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54 Title of Invention

"THE RECOVERY OF TITANIUM FROM TITANOMAGNETITE"

ABSTRACT

A process is provided for the production of a titanium rich slag and pig iron from titanomagnetite. The titanomagnetite is fed continuously, together with carbonaceous reductant, and in the absence of fluxes, to the molten bath of a circular d.c. arc furnace, preferably a plasma arc furnace, wherein the molten bath forms the anode and one or more electrodes in the furnace roof form the cathode. The feed materials are preferably preheated or prereduced using heat contained in the off-gases from the process. Titanium rich slag which can be used as the feed to a sulphate based titanium dioxide production process is recovered continuously, or intermittently, and pig iron is tapped off as a by-product.

THE RECOVERY OF TITANIUM FROM TITANOMAGNETITE

FIELD OF THE INVENTION

THIS INVENTION relates to the recovery of titanium from titanomagnetite in addition to the recovery, as in conventional processes, of vanadium together with iron.

BACKGROUND TO THE INVENTION

Generally speaking, titanomagnetite ores are

/conventionally processed

conventionally processed for the recovery of vanadium either alone or together with iron. Titanomagnetite concentrates typically contain significant quantities of titanium, generally of the order of 15% to 20% TiO_2.

In conventional smelting processes for the recovery of vanadium, in one form or the other, in a submerged arc furnace, significant proportions of fluxes such as dolomite and quartz are added and, accordingly, the ultimate slag which contains the titanium, has only approximately 30% TiO_2 by mass. It has generally been considered to be uneconomical to attempt to recover titanium from such poor grade slag and, in consequence, this titanium containing slag has, in the past, almost invariably been dumped as a residue.

With the world's decreasing supplies of rutile and growing environmental opposition to the mining of beach sand ilmenites, the common sources of titanium which occur naturally, there is increasing interest in locating other sources of titan. which can be treated to yield pigment grade titanium dioxide. As a starting material for such a process, a slag or other titanium concentrate should contain a minimum of about 70% by mass titanium dioxide failing which the recovery of the titanium dioxide is difficult or inefficient or both.

It has now, surprisingly, been found that a slag containing a satisfactorily high proportion of titanium dioxide can be produced in the treatment of titanomagnetite thereby turning to good account the titanium contained in titanomagnetite rather than discarding same.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided a process for the reduction of titanomagnetite concentrate to yield a titania rich slag and pig iron, the process comprising feeding ilmenite simultaneously with carbonaceous reductant, in the absence of fluxes, to the central region of the molten bath of a circular furnace of d.c. arc furnace type having one or more electrodes situated

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in the roof and the molten bath acting as the counter electrode, and wherein the feeding of the furnace is carried out on a continuous basis; periodically or continuously withdrawing titania rich slag and pig iron from the furnace, and wherein a frozen lining is maintained between the molten bath and refractory lining by water cooling the furnace shell.

Further features of the invention provide for the electrode or electrodes situated in the roof of the furnace to be graphite electrodes; for there to be only one electrode in the roof of the furnace; for the electrode or electrodes in the roof of the furnace to be the cathode in which case the molten bath is the anode; for the furnace to be a plasma d.c. arc furnace; for the feed materials to be pre-heated or pre-reduced, conveniently using the off-gases from the furnace; and for the temperature of the furnace to be controlled to provide a temperature of the molten bath of from 1650 ° C to 1750 ° C.

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In the context of this specification a "transferred arc thermal plasma furnace" is intended to mean a furnace containing an electrically generated plasma in which the plasma ion temperature lies between 5000°K and 30000°K and wherein the furnace bath forms an integral part of the electrical circuit, generally the anode connection to one or more anodes penetrating the base of the bath. In the case that a hollow graphite electrode (or a graphite electrode with a central hole) is employed, generally as the cathode, the feed material may be introduced into the furnace by way of the hollow electrode.

In all cases the feed rate of the material into the furnace and energy input into the plasma generating electrical circuit are adjusted to achieve and maintain suitable temperatures of both the slag and molten metal.

In order to enhance the exclusion of air, and the maintenance of a non-oxidising atmosphere, the furnace is preferably operated at a slightly positive pressure, ie. a pressure somewhat above atmospheric pressure.

The reductant for the ore is a carbonaceous reductant and, preferably, at least part of this reductant is anthracite coal. The reductant is present in at least the stoichiometric amount required and preferably in excess of the amount required to reduce all the iron oxides to metallic iron in order to ensure that oxygen in the off-gases is substantially in the form of carbon monoxide.

In order that the invention may be more fully understood, one example of a test carried out will now be described.

DETAILED DESCRIPTION OF ONE TEST OF THE PROCESS OF THIS INVENTION

In this example tests were conducted in a 200 kVA furnace manufactured by applicant. The furnace was of a known d.c. plasma arc furnace type employi[illegible] single hollow graphite electrode located centrally above the furnace bath. A direct current power supply was employed in which the molten bath formed, in use, the anode, while the graphite electrode formed the cathode.

The furnace which was circular, had an outside diameter of 750mm, and a refractory lining thickness of only 140mm. This lining was a refractory material wherein the MgO content was approximately 88 percent. The hearth was lined with a similar material to a thickness of 450mm and a number of mild steel rods were used to make the d.c. (anode) electrical connection to the molten bath through the hearth refractory from the anode cable. Spray water-cooling was incorporated on the furnace shell sidewalls in order to assist in maintaining a protective slag freeze-lining. The molten bath in the furnace was heated to the operating temperature of between 1550 ° C and 1650 ° C with an initial metal charge.

/ **TABLE 1**

TABLE 1

Chemical analysis of the feed material (mass %)

COMPONENT	MAGNETITE	ANTHRACITE
TiO_2	20,8	0,11
Fe_2O_3	73,8	1,18
MgO	0,27	0,10
CaO	0,003	0,13
Al_2O_3	1,68	2,25
SiO_2	1,10	3,75
MnO	0,30	-
V_2O_5	0,64	-
Cr_2O_3	0,04	-
P_2O_5		0,03
Na_2O		0,03
K_2O		0,21
Fixed Carbon		83,5
Volatiles		6.5
Moisture		2,0

All metal oxide components were analysed for the total metallic content and expressed as the oxide.

The feed materials consisted of titanomagnetite ore concentrate and anthracite having the compositions detailed in Table 1. The feed materials were passed through the single hollow graphite electrode, situated centrally in the furnace and the liquid products were tapped intermittently during a continuous campaign lasting 5 days at a 130 kW gross energy input. The power and feedrate were balanced in order to maintain a slag tapping temperature of between 1650 ° C and 1750 ° C. A power flux of 0,3 $MW/^2$ based on shell diameter proved suitable in order to maintain a protective freeze lining thickness of approximately 0,10m.

Results of the smelting tests showing metal, slag and dust compositions are given in Table 2.

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TABLE 2

Smelting of titanomagnetite ore concentrate

Test Series	Titano-magnetite kg	Anthracite kg	Metal kg	Slag kg	Dust kg
A	200,6	44,4	88,0	36,8	17,7
B	248,7	60,0	159,5	24,1	23,3
C	353,2	88,2	140,8	14,9	32,1
D	200,1	40,0	112,5	83,2	15,3
E	200,3	42,0	69,4	59,8	8,2

Metal Analysis	Titanium	Silicon	Manganese	Carbon	Sulphur	Phosphorus	Vanadium
A	1,16	1,26	0,086	1,84	-	-	0,33
B	1,40	1,10	0,090	2,09	-	-	0,32
C	1,48	1,00	0,081	1,74	-	-	0,31
D	0,13	0,24	0,029	2,18	-	-	0,12
E	<0,06	<0,06	0,007	1,40	-	-	<0,05

Slag Analyses	TiO_2 %	FeO %	MgO %	CaO %	Al_2O_3 %	SiO_2 %	MnO %	V_2O_5 %
A	82,1	1,26	0,40	0,49	15,70	0,38	0,18	0,10
B	81,8	1,39	0,73	0,52	14,06	0,40	0,20	0,10
C	84,2	2,77	0,69	0,52	10,48	0,97	0,16	0,23
D	63,5	4,23	20,55	0,31	9,58	3,75	0,32	0,56
E	56,9	13,54	18,91	0,21	6,88	4,36	0,36	0,90

Dust Analyses	TiO_2 %	FeO %	MgO %	CaO %	Al_2O_3 %	SiO_2 %	MnO %	V_2O_5 %
A	24,7	42,6	4,64	0,35	12,00	8,13	0,85	0,17
B	27,9	39,9	4,74	0,30	11,10	8,56	0,82	0,17
C	33,4	39,4	2,27	0,23	9,50	5,85	0,77	0,17
D	23,9	41,8	11,40	0,20	6,44	8,57	0,73	0,27
E	18,7	49,7	9,47	0,20	5,03	8,28	0,66	0,29

All metal oxide components were analysed for the total metallic content and expressed as the oxide.

From this table it will be seen that acceptable grades of titanium dioxide are produced in most instances and, accordingly, in consequence of the effectiveness of control on a furnace of the nature described above, variables can be controlled to maintain the magnesium contents of the titanium dioxide at acceptable levels. Also the titanium dioxide content itself can be maintained above the minimum of 70 percent required for the sulphate process and can be increased to 85 percent if required.

Pre-heating or pre-reduction of the feed material has not yet been tested but theoretical calculations indicate that approximately a 70 percent saving on electrical energy input may be expected if pre-reduction of the feed materials is employed. It is envisaged that pre-heated feed materials, or even hot pre-reduced feed materials will not provide any difficulty with respect to maintaining the desired high temperature in feeding through a single or small number of inlet arrangements.

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It is envisaged that an extremely effective and economic process is provided by this invention, the use of which will result in the employment of titanomagnetite as a source of high titania slag for use as a feedstock for the production of titanium dioxide pigments probably by means of the sulphate process.

/**<u>CLAIMS</u>**

CLAIMS

1. A process for the reduction of titanomagnetite concentrate to yield a titania rich slag and pig iron, the process comprising feeding ilmenite simultaneously with carbonaceous reductant, in the absence of fluxes, to the central region of the molten bath of a circular furnace of d.c. arc furnace type having one or more electrodes situated in the roof and the molten bath acting as the counter electrode, and wherein the feeding of the furnace is carried out on a continuous basis; periodically or continuously withdrawing titania rich slag and pig iron from the furnace, and wherein a frozen lining is maintained between the molten bath and refractory lining by water cooling the furnace shell.

2. A process as claimed in claim 1 in which the electrode or electrodes situated in the roof of the furnace are graphite electrodes.

/3. A process

3. A process as claimed in either of claims 1 or 2 in which there is only one electrode in the roof of the furnace.

4. A process as claimed in any one of the preceding claims in which at least one electrode is hollow and reactants are introduced into the furnace by way of the bore of such hollow electrode or electrodes.

5. A process as claimed in any one of the preceding claims in which the electrode or electrodes in the roof serve as the cathode and the molten bath serves as the anode.

6. A process as claimed in any one of the preceding claims in which air is substantially excluded from the interior of the furnace.

7. A process as claimed in claim 6 in which the furnace is operated at a slight positive pressure to achieve said exclusion of air.

8. A process as claimed in any one of the preceding claims in which the furnace is a plasma d.c. arc furnace.

9. A process as claimed in any one of the preceding claims in which the feed materials are preheated or prereduced prior to introduction to the furnace bath.

10. A process as claimed in claim 9 in which preheating or prereduction is achieved using the off-gases of the furnace, optionally after cleaning.

11. A process as claimed in any one of the preceding claims in which the carbonaceous reductant is used in quantities in excess of the stoichiometric amount required to reduce all the iron oxides to metallic iron.

12. A process as claimed in any one of the preceding claims in which the temperature of the furnace is controlled to between 1650 ° C and 1750 ° C.

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13. A process substantially as herein described and exemplified in any one of the example thereof.

DATED THIS 28TH DAY OF JUNE 1993

JOHN & KERNICK

FOR THE APPLICANT