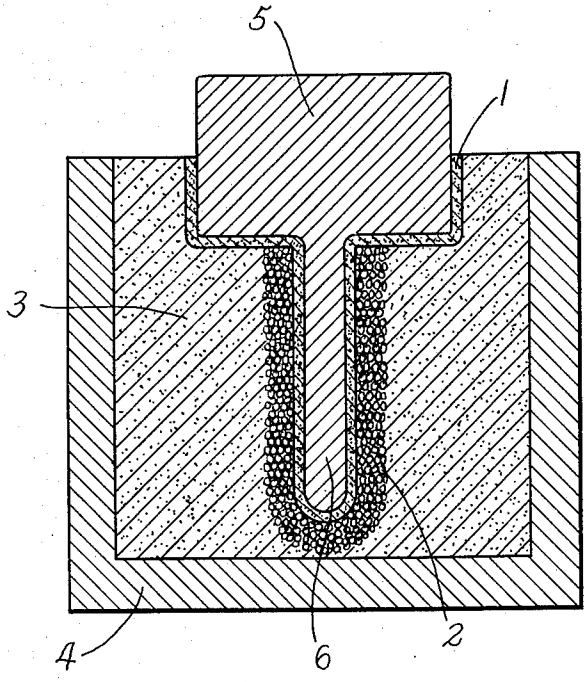
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DUCTILE IRON CASTINGS AND METHODS OF MAKING SAME

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# DUCTILE IRON CASTINGS AND METHODS OF MAKING SAME

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The present invention relates to iron castings having thin sections of high ductility as cast, to mold members for producing such castings and to a novel method of casting iron.

It is well known in the art that ductile cast iron is a high-carbon ferrous material having a characteristic microstructure containing carbon in the form of randomly dispersed, soft, gray-colored, substantially spheroidal or spherical particles or agglomerates thereof. Carbon in this form, also referred to as nodular graphite and graphite spheroids, is believed to play an important part in accounting for the superior mechanical properties, particularly strength and ductility, of ductile cast iron. By contrast, the carbon in gray cast iron is in the form of flakes which inherently form notches and other discontinuities in the matrix and is believed responsible at least in part for the more brittle and lower strength properties that are characteristic of gray iron castings.

It is also well known that the formation of nodular graphite in ductile cast iron, as distinguished from the flake graphite that is characteristic of gray cast iron, is promoted by such means as inoculating molten carbon-containing iron with magnesium or a magnesium alloy, as described for example in U. S. Patent 2,485,760. Consistent with the practice in the art, molten iron treated in this or any other manner to promote the formation of nodular graphite upon cooling is referred to herein as ductile iron, and castings produced from such melts are referred to herein as ductile cast iron.

I have found that while ductile cast iron of desirably good ductility and toughness is obtainable consistently as cast in thick casting sections, i. e., sections having a thickness of about one inch or more, the ductility of thinner sections as cast leaves much to be desired. This is so particularly in sections having thicknesses of about one-half inch or less, and to a progressively lesser extent in sections of increasing thickness ranging between about one-half inch and one inch. As a consequence, it has been considered necessary to subject castings having thin sections to an annealing treatment in order fully to develop a nodular graphitic microstructure in a substantially ferritic matrix and to thus impart to the thin sections a ductility commensurate with that possessed by the thicker sections.

An annealing treatment is expensive, time-consuming and prone to result in dimensional distortion of the casting. It involves heating the castings to temperatures of the order of 1600 or 1750° F. in a furnace in the course of say six hours, holding the temperature for an additional six or eight hours, allowing the furnace to cool to a lower temperature of say 1300° F. in eight more hours and in some instances reheating the castings after cooling. The equipment used for this represents a very considerable investment and the labor, fuel, time and plant space that are required impose a continuing high cost in producing the castings. The results, while effective in imparting ductility to thin sections by converting their microstructure from one having graphite spheroids surrounded by ferrite rings in a matrix of fine pearlite to one in which the graphite spheroids are in a ferritic matrix containing at most only traces of pearlite, are often disappointing because of the dimensional distortion that is involved. This problem is aggravated when it is desired to produce precision ductile iron castings such as tire molds, rotors or stators for blowers, turbines, or the like, or any cast iron product in which thin sections having dimensional precision and ductility are required.



This invention is addressed particularly to a solution of these problems and to avoiding the disadvantages and expense of such annealing treatments without, however, losing the benefits obtained.

I have made the surprising discovery that ductile iron can be cast to produce castings having thin sections that are ductile as cast by in effect thermally insulating surface-forming portions of the mold member against which the iron is cast. Castings made by the method of this invention require no annealing treatment to promote the formation of nodular graphite or reduce any occurrence of pearlite in the matrix.

In accordance with the invention, I reduce the rate of heat transfer from the molten iron to the mold at those portions which form thin sections that are to be ductile as cast. One method I have found to be practicable in the foundry for accomplishing this is that of backing up the facing layer of a mold member with a refractory heat insulating material in such a manner as to impede heat transfer from the section of the casting in question. While many materials are undoubtedly effective and meet the basic requirements of being refractory, having a low thermal conductivity and of being able to form a coherent layer or mass while preserving permeability in the mold member, I have found that tiny hollow spheres or spherules of refractory material such as glass, alumina, blown aluminum silicate, blown mica, and phenolic "Microballoons" are excellently suited for this purpose.

Hollow spherules of glass are available on the market under the tradename "Kanamite" and blown alumina bubbles are obtainable from the Carborundum Corporation. Blown aluminum silicate and blown mica are available under the tradenames "Perlite" and "Vermiculite," respectively, and phenolic "Microballoons," obtainable from the Bakelite Company, are tiny balloons of thermoset phenolic resin whose interiors are filled with nitrogen.

My preference at this time is for hollow glass spherules or alumina bubbles as a material for forming a refractory insulating layer or back-up for the facing layer. It is based upon my discovery that these materials are relatively inexpensive, are capable of being bonded, under conventional curing or baking conditions for refractory molds, into a coherent but permeable mass that is both light and strong, and are readily bonded under the same conditions to the facing layer and other possible mold portions. The use of blown aluminum silicate, blown mica and "Microballoons" is effective when lightness of the mold member is an important consideration, as it is with large mold members, and resistance to crushing of the spherules is of minor importance.

Generally I have found that the ability to form a cohesive mass of hollow spherules increases with a decrease in particle size and that the permeability of such a mass increases with larger particle sizes. Spherules passing through a 20 mesh screen and retained by a 100 mesh screen, i. e., those having particle sizes between about 150 and about 850 microns, have given uniformly good results in forming coherent masses of entirely adequate permeability and are therefore preferred. Insulating materials

having an average and predominant particle size of about 300 microns are considered optimum.

The particles of insulating material are bonded together in situ at mold curing conditions, preferably by employing a bonding agent such as that used in forming a bonded sand mold, e. g., a thermosetting resin such as a phenol-, urea-, or melamine formaldehyde resin, to form a coherent and permeable mass.

In the preferred embodiment of the invention, I prepare a mold member having a surface-forming portion by dusting a pattern corresponding in surface configuration to the article to be cast with a facing layer of refractory material such as fine molding sand and then backing this facing layer with a layer of hollow spherules coated with a bonding resin. This layer in turn may, if desired, be backed up by a coarse molding sand likewise containing a thermosetting bonding resin in a minor proportion by weight, say about 2 or 4%.

The mold member, after suitable vibration and packing for compacting, is then subjected to heat treatment to set the resin and bond the mold member components firmly to one another. After removal of the pattern from the surface-forming portion or facing layer, the mold member is ready for use in the casting operation.

When molten ductile iron is poured against the surface-forming portion of the mold member, the insulating layer, being in a heat transfer impeding relation thereto, apparently has the effect of extending the time during which the temperature of the ductile cast iron passes through the solidification zone. In any event, the casting surface formed by the surface-forming portion of the mold member is found, upon microscopic examination, to contain nodular graphite in a predominantly ferritic matrix. Furthermore, tests of articles so cast show conclusively that even thin sections thereof, as cast, have ductility and tensile strength values that are truly characteristic of ductile iron. They compare favorably as to ductility and toughness with thick sections as cast and with conventionally cast thin sections as annealed.

One of the most important advantages of the method of this invention is that the ductile iron castings obtainable thereby are not only truly ductile throughout, but are dimensionally accurate. Another important advantage is that the high initial and operating expenses of annealing are entirely eliminated.

These advantages, as well as the utility of the invention, will become further apparent from the following example included to illustrate the best mode now contemplated for carrying out the invention as well as from the accompanying drawing in which the sole figure illustrates schematically a mold member comprising a facing layer **1**, an insulating layer **2** of glass spherules, a back-up of regular coarse molding sand **3** and a drag **4**, the facing layer **1** surrounding a surface of a casting having a relatively large portion **5** and a relatively thin portion **6**, and the insulating layer **2** of glass spherules backing up the facing layer **1** around the thin section **6**.

*Example*

A round test bar pattern one-half inch in diameter in the test section was covered with a thin coat of kerosene and mold oil and then faced with a regular facing sand containing 2% by weight bonding resin. The facing layer was then backed up to a depth of one to 1½ inches with hollow "Kanamite" glass spherules, that were admixed with 3% by volume of the same bonding resin and had an average particle size of about 300 microns. This layer in turn was backed up by regular coarse molding sand containing 2% by weight of the bonding resin.

A number of green molds were made in this manner. Several others were made the same way, the only difference in the preparation being that the layer of glass spherules was omitted and the regular molding sand containing 2% by weight bonding resin was utilized as the sole back-up for the facing layer.

The green molds so made were then baked at about 165° C. for thirty to sixty minutes.

Molten ductile iron was poured into both sets of baked molds and removed for testing after cooling. It was found that the bars formed in the molds insulated with the layer of glass spherules had an average tensile strength of 67,000 p. s. i. and an elongation varying from 5% to 9.5% as cast, whereas the control bars cast in the other molds had an average tensile strength of approximately 85,000 p. s. i. and an elongation of between 0.5 and 1.0% as cast.

Taking into consideration that the ductility obtained in a one-inch keel block for the particular iron cast in these tests is aproximately a 10.5% elongation, it is apparent that the average ductility of the test bars cast in the molds of the invention is surprisingly high and significantly better than that obtained in the control bars.

Inspection of the test bar made in accordance with the invention also revealed that it was dimensionally accurate. No signs of bond failure between the facing layer and the insulating layer or between the insulating layer and the back-up of regular molding sand could be found. It should also be mentioned that no difficulty was experienced in removing the pattern from the facing layers, indicating that the bonds between the facing layer and the glass spherules and between the glass spherules themselves were entirely adequate for the purpose. There were no blow holes on the test bars to indicate that the mold member prepared in accordance with the invention lacked permeability.

It is to be expected that numerous modifications will occur to those skilled in the art upon reading this description. All such modifications are intended to be included within the scope of the invention as defined in the accompanying claims.

I claim:

1. Method of casting ductile iron for producing a cast article having a thin section that is ductile as cast which comprises casting the iron against a mold member having a coherent layer of hollow spherules of refractory heat-insulating material in heat transfer impeding relation to the surface-forming portion of the mold member.

2. Method of casting ductile iron for producing a cast article having a thin section that is ductile as cast which comprises casting the iron against a mold member having a coherent and permeable layer of hollow, refractory glass spherules having a particle size ranging between about 150 and about 850 microns in heat transfer impeding relation to the surface-forming portion of the mold member.

3. Method of casting ductile iron for producing a cast article having a thin section that is ductile as cast which comprises casting the iron against a mold member having a coherent and permeable layer of hollow, refractory glass spherules having a particle size averaging about 300 microns in heat transfer impeding relation to the surface-forming portion of the mold member.

4. Method of casting for producing a cast article of iron that is ductile as cast which comprises casting ductile iron against a mold member having a facing layer bonded to a coherent layer of hollow spherules of refractory heat-insulating material.

5. Method of casting for producing a cast article of iron that is ductile as cast which comprises casting ductile iron against a mold member having a facing layer bonded to a coherent and permeable layer of hollow spherules having a particle size ranging between about 150 and about 850 microns in heat transfer impeding relation to the surface-forming portion of the mold member.

6. Method of casting for producing a cast article of iron that is ductile as cast which comprises casting ductile iron against a mold member having a facing layer bonded to a coherent and permeable layer of hollow

glass spherules having a particle size averaging about 300 microns in heat transfer impeding relation to the surface-forming portion of the mold member.

7. In a method of casting ductile iron into an article having a thin section wherein the iron is cast against a mold member having a surface portion for forming said thin section, the improvement which comprises thermally insulating said surface portion of the mold member for extending the time required for the iron in the thin section to pass through the solidification temperature range and thereby promoting the formation of nodular graphite in a ferritic matrix.

8. A mold member for use in casting metal, said mold member having a permeable and coherent layer of hollow spherules of refractory heat-insulating material in heat transfer impeding relation to at least a portion of the surface-forming portion of the mold member.

9. A mold member for use in casting metal, said mold member having a permeable and coherent layer of hollow glass spherules in heat transfer impeding relation to at least a portion of the surface-forming portion of the mold member.

10. A mold member for use in casting metal, said mold member having a facing layer for forming a thin cast section backed up by a permeable and coherent layer of hollow spherules of refractory heat-insulating material.



11. A mold member for use in casting metal, said mold member having a facing layer for forming a thin cast section backed up by and bonded to a permeable and coherent layer of hollow glass spherules.

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