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(54) **PROCESS FOR PREPARING IRON- AND CHROME-CONTAINING PELLETS**

(57) The invention provides a process for preparing iron- and chrome-containing pellets comprising the steps
a) producing ore pellets comprising mixing chrome ore material, Chrome Ore Process Residue (COPR) with less than 3 % of a carbonaceous reductant components selected from anthracite, char, coke and bituminous coal,

b) optionally drying the ore pellets obtained after step a),
and
c) calcining the ore pellets,
as well as novel iron- and chrome-containing pellets obtainable by said process.

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Description

[0001] The invention relates to a process for preparing iron- and chrome-containing pellets, to iron- and chrome-containing pellets and their use for the preparation of Ferrochrome as well as to a process for the preparation of Ferrochrome using the iron- and chrome-containing pellets.

[0002] A widely used iron- and chrome-containing alloy is the so called Ferrochrome. Ferrochrome is used in the stainless-steel industry to increase the resistivity of steel against water and air to prevent the formation of rust. The iron and chrome source for the Ferrochrome production is usually chromite, a chrome ore, which is found in some parts of the world, like in South Africa.

[0003] The production of Ferrochrome is carried out in huge electrically heated arc furnaces or blast furnaces at high temperatures, using a carbon based reductant which can be part of the electrode or which is mixed in the chrome ore, or both. The consumption of electricity is significant and determines the cost effectiveness of a process using electrically heated furnaces. The process results in a liquid, molten alloy which is casted in casts, and a layer of partially molten residue floating on top of the liquid metal, the slag.

[0004] The usage of fine chrome ore material, so called "fines" or "flour", is economically of interest, because it decreases the necessary dwell time of the ore in the melt during reduction process significantly, but is practically difficult. In the arc furnaces a strong stream of hot gas is formed which results in an upstream. The particles of the fines are too small to be dropped into the furnace: they would not reach the hottest zones (melt) for reduction. Most of this material would be blown out of the furnace with the off-gas stream. In order to get the fines in a suitable shape pellets were formed out of the fines as disclosed in ZA2004-03429A. In Minerals Engineering (2012), 34, 55-62, a detailed description of the used binders and their properties and effects on the pellet strength and other properties are given.

[0005] The pellets produced according to the process of ZA2004-03429A and according to Minerals Engineering (2012), 34, 55-62, are made of chrome ore, a carbonaceous reductant and a so-called unconverted or non-activated binding agent. The binding agent is a mainly silica based clay, like Bentonite. Bentonite comprises ca. 24 weight-% of silicon.

[0006] There are some disadvantages of this process and the pellets produced according to this process: the binding agent Bentonite contains neither iron nor chrome and thus, cannot contribute to the formation of Ferrochrome afterwards. Instead, the silica contained in Bentonite increases the amount of useless and costly slag. Slag is not only an undesired by-product in the process for the production of Ferrochrome but furthermore its formation requires additional electrical energy (e.g. for heating and for the reduced throughput of the furnace). Another disadvantage of the process is the effect of Bentonite on the density of the wet pellets fed into a tunnel furnace for pre-calcining step. The Bentonite is absorbing water and decreases the density of the pellets, which leads to a lower throughput of material through the tunnel furnace, as this is limited by volume per time unit, but the producer get paid by mass of pellets produced. On the other hand, the pore volume of the pellets is important, as the reducing gases formed in the arc furnace process need to reach the oxides in the pellets. So, a higher Chrome content and an increased density of the raw, dried pellets is desired with only small changes in the porosity of the indurated, calcined pellets. This results in lower slag production, higher throughput through the (tunnel-) furnace.

[0007] Thus, it was the object of the present invention to provide a process for preparing iron- and chrome-containing pellets that avoids the disadvantages of the prior art and that leads to pellets that can preferably be used in a process for the preparation of Ferrochrome that shows a reduced slag formation, higher density in the green (not calcined) and in the calcined stage and a higher Chrome content than pellets prepared with a binder of the prior art.

[0008] Further, the pellets should preferably be usable in a process for the preparation of Ferrochrome that is more energy-efficient. For this purpose, the pellets should be prepared essentially without using carbonaceous reductants and/or reducing components, which reduce the metal oxide of the pellets during calcination. Further, it was an object of the present invention to provide iron- and chrome-containing pellets that exhibit a sufficient stability to be stored and/or transported, e.g. transported to the process for the production of Ferrochrome.

[0009] It was surprisingly found, that COPR fulfills all of the above requirements at the same or higher level than the binder used as state-of-the-art.

[0010] The invention therefore provides a process for preparing iron- and chrome-containing pellets comprising the steps:

- a) producing ore pellets comprising the mixing of chrome ore material, Chrome Ore Process Residue (COPR) and water,
- b) optionally drying the ore pellets obtained in step a), and
- c) calcining the ore pellets,

wherein essentially no carbonaceous reductant components selected from anthracite, char, coke and bituminous coal are present in step a).

Step a)Chrome ore material

5 **[0011]** Preferably, the chrome ore material used in step a) contains:

- chrome(III)oxide (Cr_2O_3): 26 to 54 weight-%, particularly preferably 40 to 45 weight-%,
- aluminum oxide (Al_2O_3): 10 to 30 weight-%, particularly preferably 13 to 18 weight-%,
- iron(II) oxide (FeO): 12 to 36 weight-%, particularly preferably 20 to 28 weight-%,
- 10 • magnesium oxide (MgO): 9 to 22 weight-%, particularly preferably 10 to 15 weight-%,
- calcium oxide (CaO): < 5 weight-%, particularly preferably < 1 weight-%, and
- silicon oxide (SiO_2): 1 to 18 weight-%, particularly preferably 2 to 5 weight-%,

whereas the weight-% refer to the weight of the chrome ore material.

15 **[0012]** The worldwide largest chrome ores deposits are located in South Africa, Zimbabwe, Turkey and the Philippines and in some other countries. The chrome ore is divided in two categories: The metallurgical grade with ≥ 45 weight-% of Cr_2O_3 and the chemical grade with < 45% weight-% and ≥ 40 weight-% of Cr_2O_3 . The largest known deposit of chrome ore is found in Zimbabwe with over 300 million tons.

20 Chrome Ore Process Residue

[0013] Chrome Ore Process Residue (COPR) sometimes also named chromite ore processing residue is known to person skilled in the art as a waste stream comprising chrome and other metal oxides from the industrial production of chromate. The Chrome Ore Process Residue (COPR) used in step a) is preferably a by-product from the sodium monochromate production process. Therein, chrome ore is mixed with soda ash and heated to a temperature of about 1200°C under oxidizing condition. The reaction mixture is leached with water, and the dried solid residue is the so-called Chrome Ore Process Residue (COPR).

[0014] Preferably, the COPR is obtained in the process for producing sodium monochromate from chromite via an oxidative alkaline digestion with sodium carbonate (no lime process, CaO content of < 5% by weight).

30 **[0015]** Preferably, COPR contains metal oxides such as chromium(III) oxide (Cr_2O_3), aluminium oxide (Al_2O_3), iron(III) oxide (Fe_2O_3), iron(II) oxide (FeO), magnesium oxide (MgO), calcium oxide (CaO), silicon oxide (SiO_2), vanadium oxide (V_2O_5), sodium oxide (Na_2O) and sodium monochromate (Na_2CrO_4).

[0016] The Cr(VI) is preferably present as sodium monochromate (Na_2CrO_4) in the COPR.

[0017] The CaO content of the COPR is preferably less than 15% by weight, particularly preferably less than 10% by weight, most preferably less than 5% by weight.

[0018] COPR preferably contains:

- chrome(III) oxide (Cr_2O_3): 7 to 13 weight-%, preferably 7,5 to 12,5 weight-%,
- aluminum oxide (Al_2O_3): 10 to 30 weight-%, preferably 18 to 24 weight-%,
- 40 • iron(II) oxide (FeO): 36 to 44 weight-%, preferably 37 to 42 weight-%,
- iron(III) oxide (Fe_2O_3): >0,5% weight-%, preferably >2 weight-%,
- magnesium oxide (MgO): 9 to 18 weight-%, preferably 10 to 17 weight-%,
- calcium oxide (CaO): < 10 weight-%, preferably < 5 weight-%,
- silicon oxide (SiO_2): 0 to 3 weight-%, preferably 1 to 3 weight-%,
- 45 • vanadium oxide (V_2O_5): < 1 weight-%, preferably < 0.5 weight-%,
- sodium oxide (Na_2O): 0 to 5 weight-%, preferably 2 to 5 weight-%, and
- sodium monochromate (Na_2CrO_4): 0 to 4,7 weight-%, preferably <0,0003 weight-%,

whereas the weight-% refer to the weight of the COPR.

50 **[0019]** Preferably, the Cr(VI) content of the COPR is 0,01 - 1 weight-%.

[0020] Preferably, the Cr content in the COPR is 2 to 25 weight-%, particularly preferably 5 to 9 weight-%.

[0021] Preferably, the Fe content in the COPR is 28 to 35 weight-%, particularly preferably 29 to 34 weight-%.

[0022] Preferably, the Si content in the COPR is 0 to 1,5 weight-%, particularly preferably 0,4 to 1,0 weight-%.

[0023] Alternatively, the Cr(VI) content of the COPR is preferably < 0,0001 weight-%.

55 **[0024]** COPR with a Cr(VI) content of < 0,0001 weight-% is preferably obtained via a reduction process of COPR with a Cr(VI) content of 0,01 - 1 weight-% in that the reduction of Cr(VI) to Cr(III) takes preferably place via polyethylene glycol (PEG) or glycerol as disclosed in WO2014/006196 or, alternatively, in an atmosphere containing less than 0,1% by volume of an oxidizing gas as disclosed in WO 2016074878A1.

[0025] All the above mentioned weight-% refer to the weight of the COPR.

Reductant component

[0026] In the present invention, essentially no reductant carbonaceous reductants selected from anthracite, char, coke and bituminous coal are present in step a). The term "essentially no" is to be understood in the context of this application as an amount of less than 3 weight-%, preferably less than 2 weight-% more preferably less than 1 weight-% and most preferably 0 weight-% (i.e. not used at all) based on the amount of chrome ore material, COPR and reductant components.

[0027] In a preferred embodiment essentially no overall carbonaceous reductants are present in step a). The term overall carbonaceous reductants refers to anthracite, char, coke and bituminous but also to all organic substances, which are capable of reducing the Fe- or Cr-oxides in the chrome ore material under the sintering conditions of step c).

[0028] In a further preferred embodiment, essentially no overall reductant components are present in step a). The term overall reductant components includes all inorganic and organic, preferably organic substances, which are capable of reducing the Fe- or Cr oxides in the chrome ore material under the sintering conditions of step c).

[0029] Typically, the amount of the reductants in the mixture obtained after the mixing in step a) or in the pellets obtained from step a) is not higher than the amount of reductant present in step a).

[0030] Anthracite contains preferably less than 1 weight-% of organic compounds. Such organic compounds preferably evaporate at temperatures above 70°C up to 1400°C in an inert atmosphere. These organic compounds are preferably saturated and unsaturated hydrocarbons.

[0031] The quantity of these organic compounds is determined by heating the reducing component in an inert atmosphere up to the target temperature and taking readings on the mass loss. This detected mass loss is subtracted from the mass loss found on heating the pellets in a second step, in order to calculate the degree of reduction.

The process

[0032] There are different ways known to the skilled person for mixing the chrome ore material, COPR and an optional reductant component before water addition in step a).

[0033] Preferably, the mixing is conducted by using a dry ball mill.

[0034] The solid components used in step a) are preferably milled. The milling can take place prior to the mixing in step a), during the mixing in step a) or after the mixing in step a).

[0035] Preferably, the chrome ore material, COPR and a reductant component are milled during mixing in step a).

[0036] Preferably, the mixture of the solids, obtained after the mixing of the chrome ore material, COPR and an optional reductant component in step a), comprises:

- 82 to 99,9 weight-%, particularly preferably 93 to 99,9 weight-% of chrome ore material,
- 0,1 to 15 weight-%, particularly preferably 0,1 to 5 weight-% of COPR, and
- 0 to <3 weight-%, particularly preferably 0 to 2 weight-%, most preferably 0 to 1 weight-% of carbonaceous reductants,

whereas the weight-% refers to the weight of the mixture obtained after the mixing of the chrome ore material, COPR and an optional reductant component in step a).

[0037] In an alternative embodiment, the mixture of the solids, obtained after the mixing of the chrome ore material, COPR and an optional reductant component in step a), comprises

- 82 to 99,9 weight-%, particularly preferably 93 to 99,9 weight-% of chrome ore material,
- 0,1 to 15 weight-%, particularly preferably 0,1 to 5 weight-% of COPR, and
- 0 to <3 weight-%, particularly preferably 0 to 2 weight-%, most preferably 0 to 1 weight-% of reductant components,

whereas the weight-% refer to the weight of the mixture obtained after the mixing of the chrome ore material, COPR and an optional reductant component in step a).

[0038] Preferably, the mixture obtained after the mixing of the chrome ore material, COPR and an optional reductant component in step a) provides a particle size distribution (d90) of 50 to 100 µm, particularly preferably of 65 to 85 µm. According to the invention, a d90 of 50 µm means that 90% by volume of the particles of the mixture have a particle size of 50 µm and below.

[0039] Preferably, the mixture obtained after the mixing of chrome ore material, COPR and an optional reductant component is further mixed with water. Thereby, the pelletization takes place. Optionally, palletization can be effected by pressing the mixture into the desired form.

[0040] The weight ratio of water to the sum of the components chrome ore material, COPR and a reductant component is preferably between 1:6 and 1: >100, particularly preferably between 1:8 and 1: >100, most preferably 1: 125.

[0041] The pelletization may take place in either a pan or drum pelletizing unit. Thereby, composite carbon containing (so called "green") ore pellets are obtained.

[0042] Preferably, the ore pellets obtained after step a) have a diameter of 4-30 mm, more preferably 8-20 mm, most preferably of 10-15 mm. For pellets with a non-spherical shape, the diameter of a sphere having the same volume as the non-spherical pellet shall be regarded to constitute the diameter of the non-spherical pellet.

[0043] Preferably, the silicon content of the ore pellets obtained after step a) is below 2,5 weight-%, particularly preferably below 2 weight-%, whereas the weight-% refer to the weight of the ore pellets obtained after step a).

[0044] Preferably, the ore pellets obtained after step a) do not crack when dropped from a height of up to 0,2 m, particularly preferably of up to 0,4 m, most preferably of up to 0,5 m, on a steel plate. The green wet ore pellets show, after drying in air, a density higher than pellets produced with a binder state-of-the-art.

Step b)

[0045] The ore pellets can be pre-dried under ambient conditions, preferably at a temperature of 18 to 30°C, for 4 to 40 hours, preferably for 12 to 30 hours, but this is optional.

[0046] The optional drying is done by heating the ore pellets under atmospheric conditions, preferably. Particularly preferably, the drying takes place at a temperature above 70°C, most preferably above 100°C. The time for the drying is preferably 2 to 50 hours, particularly preferably 6 to 30 hours, and can be performed in an oven.

Step c)

[0047] The calcining of the ore pellets obtained after step a) or step b), if step b) is performed, may be conducted in different ways known to the skilled person. This sinter process can be performed either under ambient gas atmosphere or under an atmosphere with reduced oxygen level compared to ambient atmosphere.

[0048] The heating unit is preferably a rotary kiln, a muffle furnace, a tube furnace or, preferably, a tunnel furnace.

[0049] In the heating unit, the wet or optionally dry, ore pellets obtained after step a) are exposed to temperatures of 1250°C to 1600°C, for periods of 1 minute to 8 hours, preferably of 1300°C to 1500°C for periods of 5 minutes to 5 hours.

[0050] Preferably, the inert atmosphere contains less than 0,1 vol-% of oxygen. Particularly preferably, the inert atmosphere is argon.

[0051] After heating, the ore pellets can be cooled down, preferably to a temperature of 18 to 25°C.

[0052] The pellets obtained after step c) are discharged, either via direct hot transfer to the smelting furnace or via controlled cooling of the calcined product, to yield cool, mechanically stable pellets.

[0053] In the calcined pellets obtained after step c) the Cr(VI) content is preferably <0,0001 weight-%.

[0054] The calcined pellets obtained after step c) provide increased mechanical stability compared to those obtained after step a).

[0055] The calcined pellets can be further stored or transported, e.g. to an electric submerged arc furnace for the preparation of Ferrochrome.

[0056] Preferably, the sintered pellets obtained after step c) have a cold crushing strength of at least 50kgf/pellet and an average of about 100kgf/pellet. This value is determined in consideration of DIN EN 993-5 (2018) by placing a pellet between two steel plates arranged in parallel. With an hydraulic system, the plates are constantly moved towards each other and the pellet in the gap is squeezed. The applied force is measured continuously. The measurement is stopped, as soon as the applied force decreases while the plates are still moving towards each other (pellet has cracked). The maximum force measured in the described setup is calculated as an applied weight in kgf. 1 kgf are equivalent to 9.806650 N. In the present examples, the cold crushing strength is given the as average of 100 pellets of same size. By the use of the sintered pellets obtained after step c) the electrical energy consumption for the complete reduction to iron metal and chrome metal in the arc furnace is reduced.

Iron- and chrome-containing pellets

[0057] The invention further provides iron- and chrome-containing pellets that contain:

- chrome: 25 to 36 weight-%, preferably 28 to 33 weight-%,
- iron: 14 to 24% weight-%, preferably 15 to 21 weight-%, and
- silicon: 0,4 to 2 weight-%, preferably 0,4 to 1 weight-%,

whereas the weight-% refer to the weight of the iron- and chrome- containing pellets, which have a density of >3,40 g/cm³, preferably >3,45g/cm³, more preferably >3,50 g/cm³.

[0058] Preferably, the iron- and chrome-containing pellets contain chrome as chrome(III)oxide (Cr₂O₃) and as chrome

metal, iron as iron(II) oxide (FeO) and iron(III) oxide (Fe₂O₃) and as iron metal, and silicon as silicon oxide (SiO₂).

[0059] The ratio of iron metal to iron(II,III) in the iron- and chrome-containing pellets is preferably <1:2, particularly preferably <1:10.

[0060] The ratio of chrome metal to chrome(III) in the iron- and chrome-containing pellets is preferably <1:2, particularly preferably <1:10.

[0061] The ratio of iron and chrome metal to iron(II,III) and chrome(III) in the iron- and chrome-containing pellets is preferably <1:2, particularly preferably <1:10.

[0062] In the iron- and chrome-containing pellets the Cr(VI) content is preferably <0,0001 weight-%. The iron- and chrome-containing pellets are particularly preferably free of Cr(VI).

[0063] Preferably, the iron- and chrome-containing pellets have a diameter of 6-13 mm.

[0064] Preferably, the iron- and chrome-containing pellets according to the invention are obtained by the process for preparing iron- and chrome-containing pellets according to the invention.

[0065] The invention further provides the use of iron- and chrome-containing pellets according to the invention for the preparation of Ferrochrome.

[0066] The invention further provides a process for the preparation of Ferrochrome by using iron- and chrome-containing pellets according to the invention.

[0067] The invention will be described in more detail in the following non-limiting example.

Example A:

[0068] 99,2 parts by weight of chrome ore material (milled in a dry ball mill process down to d₉₀=82μm, type: UG2 chemical grade, origin: Sibanya mine in Waterval Rustenburg, South Africa, moisture 8,7 % by weight), was mixed intensively with 0,8 parts by weight of COPR, received according to procedure described in WO2014/006196 and with less than 0,7 ppm of Cr(VI).

[0069] The material was placed in a pelletization disc and water was sprayed on the surface while the disc was turning to produce small pellets of about 3mm, which were screened out and used as seed pellets for the actual pelletizing process.

[0070] After the pelletizing process pellets with an diameter of above 11,2 mm were screened out and dried. The density of the dried pellets was determined using the displaced volume method.

[0071] Hereafter, the pellets were calcined in a chamber furnace. The temperature was increased rapidly (within few minutes) to 1400°C and hold for 10 minutes. The pellets were then left to cool down to ambient temperature. The density of the indurated pellets was determined on 200 pellets by the volume of displacement method. The cold crushing strength (CCS) was determined using 200 indurated pellets produced as above.

Comparative example according to ZA 2004-03429 A, state-of-the-art, Example B:

[0072] 99,2 parts by weight of chrome ore material (milled in a dry ball mill process to d₉₀=82μm, type: UG2 chemical grade, origin: Sibanya mine in Waterval Rustenburg, South Africa, moisture 8,7% by weight), was mixed intensively with 0,8 parts by weight of Bentonite MB100S (Supplier: LKAB Sweden, 52% SiO₂, 3% Na₂O, 1% K₂O, 0,4% S, contains 77% Montmorillonite and 6,4% of CaO and 10% of water, all % per weight).

[0073] The material was placed in a pelletization disc and water was sprayed on the surface while the disc was turning to produce small pellets of about 3mm, which were screened out and used as seed pellets for the actual pelletizing process.

[0074] After the pelletizing process pellets with an diameter of above 11,2 mm were screened out and dried. The density of the dried pellets was determined using the displaced volume method.

[0075] Hereafter, the pellets were calcined in a chamber furnace. The temperature was increased rapidly (within few minutes) to 1400°C and hold for 10 minutes. The pellets were then left to cool down to ambient temperature. The density of the indurated pellets was determined on 200 pellets by the volume of displacement method. The cold crushing strength (CCS) was determined using 200 indurated pellets produced as above.

[0076] The porosity was calculated using mass (m_{Pellets}), volume (V_{Pellets}) and density (ρ_{Pellets}) of the pellets, using the following formula:

$$Porosity = \frac{V_{pellet} - \frac{m_{pellet}}{\rho_{solid_material}}}{V_{pellet}} \cdot 100$$

Results:

Averaged density of dried pellets (volumetric displacement) / g/cm ³	
Example A	Example B (state-of-the-art)
3,30	3,09
Averaged density of sintered pellets (volumetric displacement) / g/cm ³	
Example A	Example B (state-of-the-art)
3,45	3,34
Averaged Porosity / vol-%	
Example A	Example B (state-of-the-art)
23,95	25,85
Averaged cold crushing strength / kgf/pellet	
Example A	Example B (state-of-the-art)
>120	>120

Claims

1. A process for preparing iron- and chrome-containing pellets comprising the steps:

- a) producing ore pellets comprising the mixing of chrome ore material, Chrome Ore Process Residue (COPR),
- b) optionally drying the ore pellets obtained after step a), and
- c) calcining the ore pellets,

wherein essentially no carbonaceous reductant components selected from anthracite, char, coke and bituminous coal are present in step a).

2. A process according to claim 1, wherein essentially no overall carbonaceous reductant components are present in step a).

3. A process according to claim 1 or 2, wherein the amount of overall reductant components present in step a) is less than 3 weight%, preferably less than 2 weight % more preferably less than 1 weight% and most preferably 0% based on the amount of chrome ore material, COPR and reductant components.

4. A process according to any of claims 1 to 3, wherein the COPR contains

- chrome(III) oxide: 7 to 13 weight-%, preferably 7,5 to 12,5 weight-%,
- aluminum oxide: 10 to 30 weight-%, preferably 18 to 24 weight-%,
- iron(II) oxide: 36 to 44 weight-%, preferably 37 to 42 weight-%,
- iron(III) oxide: >0,5% weight-%, preferably >2 weight-%,
- magnesium oxide: 9 to 18 weight-%, preferably 10 to 17 weight-%,
- calcium oxide: < 10 weight-%, preferably < 5 weight-%,
- silicon oxide: 0 to 3 weight-%, preferably 1 to 3 weight-%,
- vanadium oxide: < 1 weight-%, preferably < 0.5 weight-%,
- sodium oxide: 0 to 5 weight-%, preferably 2 to 5 weight-%, and
- sodium monochromate: 0 to 4,7 weight-%, preferably <0,0003 weight-%,

whereas the weight-% refer to the weight of the COPR.

5. A process according to any of claims 1 to 4, wherein the chrome ore material contains

- chrome(III)oxide: 26 to 54 weight-%, particularly preferably 40 to 45 weight-%,

- aluminum oxide: 10 to 30 weight-%, particularly preferably 13 to 18 weight-%,
- iron(II) oxide: 12 to 36 weight-%, particularly preferably 20 to 28 weight-%,
- magnesium oxide: 9 to 22 weight-%, particularly preferably 10 to 15 weight-%,
- calcium oxide: < 5 weight-%, particularly preferably < 1 weight-%, and
- silicon oxide: 1 to 18 weight-%, particularly preferably 2 to 5 weight-%,

whereas the weight-% refer to the weight of the chrome ore material.

6. A process according to any one of claims 1 to 5, wherein the Cr content in the COPR is 2 to 25 weight-%, preferably 5 to 9 weight-%, and the Fe content in the COPR is 28 to 35 weight-%, preferably 29 to 34 weight-%, whereas the weight-% refer to the weight of the COPR.
7. A process according to any one of claims 1 to 6, wherein the Cr(VI)_content of the COPR is 0,01 - 1 weight-%, preferably < 0,0001 weight-%.
8. A process according to any one of claims 1 to 7, wherein the calcining in step c) takes place at temperatures of 1250°C to 1600°C, for periods of 1 to 8 hours, preferably of 1300°C to 1500°C for periods of 2 to 5 hours.
9. A process according to any one of claims 1 to 8 wherein the calcining is carried out in an inert or reducing atmosphere.
10. Iron- and chrome-containing pellets containing:
 - chrome: 25 to 36 weight-%, preferably 28 to 33 weight-%,
 - iron: 14 to 24 weight-%, preferably 15 to 21 weight-%, and
 - silicon: 0,4 to 2 weight-%, preferably 0,4 to 1 weight-%,

whereas the weight-% refer to the weight of the iron- and *chrome-containing pellets*, and wherein the iron- and *chrome-containing pellets* which have a density of >3,40 g/cm³, preferably >3,45g/cm³, more preferably >3,50 g/cm³.

11. Iron- and chrome-containing pellets according to claim 10 having a cold crushing strength of at least 50kgf/pellet and an average of about 100kgf/pellet.
12. Iron- and chrome-containing pellets according to claim 10 or 11 wherein the ratio of iron and chrome metal to iron(II,III) and chrome(III) in the iron- and chrome-containing pellets is <1:2, preferably <1:10.
13. Iron- and chrome-containing pellets according to any of claims 10 to 13 obtained by the process according to any one of claims 1 to 9.
14. Use of iron- and chrome-containing pellets according to any of claims 10 to 13 for the preparation of Ferrochrome.
15. Process for the preparation of Ferrochrome by using iron- and chrome-containing pellets according to any one of claims 10 to 13.



EUROPEAN SEARCH REPORT

Application Number
EP 18 19 6811

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DWARAPUDI ET AL: "Development of Cold Bonded Chromite Pellets for Ferrochrome Production in Submerged Arc Furnace", ISIJ INTERNATIONAL,, vol. 53, no. 1, 1 January 2013 (2013-01-01), pages 9-17, XP002773408, DOI: 10.2355/ISIJINTERNATIONAL.53.9	1-9	INV. C22B1/24 C22B1/243 C22C35/00
A	* the whole document *	10-15	
X	TATHAVADKAR V D ET AL: "The soda-ash roasting of chromite minerals: Kinetics considerations", METALLURGICAL AND MATERIALS TRANSACTIONS B, SPRINGER-VERLAG, NEW YORK, vol. 32, no. 4, 1 August 2001 (2001-08-01), pages 593-602, XP019697245, ISSN: 1543-1916	1-3	
A	* the whole document *	4,6-15	
X	US 3 816 095 A (BRUEN C ET AL) 11 June 1974 (1974-06-11)	1-3	TECHNICAL FIELDS SEARCHED (IPC)
A	* the whole document *	4-15	C22B C22C
X	SINGH V ET AL: "Study the effect of chromite ore properties on pelletisation process", INTERNATIONAL JOURNAL OF MINERAL PROCESSING, ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, NL, vol. 88, no. 1-2, 1 August 2008 (2008-08-01), pages 13-17, XP023440242, ISSN: 0301-7516, DOI: 10.1016/J.MINPRO.2008.04.003 [retrieved on 2008-04-22]	10-15	
A	* the whole document *	1-9	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 13 February 2019	Examiner Juhart, Matjaz
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EUROPEAN SEARCH REPORT

Application Number
EP 18 19 6811

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2010/103343 A1 (TATA STEEL KZN PTY LTD [IN]; SEN RANJAN [IN]) 16 September 2010 (2010-09-16) * the whole document * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 13 February 2019	Examiner Juhart, Matjaz
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The members are as contained in the European Patent Office EDP file on
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13-02-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3816095 A	11-06-1974	NONE	
WO 2010103343 A1	16-09-2010	CN 102301016 A	28-12-2011
		FI 126945 B	31-08-2017
		WO 2010103343 A1	16-09-2010
		ZA 201104515 B	29-02-2012

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- ZA 200403429 A [0004] [0005]
- WO 2014006196 A [0024] [0068]
- WO 2016074878 A1 [0024]

Non-patent literature cited in the description

- *In Minerals Engineering*, 2012, vol. 34, 55-62 [0004]
- *Minerals Engineering*, 2012, vol. 34, 55-62 [0005]