



(11) **EP 1 927 666 A1**

(12) **EUROPEAN PATENT APPLICATION**  
published in accordance with Art. 153(4) EPC

(43) Date of publication:  
**04.06.2008 Bulletin 2008/23**

(51) Int Cl.:  
**C21B 5/02** (2006.01) **C21B 3/02** (2006.01)  
**C22C 38/08** (2006.01)

(21) Application number: **05801995.1**

(86) International application number:  
**PCT/CN2005/001828**

(22) Date of filing: **02.11.2005**

(87) International publication number:  
**WO 2006/045254 (04.05.2006 Gazette 2006/18)**

(84) Designated Contracting States:  
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI  
SK TR**

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(30) Priority: **16.09.2005 CN 200510102985**

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(54) **A SMELTING PROCESS OF FERRONICKEL WITH NICKEL OXIDE ORE CONTAINING OF CRYSTAL WATER IN A BLAST FURNACE**

(57) The present invention provides a metallurgical method of ferronickel by blast-furnace smelting nickel oxide ore containing crystal water which mainly comprises the step of crushing and sieving the raw ore, manufacturing the ore powder into sintered ore and blast-furnace smelting the mixture of sintered ore blocks, coke, limestone/calcium lime, dolomite as well as fluorite to obtain the ferronickel, wherein the weight ratio of the additives to sintered ore is: 0.3~20% fluorite, 0~8% dolomite, 4~35% limestone/calcium lime. The method further comprises crushing and sieving sintered ore blocks, magnetic sorting to obtain refined ore powder and then sintering again. Compared with the prior art, the proportion of fluor-

ite and sintered ore in the metallurgical technology of ferronickel provided by the present invention can lower the effect of chrome on the furnace temperature, meanwhile can also avoid occurring of accidents, such as burn-out of crucible caused by too high content of Fluorine; Magnesium contained in dolomite may solve the problem on bad fluidity of iron water caused by chrome in nickel and chrome ores; limestone can not only provide alkalinity but balance both of the above mentioned additives. The metallurgical method of blast furnace smelting provided by the present invention has advantages such as low cost and high recovery rate of the raw materials.

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**Description****Technical field**

5 **[0001]** The present invention relates to a method of blast-furnace smelting, more particularly to a metallurgical method of ferronickel by blast-furnace smelting nickel oxide ore with crystal water.

**Background of the invention**

10 **[0002]** Global extensive uses of stainless steel and special steel lead to supply shortage and rapid rise in price of nickel metal, a main element used to smelt stainless steel and special steel. Conventional technology is mature that nickel metal is produced by mainly extracting from nickel sulfide ore, which covers 30% of the nickel resources on the earth. But at present, reserves are in shortage and resources are in crises after continuous exploitation for near one century. People have to pay more attention to the extraction of nickel metal from laterite nickel ore (nickel oxide ore) covering 70% of nickel resources on the earth. The main reason that laterite nickel ore haven't been exploited on a large scale for a long time is that the technology extracting Ni from such mineral resources is characterized by high cost, technological complexity, low yield, severe pollution. At Present, for high-grade laterite nickel ore (nickel content above 2.0%), ore-smelting furnace is generally used to smelt on the international, however, this method is provided with disadvantages such as high power consumption, severe environmental pollution and low yield of intermittent production. For low-grade laterite nickel ore, hydrometallurgy is commonly used, namely, a method of vitriol soaking, i.e. converting solid-state nickel oxide, chromic oxide, ferric oxide or the like in the laterite nickel ore to mixed solution of liquid-state nickel sulfate, chrome sulfate, ferrite sulfate ( $\text{Fe}^{2+}$ ) and the like, then separating nickel sulfate thereby, forming nickel metal only accounting for 1-2% of the gross by electrolysis with all the other components wasted. The process equipment is characterized by large one-off investment, complex process, long periodicity, severe environmental pollution. Blast-furnace smelting may also be use, however, because  $\text{Cr}_2\text{O}_3$  as concomitant commonly exists in laterite nickel ore, extremely high melting point of its own can lead to large viscosity of molten iron water so that iron water containing nickel and chrome can't flow out successfully and cause severe results such as frozen furnace and damaged furnace. Many corporations and research organizations at home and abroad have studied the technology for a long time that ferronickel (nickel iron) can be obtained by blast-furnace smelting laterite nickel ore in one-step way, but hitherto no success is reported. Consequently, it is urgent problem to be solved in this business to find an industrial method that nickel iron is smelted directly from laterite nickel ore, which is characterized by high efficiency, low consumption, high yield, low cost and no pollution or little pollution.

**Summary of the invention**

35 **[0003]** To solve the above problem, the present invention provides a metallurgical method of ferronickel by blast-furnace smelting nickel oxide ore containing crystal water in one-step way.

**[0004]** The above inventive object is achieved by the following technical proposal.

40 **[0005]** The invention provides a metallurgical method of ferronickel by blast-furnace smelting nickel oxide ore containing crystal water, mainly comprising the steps as follows:

Crushing and sieving raw ores, mixing the feed of ore powder in grain diameter smaller than 2mm thereof with coke powder, calcium lime/limestone and sintering to obtain sintered ore blocks ;

Mixing sintered ore blocks, coke, limestone/calcium lime, dolomite and fluorite and blast-furnace smelting to obtain ferronickel; wherein, the weight ratio of the following additives to sintered ore is:

|    |                        |         |
|----|------------------------|---------|
| 45 | fluorite               | 0.3~20% |
|    | dolomite               | 0~8%    |
|    | limestone/calcium lime | 4~35%.  |

50 The metallurgical method of ferronickel by blast-furnace smelting nickel oxide ore with crystal water in the present invention further includes the following steps:

Crushing and sieving the sintered blocks obtained by first sintering by means of a sieve in 300-500 meshes, and then producing refined ore powder by magnetic sorting.

55 Mixing the feed of the refined ore powder with coke powder, calcium lime/limestone and sintering to obtain sintered ore blocks.

Mixing the sintered ore blocks obtained by second sintering with coke, lime/limestone, dolomite and fluorite, and then blast-furnace smelting to obtain ferronickel.

Wherein the main component of nickel oxide ore and the weight ratio of its own are :

Nickel: 0.5~4%;  
 Chrome: 0.3~12%;  
 iron: 7~55%.

Wherein the preferable weight ratio of the additives to the sintered ore is:

fluorite 0.3~10%  
 dolomite 0.5~5%  
 limestone/calcium lime 8~20%.

Wherein the content of CaO in limestone is greater than 50%, while that of CaO in calcium lime is greater than 80%; the content of Mg in the dolomite is higher than 10% and that of CaF in dolomite is bigger than 80%.

**[0006]** Compared with the prior art, furnace temperature can reach up to about 1700 ° C in the conventional blast-furnace smelting technology, chrome contained in nickel oxide ore mainly exists in the form of  $\text{Cr}_2\text{O}_3$  whose melting point is about 2300° C, consequently, the reduction degree of chrome in nickel oxide ore is limited to cause bad fluidity of the obtained iron water and easily to produce phenomenon of frozen furnace, and even result in accidents. In metallurgical method of ferronickel by smelting nickel and chrome iron ore provided by the present invention, the addition of fluorite can lower the influence of chrome on furnace temperature effectively and raise the fluidity of iron water, meanwhile, because the addition quantity of fluorite in metallurgical method provided by the present invention is strictly calculated, the accidents, such as burnout of the crucible, caused by too high addition quantity of fluorite, can be effectively avoided. In the metallurgical method provided by the present invention, meanwhile, magnesium contained in dolomite may also be helpful to solve the problem on bad fluidity of iron water caused by chrome in nickel and chrome ores. Limestone can not only provide alkalinity, but also can balance the above two additives. The metallurgical method of one-step blast-furnace smelting provided by the present invention is characterized by short technical process, high yield of continuous production, total extraction of nickel, chrome and iron in laterite nickel ore once for all, high ratio of resource utilization. The slag obtained by smelting is an excellent raw material to produce concrete, except the exhaustion of a given mass of  $\text{CO}_2$  gas, no other solid or liquid wastes are produced and there is no pollution.

**[0007]** By contrast, the metallurgical technology of blast-furnace smelting provided by the present invention has some advantages, for example low cost. Blast furnace in the technology provided by the present invention can consume 150-200 kilowatt-hours per ton iron, while the conventional ore smelting technology need consume 2000-4000 kilowatt-hours and coke of 0.5 ton per ton iron; For example economic resources, high yield, namely the mean yield of blast furnace is bigger than that of ore-smelting furnace; such as little pollution, little dust, high recovery rate of the raw materials which are respectively 97~98% for iron, 99% for nickel and 40~50% for chrome.

#### Specific embodiment:

**[0008]** The present invention can further be explained and described in combination with specific examples below. The following examples are not intended to limit the scope of the present invention and all the modifications and rearrangements based on the spirits of the present invention are without departing from scope of the present invention.

**[0009]** Raw ores in examples are selected from nickel and chrome iron ores imported from Albania.

**[0010]** Crushing and sieving raw ores, mixing the feed of ore powder in grain diameter smaller than 2mm thereof with coke powder, calcium lime/limestone and sintering to obtain sintered ore blocks;

**[0011]** Crushing and sieving the sintered blocks obtained by first sintering by means of a sieve in 300-500 meshes and then magnetic sorting to obtain refined ore powder.

**[0012]** Mixing the feed of the refined ore powder with coke powder, calcium lime/limestone and sintering to obtain sintered ore blocks.

**[0013]** Mixing sintered ore of the sintered ore blocks in particulate diameter of 10-50mm with other raw materials and smelting to obtain ferronickel.

**[0014]** The main components in used nickel and chrome iron ore and its content (wt.%) are:

| components<br>Series code | Fe   | Ni   | Cr    | Ca    | Si    | Mg   | Al   |
|---------------------------|------|------|-------|-------|-------|------|------|
| 1                         | 7.18 | 4.37 | 11.93 | 18.14 | 21.08 | 0.84 | 6.17 |

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(continued)

| components<br>Series code | Fe    | Ni   | Cr   | Ca    | Si    | Mg   | Al   |
|---------------------------|-------|------|------|-------|-------|------|------|
| 2                         | 17.81 | 3.21 | 9.26 | 16.25 | 18.27 | 1.18 | 5.77 |
| 3                         | 26.28 | 2.68 | 8.10 | 14.36 | 17.35 | 1.45 | 4.69 |
| 4                         | 36.54 | 2.30 | 6.32 | 11.87 | 16.09 | 1.64 | 3.14 |
| 5                         | 43.51 | 1.83 | 4.71 | 8.29  | 15.14 | 1.94 | 2.84 |
| 6                         | 54.26 | 0.57 | 0.35 | 4.57  | 5.88  | 2.11 | 2.11 |

**[0015]** The main components in obtained sintered ore and its content (wt.%) are:

| components<br>Series code | Fe    | Ni   | Cr    | Ca    | Si    |
|---------------------------|-------|------|-------|-------|-------|
| 1                         | 9.01  | 4.23 | 10.29 | 16.17 | 19.14 |
| 2                         | 23.14 | 3.60 | 7.39  | 14.19 | 16.32 |
| 3                         | 33.83 | 2.97 | 7.10  | 13.24 | 16.10 |
| 4                         | 46.83 | 2.51 | 5.48  | 12.31 | 14.26 |
| 5                         | 55.59 | 2.13 | 3.62  | 7.25  | 4.77  |
| 6                         | 65.51 | 0.63 | 0.33  | 3.67  | 2.59  |

**[0016]** Constitution of the furnace materials (Weight: Kg) is shown in following table.

| Components<br>Series code | Sintered ore | coke | fluorite | dolomite | limestone/ calcium lime |
|---------------------------|--------------|------|----------|----------|-------------------------|
| 1                         | 1000         | 455  | 200      | 80       | 350                     |
| 2                         | 1000         | 415  | 170      | 70       | 300                     |
| 3                         | 1500         | 680  | 240      | 90       | 300                     |
| 4                         | 1500         | 625  | 150      | 75       | 150                     |
| 5                         | 2000         | 920  | 100      | 20       | 160                     |
| 6                         | 2000         | 830  | 6        | -        | 80                      |

**[0017]** Metallurgical technology parameters of blast furnace:

| items<br>Type code                         | Crucible diameter | Vent diameter | fan    | Wind pressure |
|--------------------------------------------|-------------------|---------------|--------|---------------|
| Capacity of blast furnace 36m <sup>3</sup> | 2.1m              | 75mm          | 230m/s | 4200 (mmHg)   |
| Capacity of blast furnace 90m <sup>3</sup> | 2.9m              | 100mm         | 380m/s | 4600 (mmHg)   |

**[0018]** The main components in the obtained nickel iron by smelting and its content (wt. %) are:

| components<br>Series code | Fe    | Ni    | Cr    | S     | P     |
|---------------------------|-------|-------|-------|-------|-------|
| 1                         | 48.26 | 15.10 | 33.11 | 0.060 | 0.061 |
| 2                         | 52.31 | 10.59 | 23.10 | 0.059 | 0.060 |

(continued)

| components<br>Series code | Fe    | Ni   | Cr    | S     | P     |
|---------------------------|-------|------|-------|-------|-------|
| 3                         | 64.58 | 8.32 | 22.38 | 0.058 | 0.059 |
| 4                         | 75.51 | 5.98 | 13.36 | 0.059 | 0.062 |
| 5                         | 85.29 | 3.24 | 7.09  | 0.057 | 0.057 |
| 6                         | 93.46 | 0.92 | 0.63  | 0.061 | 0.058 |

**Claims**

1. A metallurgical method of ferronickel by blast-furnace smelting nickel oxide ore with crystal water, wherein the said method of blast-furnace smelting mainly comprising the following steps:

Crushing and sieving raw ores, mixing the feed of ore powder in grain diameter smaller than 2mm thereof with coke powder, calcium lime/limestone and sintering to obtain sintered ore blocks ;

Mixing sintered ore blocks, coke, limestone/calcium lime, dolomite and fluorite and blast-furnace smelting to obtain ferronickel; wherein the weight ratio of the following additives to sintered ore is:

|                        |         |
|------------------------|---------|
| fluorite               | 0.3~20% |
| dolomite               | 0~8%    |
| limestone/calcium lime | 4~35%.  |

2. The metallurgical method according to Claim 1, wherein the blast furnace smelting further comprising the following steps:

Crushing and sieving the sintered blocks obtained by first sintering by means of a sieve in 300-500 meshes, and then producing refined ore powder by magnetic sorting;

Mixing the feed of the refined ore powder with coke powder, calcium lime/limestone and sintering to obtain sintered ore blocks;

Mixing the sintered ore blocks obtained by second sintering with coke, lime/limestone, dolomite and fluorite, and then blast-furnace smelting to obtain ferronickel.

3. The metallurgical method according to Claim 1 or 2, wherein the main component of the said nickel oxide ore and the weight ratio of its own are: Nickel: 0.5~4%; Chrome: 0.3~12%; iron: 7~55%.

4. The metallurgical method according to Claim 1 or 2, wherein the preferable weight ratio of the said additives to the sintered ore is:

|                        |         |
|------------------------|---------|
| fluorite               | 0.3~10% |
| dolomite               | 0.5~5%  |
| limestone/calcium lime | 8~20%.  |

5. The metallurgical method according to Claim 1 or 2, wherein the content of CaO in the limestone is greater than 50% ,while that of CaO in calcium lime is greater than 80%.

6. The metallurgical method according to Claim 1 or 2, wherein the content of Mg in the dolomite is higher than 10%.

7. The metallurgical method according to Claim 1 or 2, wherein the content of CaF in the dolomite is bigger than 80%.

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/CN2005/001828

## A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C21B3/00-3/10 C21B5/00-5/06 C22C38/08 (2006. 01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CNPAT, CNKI

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, PAJ; nickel, iron, blast furnace, agglomerat+, sinter, lime, etc.

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                              | Relevant to claim No. |
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| A         | RU2157412C1; 10. Oct. 2000 (10. 10. 2000); see the whole document                                                                                                                               | 1-7                   |
| A         | JP2001303113A; 31. Oct. 2001 (31. 10. 2001); see the whole document                                                                                                                             | 1-7                   |
| A         | CN1603439A; 06. Apr. 2005 (06. 04. 2005); see the whole document                                                                                                                                | 1-7                   |
| A         | CN1205743A; 20. Jan. 1999 (20. 01. 1999); see the whole document                                                                                                                                | 1-7                   |
| A         | CHINESE MINING, Vol 11, No 1, Xiao Zhenmin, "STATUS OF EXPLOITATION OF LATERITE TYPE NICKEL ORE AND APPLICATION OF HIGH PRESSURE ACID LEACHING TECHNOLOGY IN THE WORLD", see the whole document | 1-7                   |

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                                 | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                                              |
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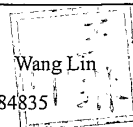
Date of the actual completion of the international search  
27. Jan. 2006 (27. 01. 2006)

Date of mailing of the international search report  
23 · FEB 2006 (23 · 02 · 2006)

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**INTERNATIONAL SEARCH REPORT**  
 Information on patent family members

 International application No.  
 PCT/CN2005/001828

| Patent Documents referred<br>in the Report | Publication Date             | Patent Family | Publication Date             |
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Form PCT/ISA/210 (patent family annex) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2005/001828

CLASSIFICATION OF SUBJECT MATTER

C21B 5/02 (2006.01) i

C21B 3/02 (2006.01) i

C22C38/08 (2006.01) n