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PRODUCTION OF RUSTLESS IRON

William B. Arness, Baltimore, Md., assignor to Rustless Iron and Steel Corporation, Baltimore, Md., a corporation of Delaware

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2 Claims. (Cl. 75—127)

This application is a division of my co-pending application Serial Number 681,373, filed July 20, 1933, and entitled Production of rustless iron, which has matured as Patent No. 2,069,203 of February 2, 1937, and the invention relates to corrosion resistant irons and steels and more particularly to an art of producing the same.

Among the objects of my invention is the simple, efficient and economical production of rustless irons and steels of a desirable fine grain size and of improved physical characteristics, made to a desired specification of iron, carbon, chromium and nitrogen, either with or without supplementary elements such as nickel, copper, cobalt, titanium, molybdenum, tungsten, vanadium and the like.

The invention accordingly consists in the combination of elements, composition of ingredients and mixture of materials and in the several steps and the relation of each of the same to one or more of the others as described herein, and the scope of the application of which is indicated in the following claims.

As conducive to a clearer understanding of certain features of my invention it may be noted at this point that, as more particularly pointed out in my co-pending application, Serial No. 645,637, entitled Noncorrosive alloy, filed December 3, 1932, many highly beneficial characteristics are given rustless iron and steel by adding to the metal a small percentage of nitrogen. The irons and steels containing nitrogen are of an inherently fine, even-grain structure; they are of improved workability over a wider range of working temperatures; they are less subject to grain growth, decarburization, brittleness and fatigue; and they are more durable and of higher impact values than heretofore known alloys of the class indicated.

One of the outstanding objects of my invention is the efficient, economical and thoroughly practical production of rustless irons and steels to a required analysis of carbon and chromium, either with or without supplementary additions indicated above, wherein a desired nitrogen content is reliably and economically achieved.

In the practice of my invention a bath of ferrous metal containing chromium is prepared as by melting down ordinary low carbon steel scrap and/or rustless iron scrap together with suitable chromium containing ingredients such as high carbon ferro-chrome or chrome ore, or by adding low carbon ferrochrome to a bath of molten iron prepared as indicated above.

To the bath containing a substantially desired final percentage of chromium there is added an alloy of appreciable nitrogen content (such as a ferro alloy of high nitrogen content preferably a nitrogen containing ferrochrome), in such quantity as to give a desired percentage of nitrogen in the final product. The nitrogen containing ferro alloy is preferably added shortly prior to tapping the heat of metal in order to permit a free dissemination of nitrogen throughout the metal and to minimize the loss of nitrogen as well as the loss of chromium (where a nitrogen containing ferrochrome is employed). Certain advantages are achieved, however, where the nitrogen containing ferro alloy is added along with the initial charge of ingredients or at a subsequent period in the operation of the particular process utilized, all as more particularly described and claimed in my co-pending application entitled Production of rustless iron, Serial No. 681,374 filed July 20, 1933.

The alloy content of the metal is adjusted and the metal finished in accordance with standard practice after which the heat of metal is poured into suitable molds and permitted to cool. The tapped metal containing a desired percentage of nitrogen is of an inherently fine grain structure which permits an improved workability over a wider range of temperatures, in addition, is less subject to grain growth, decarburization, brittleness and fatigue, and which is more durable and of higher impact values than heretofore known alloy irons and steels of the class indicated, all as more particularly pointed out in my co-pending application, Serial No. 645,637 referred to above.

As illustrative of the practice of my invention a 6-ton Heroult electric arc furnace, having graphite electrodes and rated three-phase, 25 cycle, 1500 kva, at 110 to 180 volts, is first prepared for the reception of a charge by arcing on electrode butts to heat up the furnace. The furnace is preferably provided with a chromite brick bottom which is carried up to a height somewhat above the slag line of the furnace. For reasons of economy, a lining containing chrome ore is preferably rammed in over the chromite brick hearth lining, sodium silicate being used as a convenient binder. The furnace side walls and roof are conveniently lined with silica brick.

After the preheating, as indicated above, the furnace is, illustratively, charged with 12,600 pounds of rustless iron scrap, analyzing about 17% chromium and about .10% carbon; 3250 pounds of ordinary low-carbon steel scrap; 2850

pounds of chrome ore, analyzing about 48% chromium oxide (Cr_2O_3) and about 19% iron oxide (FeO); and 1,000 pounds of roll scale which is substantially 100% magnetic iron oxide.

Electric power is applied to the furnace and the charge of ingredients is rapidly melted down to form a bath of molten iron containing chromium with a small percentage of carbon and an overlying slag containing the oxides of iron and chromium. With the continued application of power, the temperature of the bath of molten metal and the supernatant slag is brought up to a point considerably higher than that ordinarily employed in usual steel melting practice in an electric furnace.

While no reliable method is known for precisely determining the temperature of the metal bath beneath the slag blanket, it is estimated that this temperature, designated as a temperature of superheat, is approximately 3000° F. to 3200° F., which is some 100° F. to 300° F. higher than the temperature ordinarily employed in electric steel melting practice. At this temperature of superheat the oxidizing slag is more active in combining with carbon contained in the metal bath and carbon coming from the furnace atmosphere to effectively remove and/or exclude carbon from the metal bath.

Incidental to the oxidation of carbon, there is an oxidation of chromium from the bath, the chromium oxide entering the slag. The extent of the loss of chromium into the slag is minimized by the rapidity of the initial melt-down and bringing the bath and slag to the elevated temperature of superheat indicated above.

Under the strongly oxidizing action of the slag overlying the metal bath the carbon content is continuously lowered. When tests on samples taken from the bath indicate a desired low-carbon content is reached (about .05%) the melt-down and oxidizing stage is at an end.

In order to effect a recovery of the metals contained in the slag as oxides of iron and chromium, there is added, illustratively, 1400 pounds of crushed 75% ferrosilicon and 4500 pounds of hot dry burnt lime as rapidly as furnace conditions permit. The additions of ferrosilicon and lime fuse and become incorporated in the slag and effect a reduction of the oxides of iron and chromium contained therein, producing metal which goes into the underlying metal bath, and various silicates which remain in the slag and tend to render it acid in character. A neutral or basic slag is obtained as desired by the introduction of large quantities of lime as more particularly indicated above.

As the lime and ferrosilicon are added to the slag the oxides contained therein are progressively reduced and the character of the slag changes from a black to a light green color. The reducing action is accompanied by a transfer of the metal from the slag to the underlying bath of molten iron and chromium. When the color of the slag indicates that substantially all of the oxide content has been reduced this slag is preferably completely removed from the surface of the metal bath and a basic finishing slag of lime, ferrosilicon, and fluorspar, or like flux, is formed in accordance with standard practice.

In order to achieve tapped metal of a desired nitrogen content there is preferably added to the bath low-carbon ferrochrome of high nitrogen content in an amount sufficient to give the desired percentage. For the proportions of ingredients illustratively set forth above about 700 pounds of nitrogen containing low-carbon ferrochrome, analyzing 63% chromium, 2% nitrogen, .20% carbon and the balance substantially iron and produced for example as described in the copending application of James N. Ostrofsky entitled Ferro-alloy and art of producing the same, Serial No. 681,371, filed July 20, 1933. The lump low-carbon ferrochrome nitride is quickly dissolved by the bath of molten metal thus directly introducing a desired nitrogen content, the amount of which is precisely controlled, together with a supplementary amount of chromium which adjusts the chromium content of the heat.

Final additions of lump low-carbon ferrosilicon and low-carbon ferromanganese are added to adjust the analysis of the bath to the desired specifications of silicon and manganese. The addition of supplementary alloying elements, nickel, copper, cobalt, titanium, tungsten, vanadium, and the like are made as desired.

The heat of metal is then tapped into suitable molds and allowed to cool. The tapped metal, for the embodiment illustratively set forth above, weighs 17,500 pounds and analyzes about .08% carbon, 18.0% chromium, .08% nitrogen, .40% manganese, .35% silicon with the desired supplementary alloy additions indicated above, with the usual low percentages of sulphur and phosphorus, and the balance principally iron.

Thus it will be seen that there has been provided in this invention an art in which the various objects hereinbefore noted together with many thoroughly practical advantages are successfully achieved. It will be seen that the process of producing rustless irons and steels of a desired nitrogen content is simple, practical, thoroughly reliable, and that the percentage of nitrogen added lends itself to a direct and precise control, all at minimum cost and maximum efficiency.

While in the above illustrative embodiment of my invention a bath of metal of substantially a desired analysis is first prepared by melting down a charge of rustless iron scrap, ordinary low-carbon steel scrap, chrome ore and iron oxide to form a bath of metal covered by a slag containing the oxides of carbon and chromium which are subsequently reduced, thus permitting a recovery by the bath of iron and chromium, and wherein low-carbon ferrochrome of high nitrogen content is added to this bath just prior to tapping the heat of metal, it will be understood that good results are achieved where the metal of desired analysis is prepared in any desired manner from satisfactory raw materials, such as by melting down low-carbon steel scrap and/or rustless iron scrap, high-carbon ferrochrome and iron oxide to form a ferrous metal bath containing chromium covered by a slag containing the oxides of iron and chromium (which are subsequently reduced to exclude a recovery of the metal oxides in the slag) and high nitrogen containing ferrochrome is directly added thereto, all as more particularly set forth above. Or, for example, a ferrous metal bath of substantially a desired final analysis of carbon and chromium may be prepared from ordinary low-carbon scrap and low-carbon ferrochrome to which is added ferrochrome of high nitrogen content, as indicated above, to give tapped metal of a desired percentage of nitrogen.

While in the practice of my invention, as illustratively set forth above, low-carbon ferrochrome

of high nitrogen content is preferably employed to introduce a desired percentage of nitrogen in the finished metal it will be understood that low-carbon ferrochrome of either lower or higher nitrogen content may be employed where desired, although where a ferrochrome of lower nitrogen content is used, a greater quantity of this relatively expensive material is necessary in order to achieve a desired percentage of nitrogen: low-carbon ferrochrome of maximum nitrogen content is preferred since a minimum of this material introduces a desired quantity of nitrogen, this is especially true where a relatively high nitrogen content is desired in the tapped alloy.

Where the introduction of a small amount of carbon into the final metal is permissible, as for example, where the carbon content at the finishing stage is below the permissible maximum limit, good results are achieved by adding the considerably cheaper high-carbon ferrochrome of high nitrogen content, produced, for example, as described in the co-pending application of James N. Ostrofsky entitled Ferro-alloy and art of producing the same, Serial No. 681,371, filed July 20, 1933, and containing about 50 per cent to 72 per cent chromium, .5 per cent to 15 per cent nitrogen, 1 per cent to 8 per cent carbon, and the balance substantially iron, and preferably comprising about 59 per cent to 70 per cent chromium, .5 per cent to 7 per cent nitrogen, 1 per cent to 7 per cent carbon, and the balance substantially iron, as a complete or partial substitute for the low-carbon ferrochrome of high nitrogen content. For the preferred prealloy a simple arithmetical calculation indicates that the ratio of nitrogen to chromium contents ranges from about 1:140 to 1:8.

As many possible embodiments may be made of my invention and as many changes may be made in the embodiment hereinbefore set forth it will be understood that all matter described herein is to be interpreted as illustrative, and not in a limiting sense.

I claim:

1. The process of producing sound, fine-grained chromium iron castings which comprises forming a melt containing iron; adding to the said melt an iron-chromium-nitrogen prealloy containing about 60% to 70% chromium and .5% to 1% nitrogen, the ratio of nitrogen to chromium in said prealloy being between about 1:140 and 1:75; and then casting the melt.

2. The process of producing sound, fine-grained chromium iron castings which comprises forming a melt containing iron; adding to the said melt an iron chromium nitrogen prealloy containing about 59 per cent to 70 per cent chromium and .5 per cent to 7 per cent nitrogen, the ratio of nitrogen to chromium in said prealloy being between about 1:140 and 1:8; and then casting the melt.

WILLIAM B. ARNESS.