June 17, 1958 R. F. GRAEF 2,839,382

METHOD OF REFINING METALS

Filed March 20, 1956

Fig.1

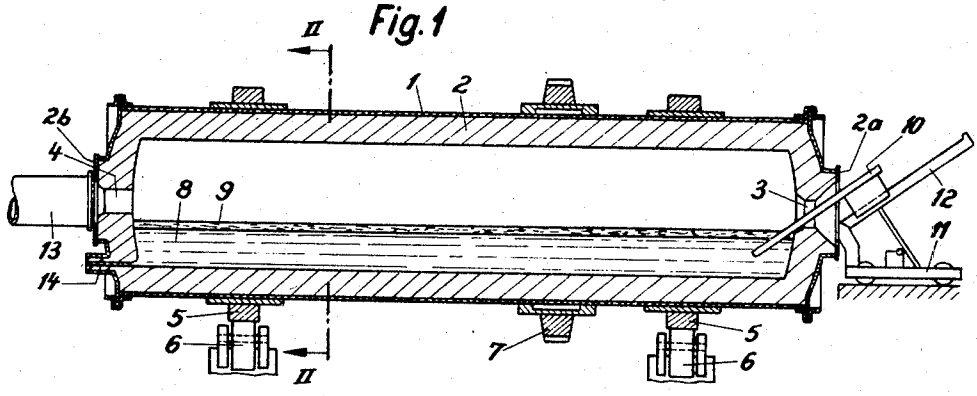
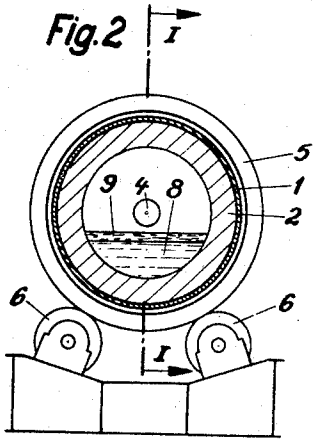


Fig.2



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United States Patent Office 2,839,382 Patented June 17, 1958

2,839,382

METHOD OF REFINING METALS

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Application March 20, 1956, Serial No. 572,686

Claims priority, application Germany June 13, 1952

4 Claims. (Cl. 75—60)

The present invention relates to a method of pre- or finish refining metals while employing refining means rich in oxygen and is a continuation-in-part application of my copending patent application Ser. No. 360,913, filed June 11, 1953. The advantages of enriching the refining means with oxygen are generally known. If the refining means rich in oxygen in a normal converter is blown into the metal bath from below, the durability of the nozzle bottom decreases with increasing oxygen content of the refining means. For this reason, attempts have been made to blow the refining means from the top into the metal bath. However, this method has the drawback that the iron content of the slag is increased to a very considerable extent and that furthermore, a considerable extent and that furthermore, a considerable evaporation of the iron occurs.

Therefore, it has been suggested, in order to reduce the burning of the iron, to decrease the local heating of the iron bath where the refining means rich in oxygen hits upon the iron bath. To this end, the refining process has been carried out in a drum which is rotatable about a horizontal axis and which rotates at a high circumferential speed. Furthermore, the refining means, prior to hitting upon the iron bath, has been mixed with the gas mixture in the interior of the drum. At a corresponding high circumferential speed of the drum, it has been made possible to cause the gas mixture rich in oxygen and contained in the interior of the drum to enter into sufficient reaction with the iron bath without unduly increasing the iron content of the slag. However, the high circumferential speed of the drum considerably decreases the life of the lining of the drum.

It is, therefore, an object of the invention to provide a method of refining metals which will overcome the above mentioned drawbacks.

It is still another object of this invention to provide a method of refining metals in a rotatable drum, which will bring about a highly efficient reaction of the refining means with the bath without undue increase in the iron content of the slag.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings in which:

Figure 1 shows a section through a refining device for carrying out the method according to the present invention.

Figure 2 is a cross section taken along the line II—II of Figure 1.

GENERAL ARRANGEMENT

Surprisingly, it has been found according to the present invention that with a relatively slowly rotating drum, a highly efficient reaction of the refining means with the bath can be obtained without undue increase in the iron content of the slag, if the refining means is introduced through nozzle means immersing below the upper surface of the iron bath. It has been proved particularly advantageous for the speeding up of the reaction and also for the durability of the refining nozzles if the nozzles are introduced into the bath with the front end of the nozzle below the upper surface of the bath at as small an acute angle as possible relative to the surface of the bath. Tests have proved that already at a circumferential speed of the inside wall of the refining drum of from 0.15 to 30 centimetres per second, preferably of from 0.25 to 20 centimetres per second, an iron content in the slag of about 14 percent or even less will be obtained. This phenomenon appears to be due to the fact that excessive iron oxide formed during the refining process is again reduced on its way through the pig iron bath to the upper surface of said bath, said reduction being effected by the elements Si, Mn, P, C, etc., to be removed from the pig iron. Of these elements, Si, Mn and P form solid oxidation products. Carbon only does not form a solid oxidation product but combines with oxygen either to CO or to CO_2 and escapes as gas bubble from the bath through the slag.

This way of refining brings about that the oxides or slag particles which are formed during the reaction of the oxygen with the pig iron and which have a lower specific weight than the iron bath have to pass through the liquid pig iron over a certain distance when rising, before they reach the upper surface of the bath. During this time, the slag particles are on all sides surrounded by pig iron and can enter into mutual reaction with said pig iron. In view of the fine distribution in the pig iron of the slag particles being formed, a reaction surface is obtained which is considerably larger than a reaction surface can possibly be when blowing oxygen upon the bath surface of the same size. The rotation of the refining vessel brings about that continuously new pig iron particles take part in the chemical reaction. Furthermore, there is obtained a mixing effect in vertical direction while the blown-in oxygen stream causes in the bath a mixing effect in the direction of the longitudinal axis of the drum.

In spite of the blowing-in of oxygen, when employing the method according to the present invention, the bath is still adapted to reduce considerable quantities of iron oxides in form of ore, roll scale, or the like. Thus, for instance, when employing an ore charge of 150 kilograms per ton pig iron and when refining the pig iron up to 0.05 percent C it was still possible to obtain an iron content in the slag of less than 10 percent.

The method according to the present invention excells, first of all, in a highly efficient exploitation of the oxygen employed, furthermore, in the shortness of the refining process and thereby in great economy concerning the exploitation of the refining vessel, with a long life of its lining, and finally in low iron losses due to the reduced iron content of the slag.

The method according to the invention is of particular advantage in connection with the pre-refining of pig iron. However, it can also be applied in connection with the finish refining of steel similar to the acid or basic blast refining process. Finally, the method according to the present invention may also be used in connection with the refining of other metals and of metal alloys.

STRUCTURAL ARRANGEMENT

Referring now to the drawings, the structure shown therein comprises a cylindrical drum 1 which is lined with a refractory liner 2. The end walls 2*a*, 2*b* are provided with substantially central openings 3 and 4. Provided on the outside of the drum 1 in spaced relationship are two raceways 5 by means of which the drum is journalled on rollers 6. Also connected to the outside of the drum 1 is a gear 7 which meshes with a pinion (not shown in

the drawing) which may be driven so that the drum **1** may be rotated about its longitudinal axis.

The drum contains the iron bath **8** to be refined which is covered with a layer **9** of slag. The arrangement is such that the surface of the layer of slag does not extend up to the openings **3** and **4** in the walls **2***a* and **2***b*, respectively. Through the opening **3** in the wall **2***a* is passed a nozzle **10**, the outer or rear end of which is adapted to be connected with a supply conduit for refining means (said supply conduit means not being shown in the drawing). It should be noticed that according to the present invention the nozzle **10** extends into the bath **8** so that the front portion of said nozzle is immersed. It should furthermore be noted that according to the invention the longitudinal axis of the front end of the nozzle **10** forms an acute angle with regard to the surface of the bath. It has been found advantageous to maintain said acute angle as small as possible for the reasons outlined in detail in connection with the description of the new refining method. The nozzle **10** is displaceably mounted on a slide **12** carried by a carriage **11**. In front of the opening **4** provided in the wall **2***b* there is arranged a gas discharge conduit **13**.

The wall **2***b* is furthermore provided near the marginal portion thereof with a discharge port **14** which latter is maintained closed during the refining process.

While the refining means is introduced through the nozzle **10** into the bath **8**, the drum **1** is rotated. The gaseous oxidation products which form during the refining process are discharged through the gas discharge conduit **13**. At the end of the refining process the drum is stopped in such a position that the discharge port **14** is located at its lowermost point. It is then merely necessary to open said discharge port **14** if it is desired to discharge the refined steel bath from the refining drum.

The advantages inherent to the method according to the present invention will best appear from the following examples carried out in connection with two melts.

As starting material in both instances, a phosphorus containing pig iron was charged as it is used in connection with the basic Bessemer process. Melt I was pre-refined only and was finish-refined in an open hearth furnace. Melt II was fully refined in the drum to ready steel.

The melts were refined in a hollow drum of a length of 13.75 metres provided with an inner lining of refractory material. With the two examples set forth below, the lining was basic and consisted of tar dolomite on magnesite. The outer diameter of the drum was 3.7 metres. The inner diameter of the lining was approximately 2.0 metres.

The drum was rotated at a speed of half a revolution per minute so that the inside of the drum had a circumferential velocity of 5.2 centimetres per second.

Customary steel works lime and rolling scale or ore were charged into the drum, and the drum was rotated.

Liquid pig iron was then filled into the drum, and blast containing about 80 percent oxygen was conveyed into the bath by means of immersed water cooled nozzles through a central opening in an end wall of the drum. Depending on whether pre-refined metal for the open hearth furnace or ready steel is to be produced, the actual blowing time per one ton of liquid discharge will vary. More specifically, when producing pre-refined metal, the actual blowing time will be approximately one minute per one ton of pre-refined metal, whereas, with steel, the blowing time will be approximately 1.7 minutes per one ton of steel.

Opposite that end wall of the drum through which extends the blowing nozzle, an exhaust for the discharge of the waste gases was provided. Due to the evaporation of iron, certain quantities of brown smoke form during the refining process. The loss in iron due to evaporation amounts to about 0.3 percent when producing steel, and to about 0.2 percent when producing pre-refined metal.

As soon as the melt has the desired composition which is ascertained by taking samples, the refining nozzles are withdrawn from the furnace and the finished melt is discharged through an opening in an end wall of the stopped drum.

Table A

	Melt I		Melt II	
	Charge	Per ton liquid discharge	Charge	Per ton liquid discharge
Pig Iron	55,300 kg.	1,005 kg.	52,000 kg.	1,040 kg.
Rolling Scale	5,500 kg.	100 kg.	4,500 kg.	90 kg.
Lime	3,000 kg.	54.6 kg.	3,800 kg.	76 kg.
Oxygen	2,820 Nm.³ [a] / 4,040 kg.	51.3 Nm.³ / 73.5 kg.	3,760 Nm.³ / 5,400 kg.	75.2 Nm.³ / 108 kg.
Gas Pressure	2.5 kg. cm.²		2.5 kg. cm.²	
Rotational Speed of Furnace	0.5 R. P. M.		0.5 R. P. M.	
Actual Blowing Time	52 minutes		80 minutes	
Quantity of Slag	10,500 kg.	191 kg.	10,600 kg.	210 kg.
De-Oxidizing Means (75% FeSi)			100 kg.	2 kg.
Liquid Discharge	55,000 kg. Pre-refined Metal.		50,000 kg. Steel	

Remarks: [a] 1 Nm.³=1 m.³ at a temperature of 0° C. and a pressure of 760 mm. Hg.

Table B

	Melt I		Melt II	
	Pig Iron, Charged	Pig Iron, Pre-Refined	Pig Iron, Charged	Steel
C percent	3.82	1.14	3.78	0.09
Si do	0.38	0.11	0.42	0.15
Mn do	1.02	0.28	0.98	0.32
P do	1.68	0.24	1.72	0.08
S do	0.05	0.02	0.05	0.02
N do	0.008	0.005	0.008	0.004
Temp °C	1,350	1,530	1,350	1,600
	Final Slag		Final Slag	
Fe percent	11.16		14.28	
MnO do	5.37		4.32	
SiO_2 do	6.51		5.30	
CaO do	40.37		40.09	
MgO do	12.50		15.46	
P_2O_5 do	17.40		17.40	

It is, of course, to be understood that the present invention is, by no means, limited to the specific examples set forth hereinbefore but also comprises any modifications within the scope of the appended claims.

What I claim is:

1. A method of refining metals in a ceramic-lined drum rotatable about a substantially horizontal axis, which includes the steps of: introducing the metal bath to be refined into said drum; rotating said drum about said horizontal axis at a circumferential velocity of the inside wall of said drum within a range of from 0.15 centi-

metre per second to 30 centimetres per second; and while said drum is being rotated introducing an oxygen enriched air blast into said bath through nozzle means immersing below the upper surface of said bath.

2. A method according to claim 1, in which the circumferential velocity of the inside wall of said drum is restricted to a range of from 0.25 centimetre per second to 20 centimetres per second.

3. A method of refining metals in a ceramic-lined longitudinal chamber of substantially circular cross section and rotatable about a substantially horizontal axis, which includes the steps of: filling less than half of said chamber with the metal bath to be refined, rotating said chamber in one and the same direction about said horizontal axis at a circumferential velocity of the inside wall of the drum within a range of from 0.15 centimetre per second to 30 centimetres per second, and during rotation of said chamber introducing an oxygen enriched air blast through a central portion of an end surface of said chamber through nozzle means immersing below the upper surface of said bath, while directing said blast so that its central axis forms an acute angle with the horizontal level of said bath.

4. A method according to claim 3, in which the circumferential velocity of the inside wall of said drum is restricted to a range of from 0.25 centimetre per second to 20 centimetres per second.

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