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CN-A- 107 363 074
US-A- 4 927 459
US-A1- 2005 103 159

DESCRIPTION

Technical Field

[0001] The present invention relates to a method for the production of secondary aluminium from scrap material by using a scrap obtained from an electrolysis cell as secondary/supplemented solid fuel for the production of primary aluminium.

Background

[0002] Primary aluminium is generally produced by smelting alumina (aluminium oxide) in an electrolysis cell according to the Hall-Heroult process. Such an electrolysis cell generally has a casing with side walls and a bottom wall which are clad with refractory material to form a reaction chamber. A carbon anode is provided on the top of the reaction chamber and a carbon cathode is provided on or near the bottom of the reaction chamber. Cryolite and alumina are introduced into the reaction chamber, and when an adequate electric current passes between the cathode and the anode, the alumina is reduced to aluminium that accumulates in the bottom of the reaction chamber via the cathodic reaction taking place in the reaction chamber.

[0003] Secondary aluminium is generally produced by re-melting aluminium, for example aluminium end-of-life scrap (after a product has been discarded by the user) or aluminium process scrap that is generated when aluminium products are produced (for example by stamping out window openings in plates for vehicle doors). This process can be repeated over and over.

[0004] While producing secondary aluminium generally requires less energy than producing primary aluminium, the energy requirements are non-negligible. In secondary aluminium, often the metal quality decreases over each repetition due to deficiencies in sorting the material into pure fractions and as impurities that are inefficient to remove accumulate. Further, virtually all secondary aluminium in existence was initially produced as primary aluminium and due to the rising global demand for aluminium, not all demand can be met by secondary aluminium. That means that the production of primary aluminium will continue.

[0005] In light of this, a more efficient method for producing primary and secondary aluminium is desirable.

[0006] US 4 927 459 A, relates to treatment of aluminum reduction cell linings combined with use in aluminum scrap reclamation where spent potlinings are fed to an aluminum reclamation furnace as a partial replacement for or supplement to the molten salt flux used in the reclamation process.

[0007] CN 107 363 074 A, an automatic English translation of this document discloses use of crushed cathodes from electrolytic cells as additional fuel in the production of cement.

Short Description of the Invention

[0008] The present inventor has found that, in view of the whole process chain, aluminium can be produced more efficiently when secondary aluminium is produced by using process waste from the production of primary aluminium in a manner described in the following.

[0009] Accordingly, the present invention provides a method for producing secondary aluminium, the method comprising providing aluminium-containing scrap material, for example having a first, lower, specific aluminium content, providing carbon-containing scrap material from an electrolysis cell for the production of primary aluminium, introducing the aluminium-containing scrap material into a rotary furnace, processing the carbon-containing scrap material to produce a scrap fuel, and melting the aluminium-containing scrap material in the rotary furnace using energy generated by burning the scrap fuel such as to produce secondary aluminium, for example having a second, higher, specific aluminium content. Conventionally, the carbon-containing scrap material is deposited as waste in landfill sites.

[0010] According to embodiments of the invention, the carbon-containing scrap material may be obtained from the anode and/or the cathode of the electrolysis cell.

[0011] According to embodiments of the invention, the aluminium-containing scrap material may comprise dross from aluminium melting and casting.

[0012] According to embodiments of the invention, the aluminium-containing scrap material may comprise end-of-life aluminium scrap or process aluminium scrap.

[0013] According to embodiments of the invention, the aluminium-containing scrap material may comprise fluorine-comprising bath material from the electrolysis cell.

[0014] According to embodiments of the invention, the processing the carbon-containing scrap material may comprise mechanical processing including crushing and/or milling the carbon-containing scrap.

[0015] According to embodiments of the invention, the carbon-containing scrap may be mechanically processed such as to obtain particles having a size between 10 μm and 300 μm , in particular between 50 μm and 100 μm .

[0016] According to embodiments of the invention, the scrap fuel may be transported pneumatically into a flame of a burner for generating the energy for melting the aluminium-containing scrap material.

[0017] According to embodiments of the invention, the scrap fuel may be transported into a flame of a burner for generating the energy for melting the aluminium-containing scrap material while being dispersed in a liquid fuel, in particular oil.

[0018] According to embodiments of the invention, the burner may be operated at least partially using natural gas to generate the flame.

[0019] According to embodiments of the invention, with respect to the caloric value, at least 30%, in particular at least 50% of the energy for melting the scrap material may be provided by the scrap fuel.

[0020] According to embodiments of the invention, in addition to the aluminium-containing scrap material, chloride salt, in particular NaCl and/or KCl, and/or a fluoride salt, in particular CaF₂, may be introduced into the rotary furnace.

[0021] According to embodiments of the invention, a fluorine content in the rotary furnace is adjusted by adjusting a ratio of bath material to other aluminium-comprising scrap.

[0022] According to embodiments of the invention, oxygen with a purity of 50% or more, in particular 80% or more, may be used as an oxidant for burning the scrap fuel.

[0023] According to embodiments of the invention, air may be used as an oxidant for burning the scrap fuel.

[0024] According to embodiments of the invention, oxygen enriched air may be used as an oxidant for burning the scrap fuel.

[0025] According to embodiments of the invention, an off-gas from melting the aluminium-containing scrap material in the rotary furnace may be led into the flame of the burner for post-combustion.

[0026] According to embodiments of the invention, oxygen may be injected into the offgas stream for post combustion, either through the burner, or through a separate lance.

[0027] According to embodiments, the invention further provides a method for producing aluminium using a substantially closed-loop mass flow, the method comprising producing primary aluminium from alumina using an electrolysis cell, producing products from the primary aluminium and from secondary aluminium, obtaining aluminium-containing scrap material from the product (end-of-life scrap) or the production of the product (process scrap), obtaining carbon-containing scrap material from the electrolysis cell, and producing secondary aluminium from the aluminium-containing scrap material and the carbon-containing scrap material using the method described above.

[0028] According to embodiments, the method may further comprise obtaining bath material from the electrolysis cell and producing secondary aluminium from the aluminium-containing scrap material, the carbon-containing scrap material and the bath material as described above.

[0029] According to the accompanying claim 1 there is described a method for producing secondary aluminium (50) in a thermal process where the method comprising;

providing aluminium-containing scrap material (35) to be thermally processed that is introduced into a rotary furnace (40) for thermal processing,

providing carbon-containing scrap material (20) from an electrolysis cell (10) for the production of primary aluminium (15) that is processed including

crushing and/or milling the carbon-containing scrap material (20) to produce a scrap fuel (55) of an average particle size between 10 µm and 300 µm,
and

thermally processing and melting the aluminium-containing scrap material (35) in the rotary furnace (40) using energy generated by the scrap fuel being pneumatically transported into a flame of a burner or while being dispersed in a liquid fuel,
and

burning the scrap fuel (55) such as to produce the secondary aluminium material (50).

[0030] Further embodiments are given by claims 2-14.

Short Description of the Figure

[0031] The figure shows a schematic view of the method according to an embodiment of the invention.

Detailed Description of the Invention

[0032] The method according to the invention produces secondary aluminium, that is, aluminium that is not directly produced from alumina, from aluminium-containing scrap material. With reference to Fig. 1, an electrolysis cell 10 produces primary aluminium 15 from alumina (not shown). Generally, this is achieved via the Hall-Heroult process involving the flow of an electric current from the cathode placed on the bottom side of the electrolysis cell through a reaction chamber of the electrolysis cell 10 to the anode placed on the upper side of the electrolysis cell 10. The reaction chamber is filled with alumina and cryolite (Na_3AlF_6) and optionally other additives such as lithium fluoride. The anode and the cathode both comprise

carbon. While the anode is consumed at a higher rate than the cathode via the oxidation of carbon that takes place during the reduction of alumina, the cathode also deteriorates over time and must eventually be replaced. As both anode and cathode come into contact with fluorine or fluorine-comprising compounds in the reaction chamber, used (also called "spent") anodes and cathodes may comprise fluorine. According to the present invention, spent/used anodes and/or cathodes from the electrolysis cell 10 are referred to as carbon-comprising scrap material 20. A further byproduct of the production of primary aluminium in the electrolysis cell 10 is bath material 25, a mixture of impurities from the alumina, the cryolite/additives, impurities from the anode/cathode and the cell itself that accumulates on the upper side of the reaction chamber of the electrolysis cell 10 and is removed from time to time. The bath material 10 may comprise significant amounts of fluorine (F).

[0033] The primary aluminium 15 is used to produce products 30 such as cast products, sheet metal, extruded products and the like. Aluminium-containing scrap material 35 is obtained from process waste that is generated during production of the products 30 (process scrap) as well as from the products 30 themselves at the end of their lifetime (end-of-life scrap). Aluminium-containing scrap material 35 may also be obtained from dross generated while casting aluminium or from casting process scrap.

[0034] The aluminium-containing scrap material 35 is according to the invention introduced into a rotary furnace 40. The rotary furnace 40 is heated by a burner 45 such as to melt the aluminium-containing scrap material 35. The melting may result in a purification of the material in the rotary furnace with respect to the specific aluminium content, as organic compounds in the aluminium-containing scrap 35 such as lacquers and coatings are burned off and other impurities and oxides may accumulate in dross that forms on top of the melt in the rotary furnace 40 and can be separated from the melt. The melted and solidified material that is produced in the rotary furnace 40 is referred to as secondary aluminium 50, as it is -in contrast to primary aluminium- not directly produced from alumina.

[0035] The secondary aluminium 50 may be used like primary aluminium 15 to produce products 30 resulting in a substantially closed cycle with respect to the mass flow of aluminium. The cycle:

product 30 -> aluminium-containing scrap material 35 -> secondary aluminium 50-product 30 -> ...

may be repeated indefinitely in principle, however in practice some aluminium is lost during recycling, there are issues with the purity of secondary aluminum 50 in some applications, and the global demand in aluminium is rising so that on a global scale secondary aluminium 50 has to be supplemented by primary aluminium 15 to meet demand.

[0036] According to the invention, the carbon-comprising scrap material 20 is processed such as to obtain scrap fuel 55. The processing may include crushing and/or milling the carbon-comprising scrap material 20 such as to reduce the particle size. Depending on the design of a burner 45, an average particle size determined using the largest circle method of the scrap fuel 55 may be between 10 µm and 300 µm, in particular between 50 µm and 100 µm. While smaller

average particle sizes have a better ratio of surface to volume than larger average particle sizes and therefore burn better in a flame of the burner 45, processing the carbon-comprising scrap material 20 is a resource-intensive and the stated average particle size of between 10 μm and 300 μm , in particular between 50 μm and 100 μm , is thought to be a good compromise between quality of the scrap fuel 55 and production efficiency of the scrap fuel 55.

[0037] The scrap fuel 55 is burned by the burner 45 to produce secondary aluminium 50 in the rotary furnace 40 by heating the carbon-containing scrap material 35. The heat produced by the burner 45 that heats the rotary furnace 40 is schematically shown by arrow 46 in Figure 1.

[0038] To improve the performance of the burner 45, the scrap fuel 55 may be supplemented by natural gas or by oil (petroleum) or hydrocarbons derived from gas/petroleum, such as diesel fuel, gasoline or otherwise processed petroleum.

[0039] The scrap fuel 55 may be blown into a flame of the burner 45 or the scrap fuel 55 may be mixed with the supplemented fuel. In case the supplemented fuel is a gas, a mixture of said gas and the particulate scrap fuel 55 may be incinerated to generate heat. In case the supplemented fuel is a liquid such as oil, the scrap fuel 55 may be dispersed in the liquid and the resulting dispersion may be incinerated to generate heat.

[0040] According to the present invention, a rotary furnace 40 is used as the flame generated by the burner 45 has a high volume and generates a large amount of (heat) radiation caused by the solid scrap fuel 55. It has been found that a rotary furnace 40 has an optimal transfer area for transfer of the energy of the flame that is generated by the burner 45 burning the scrap fuel 55. Further, a rotary furnace 40 allows to utilize off-gas cleaning of the gases generated by the burner 45 and/or generated by melting the aluminium-comprising scrap material 35.

[0041] An off-gas (not shown in Fig. 1) that is produced by heating the aluminium-containing scrap material 35 in the rotary furnace 40 may be led to the burner 45 to be burned by the burner 45. This results in a cleaning of the off-gas, as harmful compounds in the off-gas are burnt. In case the off-gas comprises compounds that can be burned in an exothermic reaction (for example stemming from organic coatings or lacquers or plastics in the aluminium-containing scrap material 35), said compounds generate additional heat and improve the energy efficiency.

[0042] According to the invention, chlorine comprising salts, such as NaCl or KCl may be introduced into the rotary furnace 40 together with the aluminium-containing scrap material 35. It has been found that such an addition of chlorine comprising salts can increase the quality of the secondary aluminium 50 produced by the rotary furnace 40. It is thought that the mechanism involves an increased accumulation of high-melting intermetallics in the dross forming in the rotary furnace 40 caused by the chlorine salt additions.

[0043] According to the invention, fluorine-comprising bath material 25 may optionally also be

introduced into the rotary furnace 40 together with aluminium-containing scrap material 35. It is thought that the fluorine from the bath material 25 reduces the surface tension of Al-droplets formed during melting in the rotary furnace 40 which results in the formation of droplets having a higher volume. The larger the droplets are, the less oxidation takes place on the surface of the droplets due to the geometric relationship of surface to volume. Further, fluorine may help in keeping the walls of the rotary furnace 40 clean.

[0044] In addition to or instead of bath material 25, optionally fluorine comprising salts such as CaF_2 and/or Na_3AlF_6 or other salts may be introduced into the rotary furnace 40 together with the aluminium-containing scrap material 35.

[0045] Accordingly, the present invention provides methods that enable an efficient production of secondary aluminium 50 by using waste material from the production of primary aluminium 15 in an electrolysis cell 10 that reduce energy consumption and reduce the amount of waste that is disposed in landfill sites

REFERENCES CITED IN THE DESCRIPTION

Cited references

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Patent documents cited in the description

- [US4927459A \[0006\]](#)
- [CN107363074A \[0007\]](#)

Patentkrav

1. Fremgangsmåde til fremstilling af sekundært aluminium (50) i en termisk proces, hvilken fremgangsmåde omfatter;
- 5 tilvejebringelse af aluminium-holdigt skrotmateriale (35), der skal behandles termisk,
- tilvejebringelse af carbon-holdigt skrotmateriale (20) fra en elektrolysecelle (10) til fremstilling af primært aluminium (15),
- 10 indføring af det aluminium-holdige skrotmateriale (35) i en rotationsovn (40) til termisk behandling,
- behandling, herunder knusning og/eller formaling af det carbon-holdige skrotmateriale (20) til fremstilling af et skrotbrændstof (55) med en gennemsnitlig partikelstørrelse mellem 10 μm og 300 μm og
- 15 termisk behandling og smeltning af det aluminium-holdige skrotmateriale (35) i rotationsovnen (40) ved anvendelse af energi genereret af skrotbrændstoffet, der pneumatisk transporteres ind i en flamme af en brænder, eller mens det dispergeres i et flydende brændstof,
- og brænding af skrotbrændstoffet (55) for at fremstille det sekundære aluminiummateriale (50).
- 20
2. Fremgangsmåde ifølge krav 1, hvorved det carbon-holdige skrotmateriale (20) opnås fra en anode og/eller en katode af elektrolysecellen (10).
- 25
3. Fremgangsmåde ifølge krav 1 eller 2, hvorved det aluminium-holdige skrotmateriale (35) omfatter slagge fra aluminiumsmeltning og -støbning.
4. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 3, hvorved det aluminium-holdige skrotmateriale (35) omfatter affaldsaluminiumskrot eller
- 30 procesaluminiumskrot.
5. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 4, hvorved det aluminium-holdige skrotmateriale (25) omfatter fluorin-omfattende badmateriale fra elektrolysecellen (10).
- 35

- 6.** Fremgangsmåde ifølge krav 5, hvorved det carbon-holdige skrotmateriale (20) behandles mekanisk, således at der opnås partikler, der har en gennemsnitlig størrelse mellem 50 µm og 100 µm.
- 5 **7.** Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvorved skrotbrændstoffet (35) transporteres pneumatisk ind i en flamme af en brænder (45) til generering af energien for at smelte det aluminium-holdige skrotmateriale (35).
- 10 **8.** Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 6, hvorved skrotbrændstoffet (55) transporteres ind i en flamme af en brænder (45) til generering af energien for at smelte det aluminium-holdige skrotmateriale (35), mens det dispergeres i et flydende brændstof, især olie.
- 15 **9.** Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 8 under henvisning til krav 7 eller 8, hvorved i forhold til den kaloriske værdi mindst 30 %, især mindst 50 % af energien til smeltning af det aluminium-holdige skrotmateriale (35) tilvejebringes af skrotbrændstoffet (55).
- 20 **10.** Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 9, hvorved der ud over det aluminium-holdige skrotmateriale (35) indføres chloridsalt, især NaCl og/eller KCl, og/eller et fluoridsalt, især CaF₂, i rotationsovnen (40).
- 25 **11.** Fremgangsmåde ifølge et hvilket som helst af de foregående krav under henvisning til krav 5, hvorved et fluorinindhold i rotationsovnen (40) justeres ved justering af et forhold mellem badmateriale (25) og andet aluminium-omfattende skrot (35).
- 30 **12.** Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 11 under henvisning til krav 7 eller 8, hvorved en afgang fra smeltning af det aluminium-holdige skrotmateriale (35) i rotationsovnen (40) ledes ind i flammen af brænderen (45) til efterbrænding.
- 35 **13.** Fremgangsmåde til fremstilling af aluminium ved anvendelse af et lukket sløjfe-masseflow, hvilken fremgangsmåde omfatter;

- fremstilling af primært aluminium (15) fra aluminiumoxid ved anvendelse af en elektrolysecelle (10),
fremstilling af produkter (30) fra det primære aluminium (15) og fra sekundært aluminium (50),
- 5 opnåelse af aluminium-holdigt skrotmateriale (35) fra produktet (35; affalds-skrot) eller fremstillingen af produktet (35; processkrot),
opnåelse af carbon-holdigt skrotmateriale (20) fra elektrolysecellen (10) og fremstilling af sekundært aluminium (50) fra det aluminium-holdige skrotmateriale (35) og det carbon-holdige skrotmateriale (20) ved anvendelse af fremgangsmåden ifølge et hvilket som helst af kravene 1 til 12.
- 10

- 14.** Fremgangsmåde ifølge krav 13, yderligere omfattende opnåelse af badmateriale (35) fra elektrolysecellen (10) og fremstilling af sekundært aluminium (50) fra det aluminium-holdige skrotmateriale (35), det carbon-holdige skrotmateriale (20) og badmaterialet (35) ifølge et hvilket som helst af kravene 1 til 12 under henvisning til krav 5.
- 15

DRAWINGS

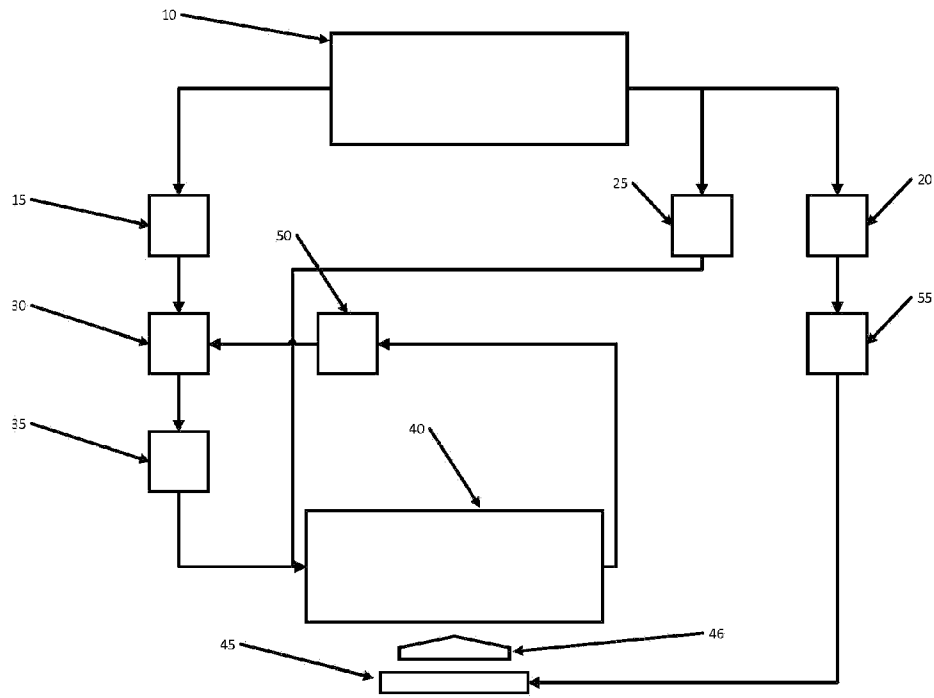


Fig. 1