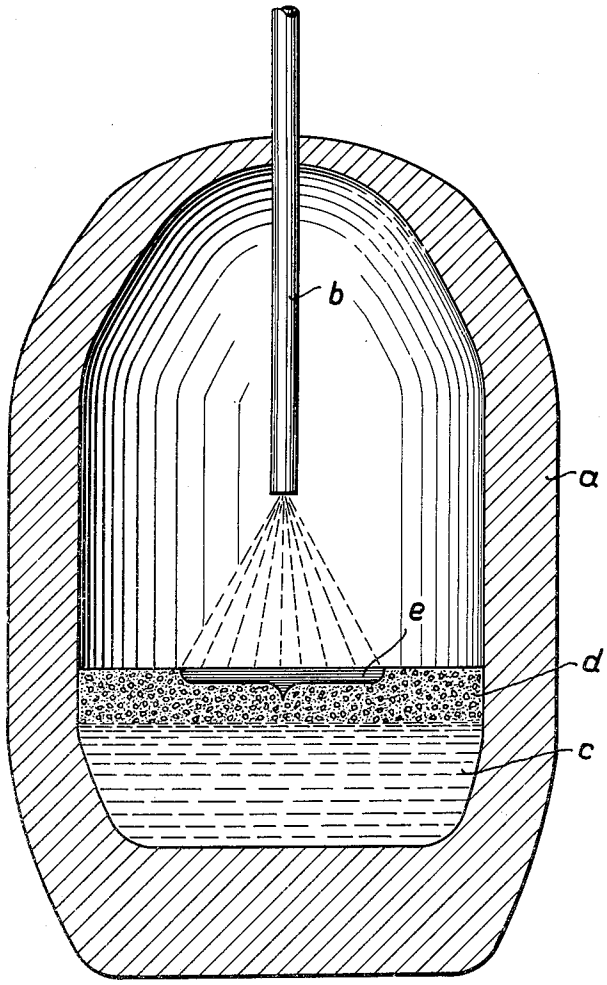
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METHOD OF PREPARING PRELIMINARY METAL OR STEEL
PIG IRON CONTAINING PHOSPHORUS
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METHOD OF PREPARING PRELIMINARY METAL OR STEEL PIG IRON CONTAINING PHOSPHORUS

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The invention relates to the method which forms the subject matter of U.S. Patent application Serial No. 626,662, now abandoned of producing preliminary metal or steel from pig iron containing phosphorus in any quantity, by refining the same with oxygen-containing refining agents blown onto the bath from above with the addition of slag-forming substances, in converters or other refining vessels, said method consisting in that the refining gas is blown onto or into the layer of slag in such a way that during an initial stage of the refining process it will not perforate the skin of slag formed on the bath and not contact the surface of the bath but continuously oxidize the FeO contained in the slag to Fe_2O_3. The Fe_2O_3 thus formed causes dephosphorisation at the interface between slag and bath, and is thereby reduced to FeO, but this is again continuously re-oxydised to Fe_2O_3 by the oxygen contained in the blast. The term "oxygen-containing refining agents" is to be understool to include pure oxygen, the use of which is preferable in the inventive method.

By thus performing the refining process indirectly through the intermediary of the slag, dephosphorisation occurs at an earlier stage, namely simultaneously with the process of decarburisation. The oxidation processes take place intermediately through the oxidising effect of the slag substantially at the interface between slag and bath by diffusion.

Since decarburisation proceeds simultaneously with dephosphorisation the slag develops considerable foam as a result more particularly of the evolution of carbon monoxide, and foaming is the stronger the greater the surface tension of the slag.

The presence of the foam increases the surface of the slag in a manner which as such is desirable, because it increases the contact area between slag and bath and thus sustains a high rate of dephosphorising activity.

Since the disequilibrium and high oxygen potential of the slag required for giving effect to this early dephosphorisation, especially if the surface tension of the slag is high and its viscosity low, may lead to such vigorous foaming as to give rise to spurting and losses of steel, the depth of the bath in the refining vessel is arranged to be low, in order of magnitude not exceeding 40 cms.

The present invention concerns improvements in the above described method with the aim of simplifying its performance, raising the economy of the procedure, and bettering the quality of the product obtained, whether steel or preliminary metal.

According to a first feature of the invention the objectionable ejection phenomena which may occur when froth formation on the slag is excessively violent, can be more effectively suppressed if in addition to restricting the depth of the bath in conformity with the proposal set forth in the aforementioned U.S. Patent application Serial No. 626,662 in order of magnitude to a maximum of 40 cms., the internal capacity of the refining vessel in relation to the charge is very large, and more particularly of such proportions that irrespectively as to the vessel

is round, hexagonal, elongated or vertical, the available capacity per ton of pig iron charge will be at least in the order of magnitude of 1.3 cubic metres.

With the omission of all details that are unnecessary to conveying an understanding of the invention the accompanying drawing in section diagrammatically shows a refining vessel that conforms with this specification, the drawing showing the considerable volume *a* available in the refining vessel above the slag when compared with the charge of pig iron and the depth of the bath. In the drawing, *b* is the tuyere and *e* the area of impingement of the blast on the layer of slag *d* on the surface of the bath.

It is especially advantageous if in the performance of the proposed method the surface tension of the slag is systematically adjusted either by reducing or by increasing the same, until foam formation is optimal in the given conditions of depth of the bath and capacity of the converter.

According to this feature of the invention this is done by the addition of pulverulent bases, such as powdered lime or soda, for reducing the tension, or by the addition of fluxes, such as more particularly of borax and fluorides, for increasing the tension.

The fact that the reaction is taking its desired course can be recognised by the absence of the evolution of brown iron fumes.

To ensure that this will also be so during the initial phase of the refining process, namely during the period a slag layer which prevents direct contact between the blast and the bath and through which the reaction is to proceed, has not yet been formed, it was proposed in the aforementioned U.S. Patent application Serial No .626,662 to add superheated steam to the blast for the purpose of sufficiently cooling the burning spot, i.e. the area of impingement of the blast on the pig iron bath, to prevent the iron from being burnt.

With a view of improving the result thus achieved a further feature of the present invention consists in limiting the period during which the addition of steam to the blast is made to a maximum of 25% of the total period of blowing, and at the same time in adjusting the proportion of steam in relation to the oxygen contained in the blast in order of magnitude to 1 : 3.

If this is observed it has been found that not only will burning of the iron during the initial stage and hence the evolution of brown iron fumes be completely suppressed but at the same time the formation of FeO will be accelerated and a desirable delay brought about in decarburisation during this stage.

Since the object of the described method is the direct production of steel instead of that of a preliminary metal of which refining to steel must be completed in another vessel, the comparative rapidity of refining germane to all blowing processes when producing higher carbon steels with contents of, in order of magnitude, over 0.1% carbon, involves the difficulty that it is not easy to judge the moment when the desired carbon content is reached.

Generally this adjustment must be made by first refining to a lower carbon content than that which is required or even by completely decarburising and by then, at additional expense and with an increased expenditure in time, to recarburise to the level required. This partly offsets the advantage gained by having created the possibility of performing the entire process in one single refining vessel.

These difficulties experienced in the direct production of steel by the method described in the introduction hereto are overcome according to another feature of the invention which at the same time further improves the quality of the resultant steel until it is equal to that of an open-hearth steel.

As is generally known, the high quality of an open-hearth steel is substantially due to its comparatively long period of boiling which, on the one hand, permits the melt to be easily caught at the time the carbon content has reached a well-defined level and which, on the other hand, has the effect of thoroughly washing out and removing all gases and non-metallic impurities contained in the melt. This long period of boiling is a necessary feature of all processes for producing steel in an open hearth furnace.

The object outlined above is achieved, according to the above-mentioned further feature of the invention, in that whilst the refining process may be performed in a vessel of arbitrary shape, for instance in a cylindrical or an elongated horizontal vessel, the further decarburisation to a required carbon content that follows refining until a definite carbon content, that may lie within very wide limits, is reached, is effected in the same vessel, after the admission of oxygen has been shut down or throttled, by reheating the bath with high-grade fuels and by thus slowing down the velocity of the reaction of the ferric oxide contained in the slag with the carbon in the bath to less than that obtaining during the first phase of the process. Variation of the nature and duration of this heating period offers an easy means of control for adjusting the final content of carbon to the specified level.

During this boiling process it is convenient, in a manner analogous to that in the open hearth process, simultaneously to wash out and remove gases and non-metallic impurities contained in the melt.

Fuel consumption during this subsequent heating period is extremely low, because only the thermal losses of the vessel need be made good which, experience shows, are, in order of magnitude, not more than 0.3×10^6 kcal./h. in the case of a 20 ton furnace.

To reduce to a minimum the volume of exhaust gases and also to avoid the need of employing a regenerative system, the oxygen required for this heating process may and should be admitted into the furnace through tuyeres, preferably in concentrated form i.e. in the form of pure oxygen or of oxygen-enriched air.

This second phase is initiated whilst the layer of slag remains on the bath to minimise iron loss. Skimming, or if the bath is skimmed several times, a first skimming is not carried out until the content of ferric oxide in the slag has been reduced as far as possible by having reacted with the bath.

The advantages gained by the last-described procedure do not merely consist in the ease with which the final carbon content can thereby be controlled and the production of a good quality steel ensured, they also include the fact that—by comparison with the open hearth process—output is greatly increased and heat consumption reduced. This low consumption of heat is the result of the carbon content in the iron itself supplying a considerable proportion of the heat required during the second stage.

Another advantage of the novel overall method over purely "pneumatic" systems of steel production is the possibility it affords of increasing the addition of scrap and ore. The method is therefore extremely adaptable to the prevailing raw material situation.

In the practical performance of the proposed method, for instance in a furnace vessel of 20 tons capacity, blowing is first continued according to the method described in the aforementioned U.S. Patent application Serial No. 626,662 for about 30 minutes until the carbon content is about 1% and phosphorus has been completely removed. This phase is followed by boiling which may last for 30 to 45 minutes according to the final carbon content desired.

The resultant total duration of the process is therefore between 60 and 75 minutes so that, with due regard to the performance of the necessary maintenance work,

a 20 ton vessel would have an output of 12 to 15 tons of steel per hour.

These figures clearly reveal the considerable improvement in output by comparison with an open hearth of similar size.

The fuel for heating during the second phase may be any suitable high grade fuel available, such as oil, pulverised coal, natural gas, or electrical energy.

An even more advantageous possibility inherent in the direct production of steel by the novel proposed method for accelerating the decarburisation process and for economising in fuels consists in that upon completion of dephosphorisation the further decarburisation process is performed in a following treatment stage in which the refining vessel is rotated about its axis. Rotation of the vessel may be with its axis placed in the horizontal or in the vertical, the latter alternative permitting a simpler structural arrangement of the plant. The speed of rotation may be comparatively low, and may be, in order of magnitude, about 30 revolutions per minute.

During this stage of the two-stage process according to the invention supplementary heating may, if desired, be by means of high-grade fuels, the admission of oxygen to the bath being either completely shut down or, should the iron-bound oxygen in the slag be insufficient for the combustion of the carbon to the desired final content, sufficient refining gas may be blown to secure the desired result.

The latter method of operation therefore represents a combination of dephosphorisation according to the aforementioned U.S. Patent application Serial No. 626,662 and of the method of refining in revolving vessels, which as such is already known. However, the following advantages are secured over the known process of steel production in rotating vessels.

Although by producing steels in revolving vessels early dephosphorisation can be successfully achieved, the extent to which dephosphorisation can be advanced in time in relation to decarburisation is subject to limits for metallurgical reasons which are connected with the inadequacy of disequilibrium between the iron oxide content of the slag and the carbon content of the bath.

On the other hand, in the production of high carburised steels, dephosphorisation at the earliest possible time, and as high as possible a carbon content when dephosphorisation is complete, is desirable to avoid the necessity of subsequent recarburisation. Full advantage is taken of this early completion of dephosphorisation—which constitutes the outstanding advantage upon which the performance of the method actually rests—if decarburisation is carried out in the manner proposed. It thus becomes possible to produce high carburised steels with carbon contents in the order of 1% without any supplementary recarburisation after tapping being required. Apart from the above-mentioned further advantages of reducing the total processing time and of effecting a saving in fuel, the novel method has yet another advantage which consists in that wear of the refractory lining of the refining vessel is slower and hence the life of the vessel extended, especially when compared with known refining processes which are entirely completed in rotating vessels.

We claim:

1. In the method for producing preliminary metal and steel from a pig iron melt having an arbitrary phosphorus content by refining said melt with oxygen-containing agents with the simultaneous addition of slag-forming substances in a refining vessel, in which a refining gas is blown onto the layer of the slag in such a manner that, during an initial stage of the refining process, said gas will not penetrate the slag layer and reach the surface of said melt and contact the latter, thereby continuously oxidizing the FeO contained in the slag to Fe_2O_3, the Fe_2O_3 causing dephosphorization at the interface between the slag and the melt and the FeO thereby formed

being reoxidized to Fe_2O_3 by the oxygen of the refining gas, the improvement which comprises stopping the said blowing with refining gas at a stage wherein dephosphorization of the melt is completed and said melt has a carbon content higher than that finally required and wherein said carbon content can be adjusted to the final carbon content required by a subsequent heat treating step; maintaining the temperature of said melt to permit further boiling thereof, and adjusting the carbon content of said melt to the content finally required during said further boiling.

2. In the method as claimed in claim 1 wherein said refining gas is selected from the group consisting of pure oxygen and oxygen-enriched air.

References Cited in the file of this patent

UNITED STATES PATENTS

2,672,413	Daubersy	Mar. 16, 1954
2,789,046	Speith et al.	Apr. 16, 1957
2,803,534	Cuscoleca et al.	Aug. 20, 1957
2,817,584	Kootz et al.	Dec. 24, 1957
2,820,706	Larsen	Jan. 21, 1958
2,853,377	Kalling et al.	Sept. 23, 1958

FOREIGN PATENTS

813,581	Germany	Sept. 13, 1951