(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 353 840 A1

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

(43) Date of publication:
17.04.2024 Bulletin 2024/16

(21) Application number: **22824549.4**

(22) Date of filing: **09.03.2022**

(51) International Patent Classification (IPC):
C21B 13/02 (2006.01) ***C22B 1/16*** (2006.01)

(52) Cooperative Patent Classification (CPC):
C21B 13/02; C22B 1/16

(86) International application number:
PCT/JP2022/010210

(87) International publication number:
WO 2022/264549 (22.12.2022 Gazette 2022/51)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **18.06.2021 JP 2021101337**

(71) Applicant: **JFE Steel Corporation**
Tokyo 100-0011 (JP)

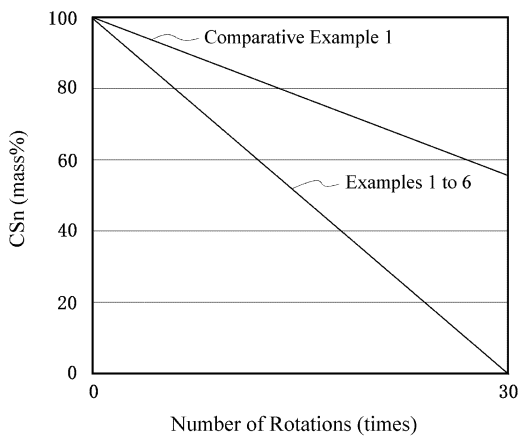
(72) Inventors:
- **MORITA, Yuya**
  Tokyo 100-0011 (JP)
- **HIGUCHI, Takahide**
  Tokyo 100-0011 (JP)
- **YAMAMOTO, Tetsuya**
  Tokyo 100-0011 (JP)
- **HIROSAWA, Toshiyuki**
  Tokyo 100-0011 (JP)
- **IWAMI, Yuji**
  Tokyo 100-0011 (JP)
- **HORITA, Kenya**
  Tokyo 100-0011 (JP)
- **FUJIWARA, Shohei**
  Tokyo 100-0011 (JP)
- **TAKEHARA, Kenta**
  Tokyo 100-0011 (JP)
- **IGAWA, Daisuke**
  Tokyo 100-0011 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) AGGLOMERATED ORE ASSESSING METHOD AND AGGLOMERATED ORE

(57) An agglomerated ore assessing method is provided that can assess clustering of reduced iron when it has been reduced at a high hydrogen concentration, with thermal compensation using blowing sensible heat taken into account. In this method, agglomerated ore is reduced while being subjected to a predetermined load at 1000°C to 1200°C, both inclusive, to produce a reduced aggregate; a tumble treatment is performed on the reduced aggregate using a tumble tester; cluster strength CS of the reduced aggregate calculated by Formula (1) below is measured; and a clustering property of the agglomerated ore is assessed using the cluster strength CS: CS = (W'/W) × 100 ··· (1), where CS is cluster strength (mass%); W is the mass (g) of a reduced aggregate that is equal to or larger than a maximum particle diameter of the agglomerated ore; and W' is the mass (g) of a reduced aggregate after a tumble treatment in the tumble tester that is equal to or larger than the maximum particle diameter of the agglomerated ore.

FIG. 1



EP 4 353 840 A1

Description

Technical Field

[0001] The present invention relates to an agglomerated ore assessing method for assessing clustering of agglomerated ore, and to agglomerated ore.

Background Art

[0002] Global warming due to increasing CO_2 has been widely taken up as an international issue, and reducing CO_2 emissions has become a challenge facing the entire world. Of about 1.9 billion tons of crude steel produced worldwide, about 1.4 billion tons are produced by a blast furnace-converter method. Because coal is used in the blast furnace-converter method, as large an amount of CO_2 as 2t-CO_2/t-Fe is emitted. The remaining 0.5 billion tons or so are produced by a method other than the blast furnace-converter method: a direct-reduction process. A shaft furnace solid reduction + electric furnace method represented by MIDREX ® that accounts for 60% or more of the direct-reduction process can reduce CO_2 emissions to about 1.1 to 1.2 t-CO_2/t-Fe. To reduce CO_2 emissions from the iron industry, it is necessary to shift from the blast furnace-converter method to the direct-reduction process, and further to increase the ratio of hydrogen reduction.

[0003] Raw materials used in the direct-reduction process tend to be of high iron grade compared with those in the blast furnace-converter method. In particular, for reduction in a shaft furnace, pellets of uniform particle size are used as the raw material to secure gas permeability inside the furnace. It is known that, when reduction progresses and the raw material descends down the furnace, clustering occurs in which reduced iron particles adhere to one another under the load of the raw material accumulated at a high-temperature area in front of a tuyere at a lower part of the shaft furnace. Occurrence of clustering is problematic because it prevents the reduced iron from being discharged from the shaft furnace. To prevent clustering, it is important to manage the properties of the raw material charged into the shaft furnace.

[0004] To what extent an agglomerated raw material adheres during reduction has been hitherto assessed by the MIDREX hot load test described in Non-Patent Literature 1. According to Non-Patent Literature 1, 2000 g of a sample is charged into a furnace, where it is reduced to a degree of reduction of 95% in an isothermal environment of 850°C with a gas composed of 45% H_2 + 30% CO + 15% CO_2 + 10% N_2 flowing at 40L/min. Sixty minutes after the start of reduction, a load of 147 kPa is applied to the surface of the charged bed of the sample. After cooling, a cluster formed during reduction is rotated ten times by a one-meter tumbler test machine, and then the ratio of particles 25 mm and over, which are defined as a cluster, is assessed as a cluster index.

Citation List

Non-Patent Literature

[0005]

Non-Patent Literature 1: L. Lu, J. Pan, D. Zhu, "Quality requirements of iron ore for iron production" Iron Ore, Elsevier Ltd., p.475-504

Non-Patent Literature 2: Dentaro Kaneko and two others, "Clustering Phenomena during Iron Oxide Reduction in Shaft Furnace" Tetsu-to-Hagané, the 64th year (1978), No. 6, p.681-690

Summary of Invention

Technical Problem

[0006] The cluster assessing method described in Non-Patent Literature 1, in which the gas contains CO and CO_2, cannot sufficiently assess the aggregability of a charged material when it has been reduced with pure hydrogen. This method may fail to assess disintegratability in the case where clustering of a material charged in a furnace is intensified as reduction is completed earlier and yields a larger amount of metallic iron due to a higher reaction rate of hydrogen reduction. When gas components include CO and CO_2, reduced iron becomes carburized and less prone to clustering (FIG. 6 of Non-Patent Literature 2). With clustering thus reduced, the conventional assessment method may fail to accurately assess a clustering phenomenon inside a hydrogen-reduction shaft furnace.

[0007] In reduction of iron oxide, CO reduction is an exothermal reaction, whereas H_2 reduction is an endothermal reaction. Therefore, when CO reduction is reduced and the ratio of H_2 reduction is increased, thermal compensation in the system becomes necessary. One possible way of this thermal compensation is to increase the blowing temperature and the blowing flow rate. In this case, in front of the tuyere, particles for which reduction has been completed would be present, and particles of which the particle temperature has been raised to near the temperature of the blown gas would be present. Thus, at the point of 95% reduction in the conventional method, clustering is less likely to occur due to the reduced particle temperature as a result of heat absorption during hydrogen reduction, and to the low test temperature of 850°C. For this reason, the conventional assessment method may fail to accurately assess clustering inside a hydrogen-reduction shaft furnace in the case where the ratio of H_2 reduction is high and thermal compensation is made using blowing sensible heat.

[0008] The present invention has been devised in view of these circumstances, and an object thereof is to provide an agglomerated ore assessing method that can assess clustering of reduced iron when it has been reduced at a high hydrogen concentration, with thermal compensation using blowing sensible heat taken into account, and to provide agglomerated ore based on this assessing method.

Solution to Problem

[0009] The present invention is an agglomerated ore assessing method characterized in that: agglomerated ore is reduced while being subjected to a predetermined load at 1000°C to 1200°C, both inclusive, to produce a reduced aggregate; a tumble treatment is performed on the reduced aggregate using a tumble tester; cluster strength CS of the reduced aggregate calculated by Formula (1) below is measured; and a clustering property of the agglomerated ore is assessed using the cluster strength CS:

$$CS = (W'/W) \times 100 \cdots (1),$$

where CS is cluster strength (mass%); W is the mass (g) of a reduced aggregate that is equal to or larger than a maximum particle diameter of the agglomerated ore; and W' is the mass (g) of a reduced aggregate after a tumble treatment in the tumble tester that is equal to or larger than the maximum particle diameter of the agglomerated ore.

[0010] In the agglomerated ore assessing method according to the present invention configured as described above, the following are considered to be more preferable solutions:

(1) that the reduced aggregate is produced using a reducing gas that does not contain a compound having a C atom; and
(2) that the reduced aggregate is produced using a reducing gas containing 70 vol% or more H_2.

[0011] Further, the present invention is agglomerated ore characterized in that cluster strength CS_{30} is 0 mass% as measured in the above-described agglomerated ore assessing method using the reduced aggregate having been reduced at 1000°C and a reduced aggregate after the tumble treatment obtained by rotating the reduced aggregate 30 times at 30 rpm.

[0012] In the agglomerated ore according to the present invention configured as described above, the following are considered to be more preferable solutions:

(1) that the particle diameter is 8 mm or larger;
(2) that the total Fe is 64.5 mass% or less; and
(3) that Formula (2) below is met:

$$Al_2O_3 + SiO_2 \geq 3.5 \text{ mass\%} \cdots (2),$$

where Al_2O_3 is the component concentration (mass%) of Al_2O_3 in the agglomerated ore, and SiO_2 is the component concentration (mass%) of SiO_2 in the agglomerated ore.

Advantageous Effects of Invention

[0013] According to the present invention configured as described above, an agglomerated ore assessing method can be obtained that assesses clustering at a higher temperature than the conventional method, and can thereby assess clustering of agglomerated ore taking into account thermal compensation that is made using blowing sensible heat in hydrogen reduction. Thus, it is possible to accurately assess clustering inside a shaft furnace and obtain agglomerated ore having favorable characteristics based on the assessment method of the present invention.

Brief Description of Drawing

[0014] FIG. 1 is a graph showing cluster strengths CS_0 (mass%) and CS_{30} (mass%) of Examples 1 to 6 and Comparative Example 1.

Description of Embodiment

[0015] An embodiment of the present invention will be specifically described below. The following embodiment illustrates a device and a method for embodying the technical idea of the present invention, and is not intended to restrict the configuration to the one described below. Thus, various changes can be made to the technical idea of the present invention within the technical scope described in the claims.

<Agglomerated Ore Assessing Method of Embodiment>

[0016] Regarding an agglomerated ore assessing method of this embodiment, a specific assessment method will be described below.

[0017] First, 500 g $\pm$ 5 g of an agglomerated ironmaking raw material (agglomerated ore) is put through a sieve to measure a particle size distribution and determine the maximum particle size of the agglomerated ore. Then, the agglomerated ore is placed in an N_2 atmosphere and heated to a temperature of 1000°C at 5°C/min. (This temperature is a predetermined temperature between 1000°C and 1200°C, which is 1000°C here.) Meanwhile, a load is gradually applied such that a load of 1 kg/cm^2 is applied when 1000°C is reached. Then, while a load of 1 kg/cm^2 is still applied at 1000°C, the gas is switched to an N_2-20 vol% H_2 gas, and the agglomerated ore is held for three hours with this gas flowing at a flow rate of 24 L/min. Then, the atmosphere is switched to an N_2 atmosphere and the agglomerated ore is cooled to room temperature. Thus, a reduced aggregate is produced.

[0018] Next, the reduced aggregate is sifted using a sieve with an opening size corresponding to the maximum particle diameter of the agglomerated ore before reduction, and the reduced aggregate on the sieve and the reduced aggregate under the sieve are weighed. Here, the mass of the reduced aggregate on the sieve is denoted by W(g). Then, the reduced aggregate on the sieve is transferred to an I-type tumble tester (132 mmφ × 700 mm) and rotated 30 times at 30 rpm. Then, the reduced aggregate taken out is put through the same sieve, and the reduced aggregate on the sieve and the reduced aggregate under the sieve are weighed. Here, the mass of the reduced aggregate on the sieve is denoted by W'_{30}(g). Thereafter, using the obtained W and W'_{30}, cluster strength CS_{30} (mass%) is measured from Formula (3) below:

$$CS_{30} = (W'_{30}/W) \times 100 \cdots (3)$$

[0019] The rpm and the number of times of rotation of the I-type tumble tester may be adjusted as necessary according to the impact applied to the sintered ore in the shaft furnace used for reduction. When cluster strength in the case where treatment is performed at the rpm and the number of times of rotation corresponding to the impact is denoted by CS, cluster strength CS (mass%) can be measured from Formula (1) below using the aforementioned W and the mass W' of the reduced aggregate on the sieve having undergone the tumble treatment in the I-type tumble tester:

$$CS = (W'/W) \times 100 \cdots (1)$$

[0020] Thus, producing a reduced aggregate at 1000°C to 1200°C, both inclusive, allows an accurate assessment of clustering in the case where hydrogen reduction is performed while thermal compensation using blowing sensible heat is made.

[0021] As mentioned above, when the gas components include a compound having a C atom, such as CO, CO_2, and methane, reduced iron becomes carburized and less prone to clustering. In the case of reduction using a reducing gas of which the gas concentration of a compound having a C atom is low and the H_2 concentration is increased, clustering cannot always be accurately assessed. In this embodiment, on the other hand, clustering is assessed using a reducing gas that is an N_2-20 vol% H_2 gas and does not contain a compound having a C atom. Thus, it is possible to accurately assess clustering in the case where a reducing gas that does not contain a compound having a C atom is used. Moreover, when such a reducing gas is used, as the number of types of gases used is fewer than in the conventional method, the assessment can be conducted in a simplified manner. From this viewpoint, in the agglomerated ore assessing method of this embodiment, it is preferable that a reduced aggregate be produced using a reducing gas that does not contain a compound having a C atom. Further, it is preferable that a reduced aggregate be produced using a reducing gas containing 70 vol% or more H_2. Thus, reduction of agglomerated ore using a reducing gas with the H_2 concentration increased to 70 vol% or more can be simulated to assess clustering in this reduction.

<Agglomerated Ore of Embodiment>

[0022] Agglomerated ore of this embodiment is characterized in that cluster strength CS_{30} measured by the above-described agglomerated ore assessing method according to the present invention is 0 mass%. When the cluster strength CS_{30} is 0 mass%, the agglomerated ore is found to have favorable disintegratability at high temperatures. Therefore, if this agglomerated ore is used to produce reduced iron in a shaft furnace etc., clustering can be appropriately reduced even when a reducing gas with an increased H_2 concentration is used.

[0023] In the agglomerated ore of this embodiment, it is preferable that the particle diameter of the agglomerated ore be 8 mm or larger. When the particle diameter is 8 mm or larger, the area of contact between the particles can be made smaller to further reduce clustering. Here, a particle diameter of 8 mm or larger means a particle diameter of agglomerated ore that remains on a sieve with a mesh size of 8 mm. It is preferable that total Fe in the agglomerated ore be 64.5 mass% or less. Here, the total Fe refers to the component concentration (mass%) of Fe contained in metal Fe and Fe compounds (iron oxide, calcium ferrite, iron sulfide, etc.). Using an ironmaking raw material in which the total Fe is 64.5 mass% or less can further reduce clustering. In addition, it is preferable that the agglomerated ore meet Formula (2) below:

$$Al_2O_3 + SiO_2 \geq 3.5 \text{ mass\%} \cdots (2),$$

where Al_2O_3 is the component concentration (mass%) of Al_2O_3 in the agglomerated ore, and SiO_2 is the component concentration (mass%) of SiO_2 in the agglomerated ore.

[0024] Clustering occurs as metallic iron particles bind to one another in a solid phase. When the component concentration of gangue components, such as Al_2O_3 and SiO_2, contained in the agglomerated ore increases, the iron concentration in the surfaces of reduced iron particles decreases, so that solid-phase binding of metallic iron particles is reduced and clustering is thereby reduced. Thus, agglomerated ore containing a large amount of gangue components that meets $Al_2O_3 + SiO_2 \geq 3.5$ mass% is reduced in clustering compared with conventional agglomerated ore in which $Al_2O_3 + SiO_2 < 3.5$ mass% applies, and is therefore preferably used to produce hydrogen-reduced iron.

Examples

[0025] Examples of the present invention will be described in detail below.

[0026] Agglomerated ores of Examples 1 to 6 and pellets of Comparative Example 1 were assessed for clustering in accordance with the above-described agglomerated ore assessing method. Table 1 below shows the sintering temperatures and the component compositions of the agglomerated ores of Examples 1 to 6 and the pellets of Comparative Example 1. As Comparative Example 1, pellets produced from a raw material that has been conventionally used was used.

Table 1

	Sintering temperature °C	Total Fe mass%	CaO/SiO_2 mass%	$SiO_2 + Al_2O_3$ mass%
Example 1	1150	63.94	0.38	5.84
Example 2	1250	64.12	0.37	5.87
Example 3	1350	64.00	0.37	5.82
Example 4	1150	63.40	0.75	5.72
Example 5	1250	63.45	0.76	5.72
Example 6	1350	63.47	0.77	5.68
Comparative Example 1	1350	65.22	0.27	2.72

[0027] For assessment of clustering, cluster strength CS_0 before the assessment and cluster strength CS_{30} after 30 rotations were obtained. CS_0, which is before the tumble treatment, is 100.0 mass%. The assessment result is shown in Table 2 below and Figure 1. The reduction temperatures and the reducing gas compositions are shown in Table 2 below.

[Table 2]

	Reduction temperature °C	Reducing gas composition (vol%)	CS_0 (mass%)	CS_{30} (mass%)
Example 1	1000	N_2-20%H_2	100.0	0
Example 2	1000	N_2-20%H_2	100.0	0
Example 3	1000	N_2-20%H_2	100.0	0
Example 4	1000	N_2-20%H_2	100.0	0
Example 5	1000	N_2-20%H_2	100.0	0
Example 6	1000	N_2-20%H_2	100.0	0
Comparative Example 1	1000	N_2-20%H_2	100.0	57.0

[0028] As shown in FIG. 1 and Table 2, compared with Comparative Example 1 in which cluster strength CS_{30} is as high as 57.0 mass%, all the agglomerated ores of Examples 1 to 6 that meet $Al_2O_3 + SiO_2 \geq 3.5$ mass% have cluster strength CS_{30} of 0 mass% and thus have proven to have favorable disintegratability. From this result, the agglomerated ores of Examples 1 to 6 that meet $Al_2O_3 + SiO_2 \geq 3.5$ mass% can be said to be agglomerated ores that are less prone to clustering, and these agglomerated ores have been confirmed to be preferably used for hydrogen reduction using a shaft furnace.

Industrial Applicability

[0029] The agglomerated ore assessing method of the present invention assesses clustering at a higher temperature than the conventional method, and can thereby assess clustering of agglomerated ore taking into account thermal compensation that is made using blowing sensible heat in hydrogen reduction, which makes the present invention industrially useful. Further, clustering inside a shaft furnace can be thus accurately assessed and agglomerated ore having favorable characteristics can be obtained based on the assessment method of the present invention, which also makes the present invention industrially useful.

Claims

1. An agglomerated ore assessing method **characterized in that**: agglomerated ore is reduced while being subjected to a predetermined load at 1000°C to 1200°C, both inclusive, to produce a reduced aggregate; a tumble treatment is performed on the reduced aggregate using a tumble tester; cluster strength CS of the reduced aggregate calculated by Formula (1) below is measured; and a clustering property of the agglomerated ore is assessed using the cluster strength CS:

$$CS = (W'/W) \times 100 \cdots (1),$$

where CS is cluster strength (mass%); W is the mass (g) of a reduced aggregate that is equal to or larger than a maximum particle diameter of the agglomerated ore; and W' is the mass (g) of a reduced aggregate after a tumble treatment in the tumble tester that is equal to or larger than the maximum particle diameter of the agglomerated ore.

2. The agglomerated ore assessing method according to claim 1, wherein the reduced aggregate is produced using a reducing gas that does not contain a compound having a C atom.

3. The agglomerated ore assessing method according to claim 1 or claim 2, wherein the reduced aggregate is produced using a reducing gas containing 70 vol% or more H_2.

4. Agglomerated ore **characterized in that** cluster strength CS_{30} is 0 mass% as measured in the agglomerated ore assessing method according to any one of claim 1 to claim 3 using the reduced aggregate having been reduced at

1000°C and a reduced aggregate after the tumble treatment obtained by rotating the reduced aggregate 30 times at 30 rpm.

5. The agglomerated ore according to claim 4, wherein a particle diameter is 8 mm or larger.

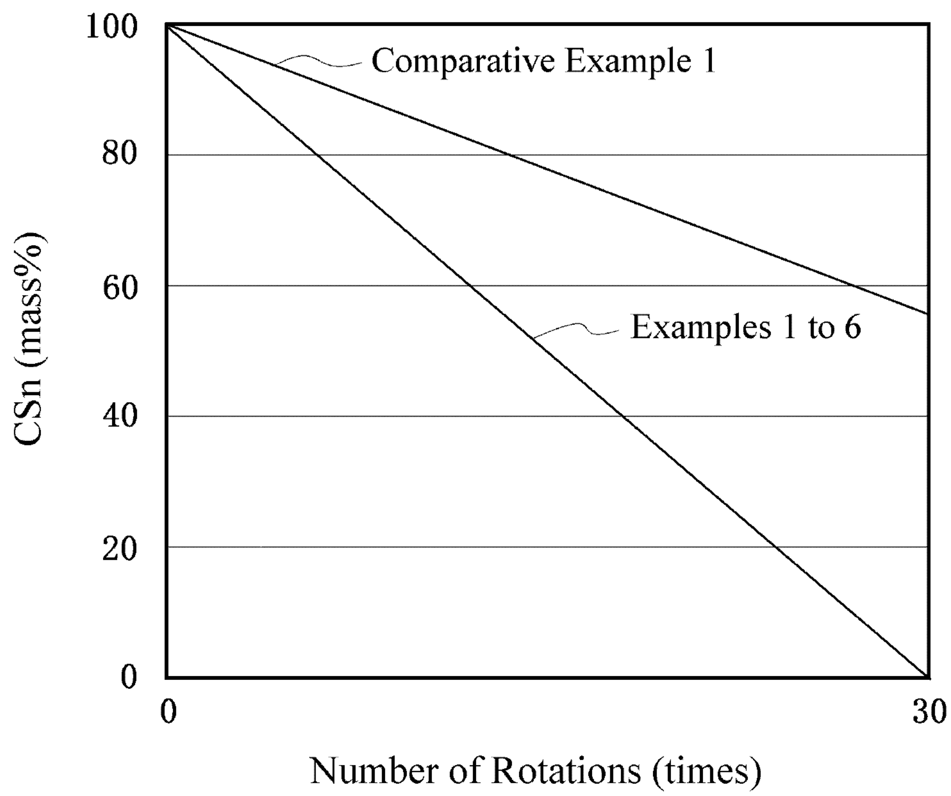
6. The agglomerated ore according to claim 4 or claim 5, wherein total Fe is 64.5 mass% or less.

7. The agglomerated ore according to any one of claim 4 to claim 6, wherein Formula (2) below is met:

$$Al_2O_3 + SiO_2 \geq 3.5 \text{ mass\%} \cdots (2),$$

where Al_2O_3 is a component concentration (mass%) of Al_2O_3 in the agglomerated ore, and SiO_2 is a component concentration (mass%) of SiO_2 in the agglomerated ore.

FIG. 1


100
80
60
40
20
0
CSn (mass%)
Comparative Example 1
Examples 1 to 6
0
30
Number of Rotations (times)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/010210

A. CLASSIFICATION OF SUBJECT MATTER

C21B 13/02(2006.01)i; ***C22B 1/16***(2006.01)i
FI: C22B1/16 Q; C21B13/02

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)

C21B13/02; C22B1/16

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018/0320246 A1 (SABIC GLOBAL TECHNOLOGIES B.V.) 08 November 2018 (2018-11-08) paragraphs [0056], [0069], [0112]-[0120]	1-7
A	WO 2015/016145 A1 (NIPPON STEEL & SUMITOMO METAL CORPORATION) 05 February 2015 (2015-02-05) paragraphs [0044], [0048]-[0052], [0055]	1-7
A	JP 2014-37575 A (NIPPON STEEL & SUMITOMO METAL CORPORATION) 27 February 2014 (2014-02-27) paragraphs [0029]-[0035], fig. 5	1-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 April 2022	**17 May 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/010210

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2018/0320246 A1	08 November 2018	WO 2017/068446 A1	
		WO 2017/068445 A1	
		CN 108474060 A	
WO 2015/016145 A1	05 February 2015	US 2016/0153061 A1 paragraphs [0057], [0060]-[0064], table 2	
		US 2020/0224285 A1	
		CN 105492633 A	
		MX 2016000953 A	
		RU 2016101528 A	
JP 2014-37575 A	27 February 2014	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- Quality requirements of iron ore for iron production. **L. LU ; J. PAN ; D. ZHU.** Iron Ore. Elsevier Ltd, 475-504 **[0005]**
- **DENTARO KANEKO.** Clustering Phenomena during Iron Oxide Reduction in Shaft Furnace. *Tetsu-to-Hagané, the 64th year,* 1978, vol. 6, 681-690 **[0005]**