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ALLOY.

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Our invention relates to methods of producing alloys of iron and chromium containing .1% or less of carbon and 12% to 16% of chromium, known in the trade as "stainless iron".

In order to secure this low carbon content in such alloys, it has been the practice heretofore to (*a*), make the addition of chromium by a low carbon ferro-chromium containing usually 60% to 70% of chromium and .1% to .5% of carbon; or (*b*), to reduce into a molten low carbon iron bath chromium direct from ore, by means of reducing agents such as silicon and aluminum. Both of these methods are expensive, due partly to the high cost of low carbon ferro-chromium and the ferro-silicon used for reduction purposes, and partly to the high chromium losses incident to such processes.

The particular object of our invention is to make possible the use of the carbon ferro-chromium such as the 4% to 6% carbon grade known to the trade. The use of this cheaper material has heretofore been impracticable because no inexpensive method has been available for de-carbonizing the iron bath to the desired degree after the chromium has been added from such a source, or, if such a method is applied, it results in such high chrome losses as to be impracticable.

In carrying out our invention, we employ an arc furnace of the usual Heroult type, or its equivalent. We can use the ordinary refractory linings employed in such furnaces for the manufacture of ordinary carbon steel, but for the bottom of the furnace, we find it highly advantageous to provide a special bottom made of ordinary commercial chrome brick cemented together with chrome cement. We are aware that it is customary to put in the bottom of such furnaces by burning in successive layers of magnesite or dolomite, or similar materials. These materials are usually bound with tar and during the burning-in operation, this tar is supposed to be completely removed. However, we find in practice, that carbonaceous material is left in such bottoms and this frequently causes carbonization of stainless iron baths molten on such bottoms. This is particularly likely should portions of the bottom become detached, due to violent mechanical agitation of the bath, which is liable to occur in most processes. These detached portions of the bottom, carrying carbon, rise through the bath and re-carbonize it, thus rendering the manufacture of low carbon chromium alloys difficult.

These disadvantages are entirely obviated by the bottom of chrome brick or lump chrome ore, or other chromiferous material, cemented together with non-carbonaceous cement, such as we use.

A further important advantage of such chromiferous bottom is that, to a considerable extent, the chromiferous oxides enter into the refining operations subsequently described in this specification. The net result of this is that the metal being refined is subject to refining action both from the slag bath and from the chrome bottom beneath, as soon as this bottom has become sufficiently heated by conduction of heat from the arcs, through the molten materials to the bottom below. We consider that this refining action has much to do with the high speed of refinement and greater degree of refinement which characterize our process, with consequent resultant elimination of chrome losses in the metal bath.

We prefer to first charge our furnace with the necessary amount of limestone, then pour upon this a suitable charge of molten low carbon iron, preferably around .05% carbon, or lower. Such iron may be conveniently and cheaply had in the form of blown Bessemer metal, or, if desired, may be tapped off from an acid or basic open-hearth furnace. We prefer also to use molten ferro-chromium as the source of our chromium addition. Such molten ferro-chromium is conveniently obtained from an auxiliary electric furnace of the Heroult type which is used as the means for remelting ferro-chromium made in the usual type of ferro-chrome smelting electric furnace. As an option, if such a ferro-chrome smelting furnace is available, the molten ferro-chromium may be tapped direct from it.

Means must be provided for weighing the charges of molten low carbon iron and molten ferro-chromium. It will be readily understood that our process can be worked with cold materials; for instance, cold scrap iron and ferro-chromium broken up into lumps of preferably not over 2" cube. However, much better control and much greater economy can be secured by the use of molten materials.

Having charged the furnace with the necessary limestone and low carbon iron, heat is applied until the bath is somewhat superheated, then an addition of ferro-chromium is made such as to give about one-third of the amount of chromium desired in the finished product. We have found in our work that certain chromium losses take place, so that if a certain content of chromium is aimed at in the finished product, more ferro-chromium must be added than would be theoretically necessary, in order to compensate for these chromium losses which are due to oxidation reactions incidental to removing the carbon. The necessary excess to be added depends somewhat upon the raw materials used and the furnace procedure, but in practice, it will be found that from 25% to 50% more chromium must be added than one expects to obtain in the finished product. Within approximately ten minutes after the first addition of chromium has been made in this manner, chemical tests should be made for carbon, and the operator should convince himself by fracture tests, hardness tests, drilling tests, or other similar physical phenomena, that the carbon of the bath is not over .3%. When the tests show that 0.3% carbon or less, is present, another addition of chromium approximately equal to that previously made, can be added. After this second addition, tests are made as before, and when the carbon content is at 0.3% or less, the subsequent additions can be made.

We have found this method of making the chromium addition by steps to be very efficacious and to promote the rapid removal of the carbon down to the low point desired in the finished product. It has been ascertained in our experiments that if the carbon at any stage is allowed to rise to .6% or .8% with a simultaneous increase in chromium from say 10% to 14%, the removal of the carbon then becomes very much more difficult and high chromium losses are bound to occur. We also found under such circumstances, that it was very difficult to secure the necessary regularity in working which is so essential to commercial success.

Working in the manner we have described, it is possible to use a variety of refining slags, bearing in mind certain general conditions which must be maintained in order to secure success. Thus, it is essential that the slag shall be strongly basic at all times. This can be insured by the use of cheap basic substances, such as lime, limestone or dolomite. It is necessary further, that the slag be maintained in a high state of fluidity. This can be brought about by the use of such fluxes as fluorspar, rutile, ilemite, or, in some cases, by the addition of silicon. In still other cases, fluidity can be conferred by small additions of powdered ferro-silicon. Proper regulation of temperature is very important in securing and maintaining fluidity of slag.

A very important condition which must be carefully observed, is to prevent the formation of an excess of iron oxide in the refining slag. Another important condition is to avoid the formation of too great a volume of slag. Should the volume of the slag, or its iron oxide content become excessive (the latter is determined by quick chemical analysis during the course of the heat) these defects are remedied by removing a portion or all of the slag and adding new slag-forming materials. It is advantageous throughout the de-carbonizing process to maintain a considerable concentration of chromic oxide in the slag. This is conveniently done by adding high grade chrome ore. It has been found in our work that such chrome ore additions, when properly made, repress the oxidation of chromium from the bath, as more particularly described in Patent No. 1,527,088, to Penniman and Shackelford.

Having thus described our invention, what we claim and desire to secure by Letters Patent, is:—

1. A process of producing an alloy of iron and chromium which includes the steps of charging a furnace with basic slag producing material and molten iron having a carbon content of .05% or under, adding a charge of ferro-chromium, working the bath until the carbon content is under .3%, adding a second charge of ferro-chromium, and repeating this step as often as necessary until the bath has the desired chromium and carbon content.

2. A process of producing an alloy of iron and chromium, which includes the steps of charging a furnace with slag forming materials, and molten iron, adding a charge of ferro-chromium to produce a content of chromium in the finished product less than that desired, working the bath until the carbon content is not more than .3% and repeating the ferro-chromium additions and working as often as necessary until the desired chromium and carbon content is reached.

3. A process of producing an alloy of iron and chromium, which includes the steps of charging a furnace with slag forming materials and iron, adding thereto intermittently charges of ferro-chromium and decarbonizing the bath after each ferro-chromium addition from the top and bottom of the bath until it has the desired chromium and carbon content.

4. A process of producing an alloy of iron and chromium, which includes the steps of charging a furnace with slag producing materials and molten iron, intermittently adding a charge of ferro-chromium and working the bath after each ferro-chromium addi-

tion until it contains a definite carbon content, and repeating the ferro-chromium additions and working until the bath has the desired chromium and carbon content.

5. A process of preparing an alloy of iron and chromium which includes the steps of charging a furnace with slag producing materials and iron, intermittently adding charges of ferro-chromium and decarbonizing the bath after each ferro-chromium addition until the carbon content is not more than a desired maximum, the ferro-chromium additions being continued with working, as necessary and until the bath contains the desired chromium and carbon content.

In testimony whereof we affix our signatures.

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