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PROCESS FOR THE PRODUCTION OF PURE IRON OR IRON ALLOYS WITH STARTING FERREOUS MATERIALS PARTICULARLY FERRIC SANDS, RESIDUAL MUDS FROM THE EXTRACTION OF ALUMINIUM, PYRITE ASHES AND SIMILAR NATURAL OR ARTIFICIAL SUBSTANCES CONTAINING NOT LESS THAN 20 PER CENT OF THE METALS TO BE EXTRACTED AND RELATIVE PRODUCT

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The present invention relates to an improvement on U. S. A. Patent Application Ser. No. 279,960, wherein a common furnace, electric or otherwise, as used for steel, may be employed for the process for the production of pure iron or iron alloys with starting ferrous materials particularly ferric sands, residual muds from the extraction of aluminium, pyrite ashes and similar natural or artificial substances containing not less than 20% of the metals to be extracted. In the case of an electric furnace the relative electrodes may be disposed in any way whatever the bottom of the furnace may be constructed according to the usual systems, for instance, with dolomite comminuted and agglomerated in any way whatever and among the agglomerating means even tar and other carbonaceous substances may be numbered. However in this case, of course, previous castings are necessary to "cook" the cake and eliminate the carbon of the binding agents. These preparatory castings of the furnace may also be executed with pig iron reserving the last casting for a soft steel. It is better, however, to construct the bottom and walls of the furnace avoiding the use of carbonaceous substances, the furnace can be made either acid or basic according to the sort of mineral employed. The mixture to be fed into the furnace need not be agglomerated, said mixture merely consisting of coal and mineral.

It is advisable that both be pulverized and this fact is mentioned because many minerals are already in such a state, which makes it difficult to use them in the known extraction systems of the metal. The quantity of the two ingredients depends on the yield of the furnace. From furnace to furnace, from one heating system to the other, and even from the rapidity the operation itself is conducted with, variations may be required in the proportions of the two ingredients.

Fundamentally, however, the proportions for the furnaces of the Héroult type are those required by the chemical formula, the products whereof are carbon oxide and iron; the corrections suggested by practice being carried out as they manifest themselves advisable. Said proportion is however subjected to variations according to the species of iron wanted and, to be more exact, the proportion has to be poorer of coal, if a particularly pure and deoxidized iron is wanted. It may seem a mistake to increase the iron-oxide to obtain more deoxidized iron, but this principle is a true one and will be enlarged upon later. In the case of a 4-6 ton furnace of the Héroult type operated in such a way that

about 800 Kwo are consumed each hour, with the doors in a medium condition of tightness relative to draughts of air and in condition of medium use thereof (that is, opening them only when it is necessary), the mixture, as an actual carbon contents, should contain twice as much charcoal in powder of a medium analysis as indicated by the above mentioned chemical formula. Since charcoal has been mentioned, it is important to add that also coke, anthracite and so on may be employed.

Besides the two fundamental elements above mentioned, fluxes may be added. These fluxes may be chosen according to the composition of the gangue of the mineral. Should one use Cogne mineral or that of the littoral titaniferous sands, the best addition is represented by calcium oxide in large pieces, in clods, and disposed on the bottom of the furnace and all around the walls, where the molten bath and especially the slags lightly lap the walls with the object of slowing down the chemical etching and avoiding such a contact as long as possible. On the contrary, one should avoid mixing the calcium oxide in the mixture, especially if it is powdery as in this case calcium carbide might be produced.

In any case the proportions of this calcium oxide in the case mentioned, and in general of the flux in other cases, are related to so many particular conditions that only practice may suggest the best ones especially to an expert operator. In general the 10% of calcium oxide with respect to the mineral charged is indicated. In any case both for calcium oxide or other fluxes and for coal or mineral the corrections may be made at will by directly adding in the furnace the other elements to the cost of which the proportion had been corrected. However, one should not repute that coal or mineral may be added in a large quantity after effecting the charge of the mixture. In fact it is necessary that this be well calculated and modified only by means of slight additions.

This mixture is fed into the furnace all at once or at intervals according to the features of the furnace and to the system of operation of the same and here also the practice acquired after the first two or three castings soon gives the rules indicated. In the case of an electric furnace wherein the mixture is charged all at once, the generation of the arc may be rather difficult, but this inconvenience is remedied then by concentrating around the electrodes some mineral which possesses a good electric conductivity both

in the case of said mineral being a part of the mixture or of a mineral extra mixture; also the tension may be elevated and at last irons may be placed in the furnace preferably scraps of the same iron produced previously, disposed under the electrodes in reciprocal contact and covered by a layer of about 3 cm of mineral. This expedient is advisable, strips of conductive slag being thus soon allowed to be formed between electrode and electrode.

It is to be remarked that since the question in general is to produce a very pure iron it is necessary to ascertain the purity of the different elements of the mixture and particularly of the coal and calcium oxide in the sense that the less impurities are added the more the purity of the material obtained increases. For instance the calcium oxide must contain the least possible quantity of sulphur and the same is said as regards coal.

Once the arc is generated, the fusion proceeds normally and the electric furnace is provided with electrodes it being of no importance that the electrodes be sunk into the mixture mass. The working of the furnace is very calm and abundant gas masses are developed. Little by little pools of molten matter are formed in the higher temperature points and finally all the mass is liquified. Towards the end very hard crusts are remarked substantially formed of spongy iron. These crusts must be melted by continuing the supply of heat and finally a bath is obtained comprising a metallic layer below and a layer of slag above. This operation (in the case above mentioned) takes about 6 hours. If the operation is conducted well, said slag should be cast nearly at once because it strongly attacks the walls of the furnace. This slag may be either too rich of metal or purified too much and in this case the metal has an appreciable contents of carbon. Should a pure iron be wanted, said slag must have about 10% metal and if there were more, a certain quantity of coal must then be charged on the slag and an increase of the quantity of metal under the coal is obtained. Vice versa if the contrary occurs, an addition of mineral may be made, but this addition is preferably made after removing the slag that is by producing a second slag richer of mineral than normally, as will be disclosed here below.

By examining some samples of the metal, one immediately remarks the fundamental fact that the successive additions of coal in the slag cause an increase of the quantity of metal without increasing the contents of carbon, at first, while afterwards this contents increases rapidly and the quantity of metal increases very little. The optimum point depends on the object wanted and the conditions in which work is effected, but the expert operator knows in a short time how to behave.

Once the slags have been removed the metal appears sufficiently deoxidised and the casting may directly take place; sometimes on the contrary the metal is oxidised more or less and if a casting should occur as in the case of steel, deoxidising additions would be necessary in the ladle or ingot mould.

These additions, if a most pure iron possible is wanted, are to be avoided for obvious reasons.

According to the present invention new additions of mineral in the furnace are on the contrary suggested. The following example may be of use:

Having charged a mixture composed of

	Kg.
Mineral of Nettuno.....	2.500
Charcoal	1.000
5 Calcium oxide.....	200

In an electric furnace of Héroult type of 800 Kwo; should the metal be found not sufficiently deoxidised about 50 Kg of mineral and some shovelfuls of calcium oxide are thrown into the furnace after having removed the first slag and after about an hour and a half a sample of metal will soon show a very remarkable improvement. This operation may be repeated several times possibly by casting nearly all the preceding slag before the new addition, till the point judged necessary. In other words the mineral (30, 50 Kg each time) and a little calcium oxide is to be added and after about 20 minutes a sample should be examined. Should this spurt strongly or be agitated, and ascending, then it is necessary to slag and to execute another addition of mineral with calcium oxide as above mentioned. After 20 minutes more a new sample is examined and so on till the metal may appear as completely deoxidised, that is calm and ascending but little.

The sectioned test piece must appear compact with a bubble only on the upper side. The metal when cooled abruptly in water must be bright and of a moon-like white colour. At this point the casting may take place and only 0,2-0,4% aluminium, immersed in the ladle as mentioned, will do to make the ingot absolutely pure and without gas.

The scientific reasons of this fact apparently paradoxical and till now unknown in Steelwork practice are owing to the fact that the iron, obtained by means of these systems from mineral reduction especially if pure as those of Cogne or of the littoral sands with coal defectively dosed, possesses very remarkable features of inoxidability even at a high temperature and consequently the more the decarburisation is pushed on the more the tendency not to absorb oxygen is increased. Of course the presence in the iron of other elements as for instance manganese, phosphorus, silicium, aluminium sometimes determine a great deal more than carbon this characteristic of pure iron, but as already remarked for carbon the oxidising addition by diminishing or destroying all said impurities causes with the increase of the purity of iron also a diminution of its contents in oxygen.

It is to be remarked that the same additions of mineral are to be made also in the apposite case that is when the metal is carburised and one wishes to decarburise it.

In any case as above mentioned an addition of deoxidising elements may be necessary and made in the ladle or ingot moulds according to normal practice of good steelworks.

In the case of the present example it may be asserted that 1250 Kg of iron may be obtained with Fe equal to or more than 99,95% and consuming about 4000 Kwo per ton and taking about seven hours and a half from the beginning of the charge to the end of the casting. These consumptions and yields are however in function of the size of the furnace and its perfection and consequently they are susceptible to be remarkably improved.

The use of aluminium in cakes is suggested if the deoxidation occurs in the ladle in the proportion above mentioned of about 0,4% of the metal to be deoxidised. Of course it would be prefer-

able to use compound alloys: aluminium calcium, aluminium calcium magnesium, and the like even with sodium potassium, boron and the like with the object of making more the product of the oxidation of said deoxidising substances more easy to be melted and consequently easier to be separated from the metal. However with the aluminium alone the result is already good. Of course these deoxidising means are to be dissolved in the metal to be deoxidised without being burnt in the air and slags. By using aluminium this for example may be fixed on the top of a rod of the same iron obtained in some preceding casting and kept at the bottom of the ladle and here uniformly agitated till it is completely dissolved. This takes about 6 minutes in the case above mentioned and if even a part of the iron rod is melted this will not disturb at all. It is convenient that the casting takes place in the ladle in a neither too hot nor too cold state and also as regards these details experience will give in each case the necessary indications. Should the furnace be electric with electrodes, the smallest tension possible has to be used compatible with the fundamental fact that, after the formation of the bath, the electrodes have to carry no coal at all, which would unavoidably occur if they were in contact with the slag or still worse in contact

with the metal. About 80 volts are sufficient if there are graphite electrodes normally loaded in ampere.

When the casting is done, the furnace may be charged again with a new mixture and the operation is recommenced again. Of course owing to the high temperature required for casting pure iron it may happen that the walls of the furnace show traces of corrosion. This inconvenience is remedied by means of additions of dolomite or other refractory substance directly on the points corroded and disposing calcium oxide in clods of the mixture of the new charge preferably on the more corroded zones. In such a way the furnace will last for a normal number of castings.

It is clear that the capacity of the furnace has to be proportioned to the amount of the charge wanted in order to avoid that a too thin layer of metal may produce a superheating of the refractory material and of the bottom in the points nearest to the electrodes, this implying the passage of a part of said refractory material into the bath with the impurities contained therein, which would be particularly dangerous in the case the refractory material contains carbon.

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