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**HIGH-GRADE CAST IRON HAVING IMPROVED
CONSTANCY OF SHAPE AND VOLUME**Kurt Schwindt, Otto Lucas, and Baldur Sauer, Herdorf
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This invention relates to high-grade cast iron having improved constancy of shape and volume and more particularly to an improved chemical composition for such cast iron which will appreciably increase its constancy of shape and volume.

High-grade cast iron is required to possess a number of qualities among which are included good casting properties, low piping, low shrinkage and contraction tendencies, impermeability, good workability, freedom from tension, and resistance to expansion, and good vibration damping properties characteristics. Low shrinkage, low contraction tendency, freedom from tension and warping and resistance to expansion are here combined in the expression "constancy of shape and volume."

It would be most advantageous to have gray cast iron which will result in an article of manufacture having appreciable constancy of shape and volume (besides good resistance to mechanical stress) such as is applied in connection with parts used in hydraulic machinery and high-grade machine castings. Such articles include parts for compressors and pumps, cylinder liners, turbine casings, lathe beds, lathe spindles, pump impellers, volute casings, shut-off valves, slide valves, steering gear casings, motor casings, sleeve valves, machine uprights, and male and female deep-drawing dies.

It is, therefore, a general object of the invention to provide a new and improved chemical composition for high-grade cast iron which will result in an article of manufacture having a high degree of constancy of shape and volume.

A more specific object of the invention is to provide a gray cast iron composition having a high manganese content of the order of 2.2-3.0% and which results in articles of manufacture having a high degree of constancy of shape and volume besides good resistance to mechanical stress.

Other objects and advantages of the invention will be apparent from the following description: In accordance with the invention, it has been discovered that a high-grade cast iron composition producing castings having the properties above set out and, in addition, such improved constancy of shape and volume has the following composition:

	Percent
Carbon	2.9-3.6
Manganese	2.2-3.0
Silicon	1.5-2.6
Sulfur	maximum 0.06
Phosphorus	do 0.15
Balance, substantially iron.	

wherein the manganese content is 0.2 to 1.3% higher than the silicon content and the bound carbon, at a saturation of 0.8 to 1, amounts to 0.7 to 0.9.

It will be understood that while the above-listed limits in the percentages of sulfur and phosphorus are desirable, the amounts of such elements in the preferred composition, in actual practice, will usually be controlled by the amounts of such elements already existing in the materials used to make up the composition. Sulfur contents up to 0.09% and phosphorus contents up to 0.25 are permissible.

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Where the gray iron castings are not to be subjected to thermal stress, the manganese content is preferably maintained between about 2.4 and 2.6% and for gray cast iron to be subjected to thermal stress, the manganese content most preferably lies between about 2.8 and 3.0%.

Iron alloys prepared in accordance with the invention have a very fine perlitic matrix. The cementite has a very short lamellar structure, and the matrix displays a clear tendency towards the granular perlite. The graphite is in the form of short lamellae of random orientation. The mechanical strengths of such alloys are: tensile strength 30-46 kg./mm.² and transverse or bending strength 40-65 kg./mm.² at a deflection of 9-16 mm. The hardness of cast iron in accordance with the invention can be adjusted precisely to a value within the range of from 180 to 270 Brinell. Even at the hardness of 250 to 270 Brinell, the cast iron alloys of the invention can be machined without difficulty, so that cutting speeds of up to 120 m./sec. (hard alloy or metal) can be used. The excellent machinability, even at a Brinell hardness of 250 to 270 is a result of the matrix of the alloy. When the cast iron alloys of the invention are subjected to a subsequent heat treatment as to a spherodize annealing, the hardness thereof can be reduced to 150 to 180 Brinell, the perlite as a result being completely transformed into granular perlite without any decomposition of the cementite, i.e., separation of carbon. The high percentage of manganese and the maintenance of the relationship between the manganese, silicon, and carbon content in accordance with the invention results in a casting which is comparatively rigid and has relatively high strength characteristics as well as improved constancy of shape and volume. The mechanical strength of the heat-treated product, such as the tensile strength and transverse or bending strength, is only slightly altered. Tensile strengths of from 30 to 40 kg./mm.² can still be consistently achieved.

The above-described gray cast iron alloy is distinguished furthermore by an excellent resistance to expansion. Even after a casting in accordance with the invention has been subjected to 200 alternating annealing cycles, or to a soaking carried out for 24 hours, no disintegration of the cementite can be detected.

By precisely adjusting the manganese and silicon content in the casting composition, it is possible to limit the total shrinkage to a minimum of 0.3% even with carbon contents of C (total) 3.3% and C (bound) 0.8%, a fact which is most important for the casting of gray alloys. Because of a small change in volume during the solidification process, shrinkage is substantially non-existent even in connection with large castings. The machining allowances can, therefore, be made much smaller. As a result, the piece weight is lower and the subsequent machining can be performed substantially much more economically.

The manganese alloying, i.e., the introduction of manganese into the composition, is preferably carried out using a gas-poor manganese material and most preferably a hot metal coming directly from the blast furnace, that has been degassed in a mixer and preferably a basic-lined mixer, and or by centrifugation in a centrifugal ladle. The manganese and silicon contents of the gray cast alloy have to be adjusted precisely, if necessary, by corrective additions of ferromanganese and ferrosilicon. If a direct addition of such alloys in the ladle is not possible, the addition can be performed in a succeeding melting unit, as for example in an arc furnace or an induction furnace.

Example

Hot metal having 3.40% C, 2.23% Mn, 1.71% Si, 0.080% S and 0.144% P coming out of the blast furnace was degasified in a centrifugal ladle rotating at up to 100 revolutions per minute and repeated reversal of the revolu-

tion direction. A mixture of 5 kg. of soda and 2 kg. lime per metric ton of hot metal was added to form desulfurizing slag. After deslagging the metal was put through a mixer having a basic lining (magnesite) and therefrom 4 metric tons of the metal were transferred to an electric furnace of the line frequency induction type. In this furnace the hot metal was heated up to 1400° C. 15 kg. of ferromanganese (75% Mn) and 18 kg. ferro-silicon (65% Si) were added and a sample taken had the following composition: 3.31% C, 2.49% Mn, 1.98% Si, 0.04% S and 0.146% P.

This metal was tapped into a ladle and poured into a mould for a lathe-bed. During pouring all slag particles were retained to prevent them from going into the pouring gate.

36 hours later when the casting had cooled to about 300° C., it was removed from the mould, cleaned and trimmed and transferred to finish machining. The casting showed no substantial warping and no deflection. After cooling, it was practically free from internal tensions. The machining allowance was not higher than 6 millimeters. The casting had a Brinell hardness of 240 HB and a tensile strength of 37 kg./mm.² without heat treatment.

As the method described in the example above is preferred, it is also possible to prepare a casting metal of the desired composition by other methods, as by melting solid pig iron, scrap and adding ferromanganese, ferro-silicon and, if any, carburizing agents in the limits given by the composition prescribed according to the invention.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

We claim:

1. Gray cast iron characterized by improved non-deformability characteristics, consisting of carbon, manganese, silicon, iron and incidental impurities, the percentages by weight of the constituents of the gray cast iron being about 2.9 to 3.6% carbon, 2.2 to 3.0% manganese and 1.5 to 2.6 silicon, balance iron and sulfur and phosphorus impurities, wherein the manganese content is 0.2 to 1.3% higher than the silicon content and wherein at a saturation degree of 0.8 to 1, the bound carbon amounts to 0.7 to 0.9%.

2. Gray cast iron according to claim 1, wherein the percentage in sulfur does not exceed 0.06%.

3. Gray cast iron according to claim 1, wherein the percentage in phosphorus does not exceed 0.2%.

4. Gray cast iron according to claim 1, wherein the

percentage in sulfur does not exceed 0.06% and the percentage in phosphorus does not exceed 0.2%.

5. Gray cast iron according to claim 1, wherein the manganese is present in an amount of from 2.4 to 2.6%.

6. Gray cast iron according to claim 1, wherein the manganese is present in an amount of from 2.8 to 3.0%.

7. A method of producing a cast iron characterized by improved non-deformability characteristics, which comprises establishing a bath of molten metal having a composition of about 100 parts by weight of an iron composition consisting of carbon, manganese, silicon, iron and incidental impurities, introducing into the molten composition further quantities of manganese and silicon sufficient to provide a gray cast iron casting having the following composition in percentages by weight: 2.9 to 3.6% carbon, 2.2 to 3.0% manganese, and 1.5 to 2.6% silicon, balance, iron and sulfur and phosphorous impurities wherein the manganese content is 0.2 to 1.3% higher than the silicon content, and at a saturation degree of 0.8 to 1, the bound carbon amounts to 0.7 to 0.9%, and casting the molten composition to obtain a gray cast iron containing the aforesaid amounts of manganese and silicon.

8. A method according to claim 7, wherein the percentage in sulfur does not exceed 0.06%.

9. A method according to claim 7, wherein the percentage in phosphorus does not exceed 0.2%.

10. A method according to claim 7, wherein the percentage in sulfur does not exceed 0.06% and the percentage in phosphorus does not exceed 0.2%.

11. As an article of manufacture a gray cast iron casting characterized by improved non-deformability characteristics consisting of carbon, manganese, silicon, iron and incidental impurities, the percentages by weight of the constituents of the gray cast iron being about 2.9 to 3.6% carbon, 2.2 to 3.0% manganese, 1.5 to 2.6% silicon, balance, iron and sulfur and phosphorous impurities, wherein the manganese content is 0.2 to 1.3% higher than the silicon content and wherein at a saturation degree of 0.8 to 1 the bound carbon amounts to 0.8 to 0.9%.

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