OPIC
OFFICE DE LA PROPRIÉTÉ
INTELLECTUELLE DU CANADA

CIPO
CANADIAN INTELLECTUAL
PROPERTY OFFICE

(12) (19) (CA) **Brevet-Patent**

(11) (21) (C) **2,192,084**

(86) 1996/04/10
(87) 1996/10/17
(45) 2001/06/26

(72) Dañobeitia Sierra, Iker, ES
(72) Vallejo Ochoa De Alda, Javier, ES
(72) Goicoechea Gandiaga, Nestor, ES
(73) COMPAÑIA INDUSTRIAL ASUA-ERANDIO, S.A. (ASER, S.A.), ES
(51) Int.Cl.^{6} C22B 3/12, C22B 19/28, C22B 3/20, C22B 7/02
(30) 1995/04/10 (P 9500713) ES

(54) PROCEDE DE TRAITEMENT HYDROMETALLURGIQUE POUR LA DEPURATION D'OXYDES DE WAELZ PAR LIXIVIATION AVEC DU CARBONATE DE SODIUM

(54) HYDROMETALLURGICAL TREATMENT FOR THE PURIFICATION OF WAELZ OXIDES THROUGH LIXIVIATION WITH SODIUM CARBONATE

(57) The process allows the elimination of contaminants from waelz oxide, (chlorine, sodium, potassium, sulfur and fluorine, fundamentally), by means of its hydrometallurgic treatment in the following stages: - Leaching with sodium carbonate in warm aqueous alkaline medium. - Solid - liquid separation of the effluent and the solid material. - Purification of the effluent by the elimination of the heavy metals, and optionally, the undesired anions. - Washing with water of the solid material obtained after the sodium leaching. - Solid - liquid separation of the water and the purified waelz oxide. - Recirculation and warming of the effluent obtained from the washing stage, for its reutilization in the sodium leaching stage.

ABSTRACT

HYDROMETALLURGICAL TREATMENT FOR THE PURIFICATION OF WAELTZ OXIDES THROUGH LIXIVIATION WITH SODIUM CARBONATE

This process allows the elimination of contaminants from waelz oxide, (chlorine, sodium, potassium, sulfur and fluorine, fundamentally), by means of its hydrometallurgic treatment in the following stages :

- Leaching with sodium carbonate in warm aqueous alkaline medium.
- Solid - liquid separation of the effluent and the solid material.
- Purification of the effluent by the elimination of the heavy metals, and optionally, the undesired anions.
- Washing with water of the solid material obtained after the sodium leaching.
- Solid - liquid separation of the water and the purified waelz oxide.
- Recirculation and warming of the effluent obtained from the washing stage, for its reutilization in the sodium leaching stage.

HYDROMETALLURGICAL TREATMENT FOR THE PURIFICATION OF WAELTZ OXIDES THROUGH LIXIVIATION WITH SODIUM CARBONATE

DESCRIPTION

The present invention relates to a process for the hydrometallurgic treatment of waelz oxides, with a final yield and total elimination of the contaminants found in the waelz oxide, above, generally, 95 %.

By the use of the process of the present invention, a purified waelz oxide is produced, denominated ASER OXIDE from here on, with a very low content in mainly alkalines, halogens and sulfur, such that it enables its use in electrochemical processes.

BACKGROUND TO THE INVENTION

Traditionally, steel was produced in blast furnaces by feeding them with iron ore and metallurgic coke as reducer. As time went by, the amount of discarded steel scrap reached such dimensions that it began to be reused to produce steel again, hence not having to depend exclusively upon iron ore.

This is how the binomial electric furnace - scrap began to be used in the production of steel.

During the treatment of scrap in the electric furnace, solid particulates (some 10 - 20 Kg/ Ton. of steel produced), known as steelworks dust or Electric Arc Furnace Dust (EAFD), are emitted, which are collected during gas cleaning.

This steelworks dust is basicaly constituted by metallic oxides of variable composition, making its treatment a necessity in order to remove the problem of its storage, caused by its low - medium content of zinc and lead as main metallic species, and variable contents of other metals, some of which are considered hazardous, such as Cd or Cr. Steelworks dust is classified as a hazardous waste due to the leacheates which solubilize its heavy metals.

Zinc contained in steelworks dust approaches 25 %, being principally found in the form of oxide or ferrite. Maximum recovery of this zinc will be achieved by the process which manages to destroy the ferrites, liberating from them the zinc held within. This is basicaly achieved by means of the pyrometallurgic processes considered as the best available technology for the treatment of steelworks dust.

In industrial practice, steelworks dusts are treated my means of several pyrometallurgic processes, out of which, perhaps, the most suitable and widely used, is the Waelz Process, there being others, such as the Contop Process of hydrocyclone smelting, the flame cyclone process, the plasma fusion process, the direct reduction process, etc..

In the waelz process, steelworks dusts are introduced, together with coke, as fuel and as reducing agent, and with siliceous sand as slag enhancer, in a rotating furnace, where the metals of interest (Zn, Pb, Cd) are reduced to their metallic state, sublime into the free atmosphere of the furnace and are finally reoxidized with an air current, obtaining an impure oxide with typical contents of about 54% Zn, 9% Pb and 0.25% Cd, aside other impurities.

These impure oxides are called waelz oxide, characterized in that the content of zinc and lead is high, that of iron having decreased significantly in comparison with that of steelworks dust.

Unfortunately, the presence of certain elements, specially halogens, alkalines and sulfur, forbid their use in electrochemical processes and restrict their field of use to Imperial Smelting furnaces.

Consequently, by means of the present invention, there being very little or no literature about its application in this field, an improved ASER oxide is produced for use in Imperial Smelting furnaces and usable in electrochemical processes.

DESCRIPTION OF THE INVENTION

The object of the present invention relates to a process for the obtention of a purified waelz oxide, denominated ASER oxide, improved for its use in Imperial Smelting furnaces and usable also in electrochemical processes.

This process presents the following advantages :

- It finishes in a product with no contamination from mainly alkalines, halogens and sulfur.
- Absence of polluting substances.
- Reduced investment.
- Low operating costs.

Getting into the fundamental contents of this patent, it is important to note in the first place that, the starting material is waelz oxide or any impure oxide of zinc, obtained by natural means or by diverse processes.

To serve as an indication, the typical grade of these waelz oxides is the following :

Zn	54 %
Pb	9 %
Cd	0.25 %
Cl	4 %
Na	1.5 %
K	2 %
S	1 %
F	0.4 %

being it possible for these grades to depart from the values given.

The single figure shows the outline of the stages wich are described below :

These oxides, from here on called waelz oxides, are subjected to a leaching process with water and sodium carbonate at a constant temperature and alkaline pH, until a constant pH is achieved without the addition of any extra sodium carbonate. The number of steps and the leaching time must be the necesary to obtain the maximum removal of contaminating elements.

Leaching will be carried out at a temperature between aproximately 50 ºC and 90 ºC, being 65 - 75 ºC an optimum temperature, achieving a shorter leaching time and stimulating the transformation of insoluble halogens into soluble halogens.

The pH must be kept between about 8.0 and 10.0 during the leaching process, being 9.0 ± 0.2 an optimum working pH. Sodium carbonate consumption will depend upon the nature of the starting material, with typical values of 60-140 g/Kg. of solid starting material.

The initial waelz oxide / solution ratio may vary between 100 and 500 g of waelz oxide per liter of solution, being 200 - 300 g/L an optimum value.

In this leaching process, saturated with carbonate by the addition of solid Na_2CO_3, double decomposition of the salt is favoured, and the presence of all the anions is assured in the alkaline liquid, even of those that can form quite insoluble precipitates in the alkaline conditions created by the hydrolisis of sodium carbonate, but has the drawback that an excessive rise in pH would solubilize most of the amphoteric oxides ($Al(OH)_3$, $Sb(OH)_3$, etc.) which may have precipitated, or that the large quantity of sodium salts could give rise to the, at least partial, formation of double and soluble carbonates of the cation and sodium, as could be those of lead, copper, nickel, mercury and magnesium. On the contrary, too weak a carbonate concentration in the solution would leave back some precipitated anions and would solubilize some cations of interest.

Aqueous solutions of Na_2CO_3 undergo strong hydrolisis because they are a strong salt of the weak carbonic acid. The CO_3^{-2} anion, originating from the nearly total dissociation of the salt, is hydrolised according to :

$CO_3^{-2} + H_2O \rightarrow HCO_3^- + OH^-$ (a)

$HCO_3^- + H_2O \rightarrow H_2CO_3 + OH^-$ (b)

The degree of hydrolisis of reaction (a) is far greater than that of (b), therefore, basicaly all hydroxyls, and hence the alkalinity, are generated by the first reaction. Consequently, in a solution of sodium carbonate there will be CO_3^{-2} and HCO_3^- ions, to a lesser extent, and OH^-, and the precipitates originated by the various cations will depend upon their special affinity to react with one or another of the ions which are present.

The existence of the bicarbonate anion is deleterious, since most bicarbonates are soluble. The concentration of this bicarbonate anion increases when ammonium salts are present, but decreases with the rise in temperature which favours double decomposition and transforms the bicarbonate anion into carbonate according to $2HCO_3^- \rightarrow CO_2 + CO_3^{-2} + H_2O$, thus avoiding the formation of soluble bicarbonates.

Therefore, due to the hydrolisis of the carbonate anion, there are mainly CO_3^{-2} and OH^- ions in solutions of Na_2CO_3 at alkaline pH's (≥8.5), and hence, during leaching, neutral carbonates, basic carbonates, hydroxides or oxides can be precipitated or maintained precipitated, the precipitate depending upon the nature of the cation. Thus, cations considered neutral or scarcely acidic (alkaline earths) will precipitate neutral carbonates; those that have a marked acidic character (they require acidity to remain in solution) such as Pb^{+2}, Cu^{+2}, Zn^{+2}, etc., will precipitate a more or less basic carbonate, and those whose hydroxide is less soluble than the carbonate (Fe^{+3}, Al^{+3}, Cr^{+3},...), will precipitate the corresponding hydroxide.

After leaching with Na_2CO_3 at the indicated pH, temperature and time, a solid - liquid separation is performed, whereby a liquid (L1) and a solid material (S1) are obtained. This liquid L1 contains nearly 90% of the halogens, alkalines and sulfur which were found in the original waelz oxide, and small amounts (at the < 1 ppm level) of heavy metals.

The solid material S1 is washed in a vessel, under stirring, with water, preferably warm (at temperature similar to that of the leaching stage), for a time no shorter than half an hour, and without addition of sodium carbonate in one or several stages. As long as the alkaline leaching step has been properly completed, the pH will remain alkaline (> 8), hence, acid metallic cations such as zinc, lead, cadmium or iron will not go into solution. The elimination of virtually over 95% of the halogens, alkalines and sulfur present in the original waelz oxide, is completed during this washing stage.

Finally, a solid - liquid separation is performed, giving rise to a liquid L2 and to a solid material S2. Liquid L2 is recirculated and taken back to the carbonate leaching step, previously being warmed to the temperature desired for that stage.

The solid S2 obtained is the electrochemical grade ASER oxide, which can be subsequently physically treated (dried, pelletized, bricketized, etc.) in order to adapt it to the needs of the process for which it is intended. The mass yield for the obtention of ASER oxide from waelz oxide is of approximately 92.5%.

On the other hand, liquid L1 obtained from the carbonate leaching step can give rise to problems in relation to pollution caused by its discharge, depending on the nature of the receiving medium. Because of this, an agent that will precipitate its heavy metals is added to this liquid, such as Na_2S or hydroxyapatite $Ca(OH)_2*3Ca_3(PO_4)_2$, chosen after assessing the different solubility products of the variety of heavy metal compounds involved. Optionally other compounds for precipitating the anions present in liquid L1, the elimination of which could be desirable, can be added, such as $CaCl_2$ to precipitate fluorides as CaF_2, or $BaCl_2$ to precipitate sulfates as $BaSO_4$, etc..

Once the desired cations and anions have been precipitated, a liquid - solid separation is performed, giving rise to a liquid L3, free of heavy metals and, optionally, of anions, which can be easily discharged by virtue of it not being polluting, and on the other hand, a solid S3 is obtained in small amounts, composed by heavy metal sulfates or phosphates (depending upon the chosen flocculant) and, optionally, by salts such as CaF_2, $BaSO_4$, etc.

This S3 solid is a material which is easily assimilated by the waelz process.

In summary, the set of individual operations described to this stage result in :

- An ASER oxide of electrochemical grade which may be used in Imperial Smelting or electrolysis processes.
- A residual liquid which, after eliminating the desired heavy metals and anions, can be discharged by virtue of it not being polluting.
- A solid, in small amount, resulting from the heavy metals, and optionally the anions, precipitated from the residual liquid originating from the carbonate leaching step, which may be perfectly incorporated to the waelz process.

Typical characteristics of the ASER oxide are listed in table I.

TABLE I

ASER OXIDE

Element	Low	High	Typical
Zn	52.00	62.00	58.50
Pb	6.00	11.00	8.50
Cl	-	-	≤0.15
Cd	0.20	0.55	0.40
FeO	4.00	7.00	5.50
SiO_2	0.50	1.50	1.00
CaO	0.50	1.50	1.00
MgO	0.10	0.50	0.20
Al_2O_3	0.10	1.00	0.25
MnO	0.10	0.50	0.25
Cu	0.20	0.60	0.40
Sn	0.05	0.25	0.10
C	-	-	≤2.50
F	0.05	0.30	0.15
K_2O	-	-	≤0.15
Na_2O	-	-	≤0.15
S	-	-	≤0.15

The chemical analyses mentioned in table I may change in certain cases, due to the nature of the raw material intruduced into the waelz process and its influence upon the composition of the waelz oxide used as starting material in this invention.

PRACTICAL EXAMPLE OF THE INVENTION

Initially, 200 g of waelz oxide were leached with 1 liter of aqueous solution in a 1.5 liter reactor, at a temperature of 70±2 ºC. Solid Na_2CO_3 was gradually added to the solution in order to maintain a constant pH of 9.0±0.2, until there was virtually no variation of pH with time.

This time depends upon the waelz oxide from which we started, but approximately 30-45 minutes will usually suffice. The solution is stirred by means of a blade impeller at a speed ranging between 150-200 r.p.m.

After vacuum filtration of the aforementioned solution, the resulting solid is introduced again into the reactor together with an extra 1 liter of water, with no Na_2CO_3 addition, and kept under stirring for no less than 30 minutes.

Finally this new solution is vacuum filtered, yielding a solid which, in this patent, will be called ASER oxide. The filtrate from this second filtration is reused in the carbonate leaching step, after being warmed to the desired temperature.

On the other hand, Na_2S (35%) is added to the filtrate obtained form the carbonate leaching process, resulting in a precipitate which gives a lightly brown tone to the solution.

These precipitated sulfides have a very slow decanting rate, and are separated by vacuum filtration. The filtrate obtained is a colourless liquid which is free of heavy metals, the solid being composed mainly by heavy metal sulfides.

The data obtained from these assays is comprised in tables II and III.

Stage	Initial amounts Solid	Liquid	Amount obtained Solid		Liquid		Amounts added (g)	
	m (g)	v (ml)	m (g)	moisture (%)	v(ml)	pH	Na2CO3	Na2S (35%)
Leaching with Na2CO3	200 dry waelz oxide	1000 L2 pH=8.6	S1 263wet 185 dry	29.7	L1 920	9.1	16	-
S1 washing with water	263 humid S1	1000 pH=7.6	S2 282 wet 194 dry	31.2	L2 920	8.6	-	-
Treatment of effluent L1	-	1000 L1 pH=9.1	S3 1.1 wet 0.75 dry	31.8	L3 910	9.2	-	1.4

Na_2CO_3 consumption: 80 g per Kg of waelz oxide leached.

Na_2S (pure) consumption : 2.5 g per Kg of waelz oxide leached.

Table II. Initial amounts, added amounts and obtained amounts of the various solids and liquids, during the different stages of the process.

			Leaching with Na_2CO_3		Washing of S1 with water		Treatment of effluent L1	
Elements	Initial waelz oxide (%)	Initial industrial water mg/L	S1 Solid (%)	L1 Liquid (mg/L)	S2 Solid (%)	L2 Liquid (mg/L)	S3 Solid (%)	L3 Liquid (mg/L)
Zn	54.20	<0.05	57.6	0.5	57.6	<0.1	*	0.13
Pb	8.10	<0.1	8.61	<0.1	8.61	<0.1	*	<0.1
Cd	0.16	<0.05	0.16	0.94	0.16	<0.05	*	<0.05
Total C	1.44	N.A	2.22	N.A.	2.22	N.A.		N.A.
Na	0.61	40	0.33	7200	0.10	400		7300
K	1.67	4	0.24	2800	0.08	350		2850
Cl	4.25	28	0.35	8100	0.05	700	*	8200
F	0.25	0.75	0.12	280	0.10	50		290
S	1.10	14	0.17	1800	0.07	250	*	1900

(*) Detected qualitatively but not quantified.

Table 3 : Chemical analysis of the solids and liquids which take part in the different stages of the process.

DESCRIPTION OF THE DRAWINGS

Figure 1 enclosed shows an outline of the process of the invention. It is important to point out that the following boxes represent :

1. Waelz oxides
2. Sodium carbonate
3. Sodium leaching at controlled pH and temperature.
4. Solid - liquid (S/L) separation.
5. Washing with water.
6. Water
7. Solid - liquid (S/L) separation.

8. ASER oxide.
9. Heating of the liquid.
10. Sodium leaching effluent.
11. Sodium sulfide and, optionally, other precipitants.
12. Heavy metal precipitation and, optionally, of undesired anions.
13. Solid - liquid (S/L) separation.
14. Precipitated solids : metallic sulfides and, optionally, other precipitated compounds of undesired anions.
15. Treated effluent. Discharge.

CLAIMS:

1. Process for the hydrometallurgic purification treatment of waelz oxides which comprises leaching said waelz oxides with an aqueous solution of sodium carbonate, characterized by the following stages:

a) leaching said waelz oxides with sodium carbonate at a pH between 8.0 and 10.0, at a temperature between 50°C and 90°C, during a holding time between 20 minutes and 4 hours and with a solid-liquid ratio between 100 and 500 grams of the waelz oxides per liter of solution, in order to solubilize the contaminants found in said waelz oxides consisting essentially of chlorine, fluorine, sulfur, sodium and potassium;

b) separating the material contained in the solution resulting from stage a) into a solid (S1) material and a liquid (L1) material containing said contaminants;

c) washing said solid (S1) material with water;

d) separating the material contained in the solution resulting from stage c) into a solid (S2) material containing a purified zinc oxide-containing material, identified as ASER OXIDE, and a second liquid (L2) material; and

e) warming said liquid (L2) material for its reutilization in stage a),

resulting in the production of a purified zinc oxide-containing material, identified as ASER OXIDE, of improved electrochemical grade, suitable for use in Imperial Smelting furnaces and in electrochemical processes.

2. Process according to claim 1, characterized in that the consumption of solid sodium carbonate is comprised between 60 and 140 g/kg of waelz oxides.

A

3. Process according to claim 1, characterized in that the pH of the leaching step of stage a) is between 8.8 and 9.2.

4. Process according to claim 1, characterized in that the temperature of the leaching step of stage a) is between 65°C and 75°C.

5. Process according to claim 1, characterized in that the holding time of the leaching step of stage a) is between 30 minutes and 1 hour.

6. Process according to claim 1, characterized in that the solid-liquid ratio of the leaching step of stage a) is between 200 and 300 grams of the waelz oxides per liter of solution.

7. Process according to claim 1, characterized in that stages b) and d) are carried out in a filter press.

8. Process according to claim 1, characterized in that the pH of the washing step of stage c) is between 8.0 and 10.0.

9. Process according to claim 8, characterized in that the pH of the washing step of stage c) is between 8.5 and 9.0.

10. Process according to claim 1, characterized in that the temperature of the washing step of stage c) is between 10°C and 90°C.

11. Process according to claim 10, characterized in that the temperature of the washing step of stage c) is between 65°C and 75°C.

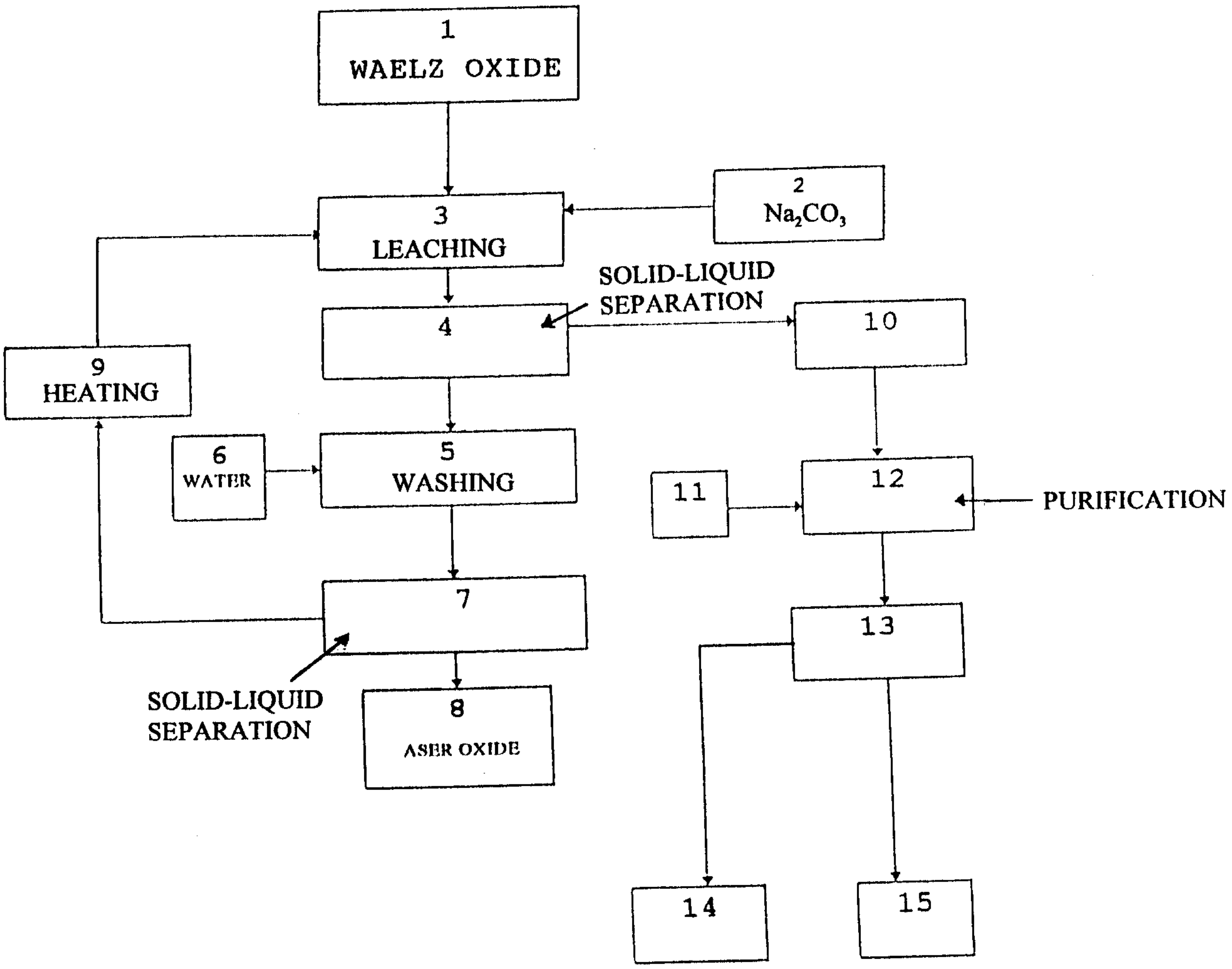
12. Process according to claim 1, characterized in that the holding time of the washing step of stage c) is between 10 minutes and 2 hours.

13. Process according to claim 12, characterized in that the holding time of the washing

step of stage c) is between 20 minutes and 40 minutes.

14. Process according to claim 1, characterized in that the solid (S1) material-liquid ratio of the washing step of stage c) is between 100 and 500 grams of the solid (S1) material per liter of water.

15. Process according to claim 14, characterized in that the solid (S1) material-liquid ratio of the washing step of stage c) is between 200 and 300 grams of the solid (S1) material per liter of water.


1
WAELZ OXIDE
2
Na2CO3
3
LEACHING
SOLID-LIQUID
SEPARATION
4
10
9
HEATING
6
WATER
5
WASHING
11
12
PURIFICATION
7
13
SOLID-LIQUID
SEPARATION
8
ASER OXIDE
14
15

A