



(11) **EP 3 712 281 A1**

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

(43) Date of publication:
23.09.2020 Bulletin 2020/39

(21) Application number: **18879916.7**

(22) Date of filing: **04.07.2018**

(51) Int Cl.:
C21B 5/00 (2006.01) **C21B 7/24** (2006.01)
C21B 7/16 (2006.01) **F27B 1/26** (2006.01)
F27B 1/28 (2006.01) **F27D 21/00** (2006.01)
F27D 19/00 (2006.01)

(86) International application number:
PCT/KR2018/007588

(87) International publication number:
WO 2019/098484 (23.05.2019 Gazette 2019/21)

(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: **14.11.2017 KR 20170151770**

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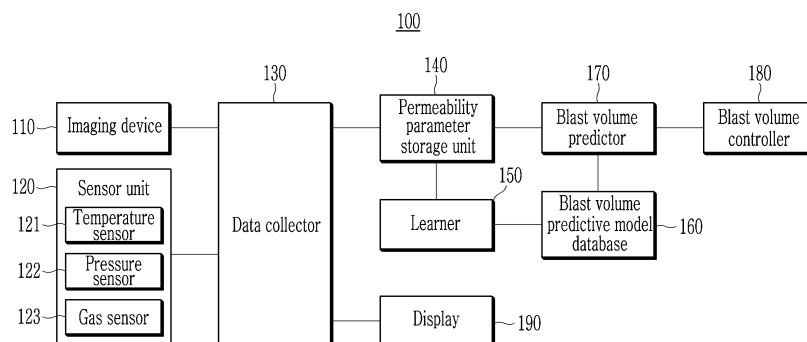
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(54) **BLAST CONTROL DEVICE FOR BLAST FURNACE AND METHOD THEREFOR**

(57) A device for controlling a blast in a blast furnace includes: an imaging device for capturing an image of a charging material charged into the blast furnace; at least one sensor for measuring a condition of the blast furnace; a data collector for obtaining particle size data of the charging material from the image; a blast volume predic-

tor for obtaining a blast volume predictive value of the blast furnace from the particle size data; and a blast volume controller for controlling a hot-blast volume supplied into the blast furnace according to the blast volume predictive value.

FIG. 2



Description**[Technical Field]**

[0001] An exemplary embodiment of the present invention relates to a device for controlling a blast in a blast furnace and a method thereof.

[Background Art]

[0002] In a blast furnace, pig iron is manufactured by reducing natural iron ore by use of a carbon monoxide produced in reaction of coke that is a fuel and oxygen. From among various operational factors for indicating an inner furnace condition of a blast furnace in a blast furnace process (referred to as a condition of a blast furnace hereinafter), permeability that represents a gas flowing degree in the furnace is one of very important factors for determining efficiency and safety of a blast furnace operation.

[0003] The blast furnace operation is performed when a reduction gas rises in the furnace to contact the charged iron ore, and the iron ore having received heat according to a contact with the reduction gas is fused and reduced into pig iron. During the above-noted process, thermal energy and the reduction gas needed in fusion and reduction of iron ore are supplied by a hot blast supplied through a lower portion of the furnace, and for the purpose of stabilizing the condition of the blast furnace, it is very important to appropriately control an amount of the hot blast input through the lower portion, that is, a blast volume.

[0004] The blast volume supplied into the furnace is controlled according to the permeability in the furnace. Conventionally, as the blast volume supplied into the furnace increases, the volume of pig iron produced in the blast furnace increases, but there may be a stabilization drawback when the blast volume increases while the permeability in the furnace is not good. Therefore, an operator decreases the blast volume so as to stabilize the operation when permeability in the furnace is bad, and increases the blast volume so as to increase operation efficiency when the permeability is good.

[0005] Particle sizes and particle size distribution of raw material (sintered ore, pellets, sized lumps, etc.) fuels (cokes) charged through an upper portion of the blast furnace determine porosity of a charging layer, which is a very important factor for determining permeability at the upper portion in the furnace.

[0006] In prior art, so as to confirm the particle sizes and the particle size distribution of the charging material charged into the blast furnace, a method for the operator to gather specimens and measure the same three to four times a day is used. However, the confirmation method has a limit in understanding in detail a physical description of the charging material because of a lack of data and a limit of representation of data.

[0007] The above information disclosed in this Back-

ground section is only for enhancement of understanding of the background of the invention, and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

[Disclosure]**[Technical Problem]**

[0008] The present invention has been made in an effort to provide a device for controlling a blast for confirming a particle size and a particle size distribution of a charging material charged into a furnace in real time and controlling a hot-blast volume supplied therein, and a method thereof.

[Technical Solution]

[0009] An exemplary embodiment of the present invention provides a device for controlling a blast in a blast furnace, including: an imaging device for capturing an image of a charging material charged into the blast furnace; a data collector for obtaining particle size data of the charging material from the image; a blast volume predictor for obtaining a blast volume predictive value of the blast furnace from the particle size data; and a blast volume controller for controlling a hot-blast volume supplied into the blast furnace according to the blast volume predictive value.

[0010] The data collector may obtain the particle size and the particle size distribution of the charging material according to an image analysis of the image.

[0011] The device may further include at least one sensor for obtaining at least one piece of sensing data for indicating permeability of the blast furnace, wherein the blast volume predictor may obtain the blast volume predictive value by using the particle size data and the at least one piece of sensing data.

[0012] The at least one sensor may include: a pressure sensor for measuring a pressure in the blast furnace; a temperature sensor for measuring a temperature in the blast furnace; or a gas sensor for measuring a gas component discharged from the blast furnace.

[0013] The device may further include a blast volume predictive model database for storing a blast volume predictive model for estimating a blast volume of the blast furnace, wherein the blast volume predictor obtains the blast volume predictive value by using the particle size data and the at least one piece of sensing data as input data of the blast volume predictive model.

[0014] When the particle size data that are time-series data and the at least one piece of sensing data are input, the blast volume predictive model may output the blast volume predictive value corresponding to the particle size data and the at least one piece of sensing data.

[0015] The blast volume predictive model may be based on a neural network algorithm.

[0016] The blast volume controller may control the hot-blast volume by controlling an opened or closed degree of a blast valve between a hot stove and the blast furnace.

[0017] Another embodiment of the present invention provides a method for controlling a blast in a blast furnace, including: capturing an image of a charging material charged into the blast furnace through a camera; obtaining particle size data of the charging material from the image; obtaining a blast volume predictive value of the blast furnace from the particle size data; and controlling a hot-blast volume supplied into the blast furnace according to the blast volume predictive value.

[0018] The obtaining of particle size data may include obtaining a particle size and a particle size distribution of the charging material according to an image analysis on the image.

[0019] The method may further include obtaining at least one piece of sensing data for indicating permeability of the blast furnace through at least one sensor, wherein the obtaining of a blast volume predictive value may include obtaining the blast volume predictive value by using the particle size data and the at least one piece of sensing data.

[0020] The at least one piece of sensing data may include a pressure in the blast furnace, a temperature in the blast furnace, or a gas component discharged from the blast furnace.

[0021] The obtaining of a blast volume predictive value may include obtaining the blast volume predictive value by using the particle size data and the at least one piece of sensing data as input data of a blast volume predictive model for estimating a blast volume of the blast furnace.

[0022] The controlling of a hot-blast volume may include controlling the hot-blast volume by controlling an opened or closed degree of a blast valve between a hot stove and the blast furnace.

[Advantageous Effects]

[0023] According to the exemplary embodiment of the present invention, the change of the condition of the blast furnace may be minimized, the blast furnace operation may be stabilized, and efficiency may be increased by confirming the particle size and the particle size distribution of the charging material charged into the furnace and accordingly controlling the blast volume.

[Description of the Drawings]

[0024]

FIG. 1 shows an example of blast furnace equipment.

FIG. 2 shows a device for controlling a blast in a blast furnace according to an exemplary embodiment of the present invention.

FIG. 3 shows a method for controlling a blast in a blast furnace according to an exemplary embodi-

ment of the present invention.

[Mode for Invention]

[0025] The present invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention.

[0026] The drawings and description are to be regarded as illustrative in nature and not restrictive, and like reference numerals designate like elements throughout the specification.

[0027] Throughout this specification and the claims that follow, when it is described that an element is "coupled" to another element, the element may be "directly coupled" to the other element or "electrically coupled" to the other element through a third element.

[0028] A device for controlling a blast in a blast furnace and a method thereof will now be described with reference to accompanying drawings.

[0029] FIG. 1 shows an example of blast furnace equipment.

[0030] The blast furnace equipment is for generating pig iron in a steel process.

[0031] Referring to FIG. 1, the blast furnace 10 is a furnace into which an iron ore that is a raw material is charged and is fused and reduced to pig iron.

[0032] A burden hopper 11 for storing a raw material or fuel charged through a charging conveyor belt 5 is positioned at an upper portion of the blast furnace 10. The raw material or the fuel stored in the burden hopper 11 is charged into the blast furnace 10 according to a burden charging process.

[0033] A blast port 12 for inputting a hot blast supplied by a hot stove 20 into the blast furnace 10 is positioned on a lower portion of the blast furnace 10. An inflow amount of the hot blast supplied by the hot stove 20 into the blast furnace 10 (referred to as a blast volume hereinafter) is controlled according to an opened or closed degree of the blast valve 21.

[0034] The fuel (e.g., cokes) input into the blast furnace 10 is combusted in reaction with oxygen to generate high-temperature gas (referred to as reduction gas hereinafter). The reduction gas rises in the furnace to contact the iron ore charged into the blast furnace 10. The iron ore having received heat according to the contact with the high-temperature reduction gas in the furnace is fused and reduced into pig iron.

[0035] The pig iron fused and reduced in the blast furnace 10 is stored at a lower portion of the furnace, and it is then discharged to the outside of the furnace through a tap hole at regular intervals.

[0036] FIG. 2 shows a device for controlling blast in a blast furnace according to an exemplary embodiment of the present invention.

[0037] Referring to FIG. 2, the device 100 for controlling a blast according to an exemplary embodiment of the present invention may include an imaging device 110, a sensor unit 120, a data collector 130, a permeability parameter storage unit 140, a learner 150, a blast volume predictive model database 160, a blast volume predictor 170, a blast volume controller 180, and a display 190.

[0038] The imaging device 110 may be installed on a charging conveyor belt 5, and may photograph the raw material (sintered ore, pellets, sized lumps, etc.) or the fuel (coke, etc.) charged into the blast furnace 10 by use of the charging conveyor belt 5. The image photographed by the imaging device 110 is used to obtain particle size data (particle sizes and particle size distribution) of the charging material (fuel or raw material). Therefore, a high-quality camera may be used as the imaging device 110 so as to enable obtainment of the particle size and the particle size distribution of the charging material from the image on the charging material.

[0039] The sensor unit 120 may include at least one sensor for measuring factors (e.g., a pressure, a temperature, an exhaust gas component, etc.) for determining permeability inside the blast furnace 10.

[0040] The sensor unit 120 may include a temperature sensor 121 for measuring a temperature inside the blast furnace 10. The temperature sensor 121 may be attached to the inside of the blast furnace 10, and it may also be positioned outside the blast furnace 10 to measure the temperature when the pig iron discharged from the blast furnace 10 is tapped. In the latter case, the temperature inside the blast furnace 10 may be estimated from the temperature of the pig iron.

[0041] The sensor unit 120 may include a pressure sensor 122 for measuring the pressure inside the blast furnace 10.

[0042] The sensor unit 120 may also include a gas sensor 123 for detecting a component of an exhaust gas (blast furnace gas) discharged by the blast furnace 10.

[0043] The data collector 130 may obtain particle size data (particle sizes and particle size distribution) on the charging material charged to the blast furnace 10 through the charging conveyor belt 5 according to real-time image analysis of the image of the charging material obtained by the imaging device 110. Further, the data collector 130 may obtain sensing data (a temperature, a pressure, an exhaust gas component, etc.) measured by the sensor unit 120 as a permeability parameter. The permeability parameters (particle size data and sensing data) obtained in this way may be stored in the permeability parameter storage unit 140 as time-series data. They may also be displayed on a blast furnace operating screen through the display 190 so that an operator may confirm a situation in the blast furnace 10 in real time.

[0044] The learner 150 may learn the permeability parameter (particle size data, sensing data) collected by the data collector 130 as learning data for a predetermined time, and may generate a neural-network-algorithm-based blast volume predictive model. The learner

150 may make a neural network learn by using collected permeability parameters and blast volume control values proposed by an expert as neural network algorithm learning data, and may produce a blast volume predictive model for predicting the blast volume based on present permeability parameters from learning results. Here, the neural network algorithm used in the learning may be configured with a neural network with a plurality of layers. The blast volume predictive model produced by the learner 150 is stored in the blast volume predictive model database 160 and is used for the blast volume predictor 170 to predict the blast volume.

[0045] The blast volume predictor 170 may estimate the blast volume of a charging layer inside the blast furnace 10 from the permeability parameters that are time-series data by using a neural-network-algorithm-based blast volume predictive model. The blast volume predictor 170 may input the permeability parameters collected by the data collector 130 as time-series input data of the blast volume predictive model, and may obtain an output value of the blast volume predictive model as a corresponding blast volume predictive value.

[0046] The blast volume controller 180 may determine an amount of the hot blast, that is, the blast volume, supplied into the blast furnace 10 based on the blast volume predictive value output by the blast volume predictor 170, and may control an opened or closed degree of the blast valve 21, thereby controlling the blast volume input into the blast furnace 10.

[0047] Regarding the above-configured blast control device 100, functions of the data collector 130, the learner 150, the blast volume predictor 170, and the blast volume controller 180 may be performed by a processor realized with at least one central processing unit (CPU), other chipsets, or a microprocessor.

[0048] FIG. 3 shows a method for controlling a blast in a blast furnace according to an exemplary embodiment of the present invention.

[0049] Referring to FIG. 3, the device 100 for controlling a blast according to an exemplary embodiment of the present invention photographs the charging conveyor belt 5 by using the imaging device 110 to thus capture an image of the charging material (a raw material or fuel) moved to the blast furnace 10 (S100). Particle size data on the charging material are obtained by image analysis of the obtained charging material image (S110).

[0050] The device 100 for controlling a blast obtains sensing data indicating permeability inside the blast furnace 10 through at least one of sensors 121, 122, and 123 (S120).

[0051] The particle size data and the sensing data obtained through the step S110 and the step S120 are stored in the permeability parameter storage unit 140 as permeability parameters.

[0052] The device 100 for controlling a blast continuously obtains the permeability parameters through the step S110 and the step S120, and uses the same as time-series input data of the neural network algorithm

based blast volume predictive model to obtain the predictive value of the blast volume in the blast furnace 10 (S130). The device 100 for controlling a blast controls the blast volume supplied into the blast furnace 10 by controlling the opened or closed degree of the blast valve 21 based on the obtained blast volume predictive value (S140).

[0053] According to the above-described example, the device 100 for controlling a blast supports confirmation of the particle size and the particle size distribution of the charging material charged into the blast furnace 10 in real time. The device 100 for controlling a blast supports automatic control of the blast volume according to the condition of the blast furnace by providing a predictive model for predicting the blast volume according to the present condition of the blast furnace through learning. Therefore, the device 100 for controlling a blast may control the blast volume in real-time reaction to the condition of the blast furnace, thereby minimizing changes of the condition of the blast furnace and resultantly stabilizing an operation of the blast furnace and increasing efficiency.

[0054] The method for controlling a blast according to an exemplary embodiment of the present invention may be performed by using software. When performed through software, configurational tools for the present invention are code segments for performing necessary tasks. The program or the code segments may be stored in a computer-readable recording medium.

[0055] Computer-readable recording media include all types of recording apparatuses in which data readable by a computer system are stored. Examples of the computer-readable recording devices include a ROM, a RAM, a CD-ROM, a DVD_ROM, a DVD_RAM, a magnetic tape, a floppy disk, a hard disk drive, and an optical data storage device. Further, the computer-readable recording media may be distributed to a computer device connected by a network, and computer-readable codes may be stored and performed in a distributed fashion.

[0056] The accompanying drawings and the exemplary embodiments of the present invention are only examples of the present invention, and are used to describe the present invention but do not limit the scope of the present invention as defined by the following claims. Therefore, those having ordinary skill in the art will appreciate that various modifications or changes and other equivalent embodiments are possible from the exemplary embodiments. Further, a person of ordinary skill in the art can omit some of the constituent elements described in the specification without deterioration of performance, or can add constituent elements for better performance. In addition, a person of ordinary skill in the art can change the specifications depending on the process conditions or equipment. Hence, the range of the present invention is to be determined by the claims and equivalents.

<Description of Symbols>

[0057]

5	5:	charging conveyor belt
	10:	blast furnace
	20:	hot stove
	21:	blast valve
	100:	blast control device
10	110:	imaging device
	120:	sensor unit
	121:	temperature sensor
	122:	pressure sensor
	123:	gas sensor
15	130:	data collector
	140:	permeability parameter storage unit
	150:	learner
	160:	blast volume predictive model database
	170:	blast volume predictor
20	180:	blast volume controller
	190:	display

Claims

- 25 1. A device for controlling a blast in a blast furnace, comprising:
 - 30 an imaging device for capturing an image of a charging material charged into the blast furnace;
 - a data collector for obtaining particle size data of the charging material from the image;
 - 35 a blast volume predictor for obtaining a blast volume predictive value of the blast furnace from the particle size data; and
 - a blast volume controller for controlling a hot-blast volume supplied into the blast furnace according to the blast volume predictive value.
- 40 2. The device according to claim 1, wherein the data collector obtains the particle size and the particle size distribution of the charging material according to an image analysis of the image.
- 45 3. The device according to claim 1, further comprising at least one sensor for obtaining at least one piece of sensing data for indicating permeability of the blast furnace,
 - 50 wherein the blast volume predictor obtains the blast volume predictive value by using the particle size data and the at least one piece of sensing data.
- 55 4. The device according to claim 3, wherein the at least one sensor includes:
 - a pressure sensor for measuring a pressure in the blast furnace;
 - a temperature sensor for measuring a temper-

- ature in the blast furnace; or
a gas sensor for measuring a gas component discharged from the blast furnace.
5. The device according to claim 3, further comprising a blast volume predictive model database for storing a blast volume predictive model for estimating a blast volume of the blast furnace, wherein the blast volume predictor obtains the blast volume predictive value by using the particle size data and the at least one piece of sensing data as input data of the blast volume predictive model. 5
 6. The device according to claim 5, wherein when the particle size data that are time-series data and the at least one piece of sensing data are input, the blast volume predictive model outputs the blast volume predictive value corresponding to the particle size data and the at least one piece of sensing data. 10
 7. The device according to claim 6, wherein the blast volume predictive model is based on a neural network algorithm. 15
 8. The device according to claim 1, wherein the blast volume controller controls the hot-blast volume by controlling an opened or closed degree of a blast valve between a hot stove and the blast furnace. 20
 9. A method for controlling a blast in a blast furnace, comprising: 25
 - capturing an image of a charging material charged into the blast furnace through a camera; 35
 - obtaining particle size data of the charging material from the image;
 - obtaining a blast volume predictive value of the blast furnace from the particle size data; and
 - controlling a hot-blast volume supplied into the blast furnace according to the blast volume predictive value. 40
 10. The method according to claim 9, wherein the obtaining of particle size data includes obtaining a particle size and a particle size distribution of the charging material according to an image analysis on the image. 45
 11. The method according to claim 9, further comprising obtaining at least one piece of sensing data for indicating permeability of the blast furnace through at least one sensor, wherein the obtaining of a blast volume predictive value includes obtaining the blast volume predictive value by using the particle size data and the at least one piece of sensing data. 50
 12. The method according to claim 11, wherein the at least one piece of sensing data include a pressure in the blast furnace, a temperature in the blast furnace, or a gas component discharged from the blast furnace. 55
 13. The method according to claim 11, wherein the obtaining of a blast volume predictive value includes obtaining the blast volume predictive value by using the particle size data and the at least one piece of sensing data as input data of a blast volume predictive model for estimating a blast volume of the blast furnace.
 14. The method according to claim 13, wherein when the particle size data that are time-series data and the at least one piece of sensing data are input, the blast volume predictive model outputs the blast volume predictive value corresponding to the particle size data and the at least one piece of sensing data.
 15. The method according to claim 14, wherein the blast volume predictive model is based on a neural network algorithm.
 16. The method according to claim 9, wherein the controlling of a hot-blast volume includes controlling the hot-blast volume by controlling an opened or closed degree of a blast valve between a hot stove and the blast furnace.

FIG. 1

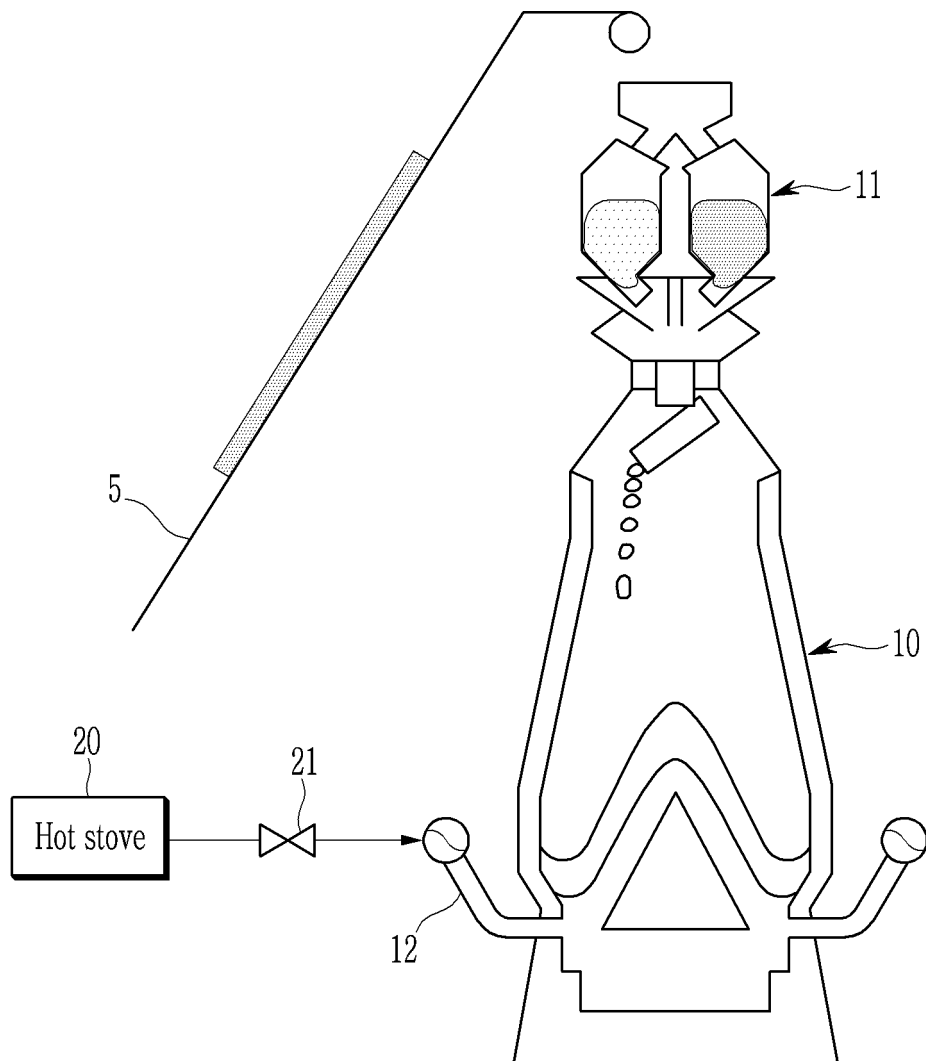


FIG. 2

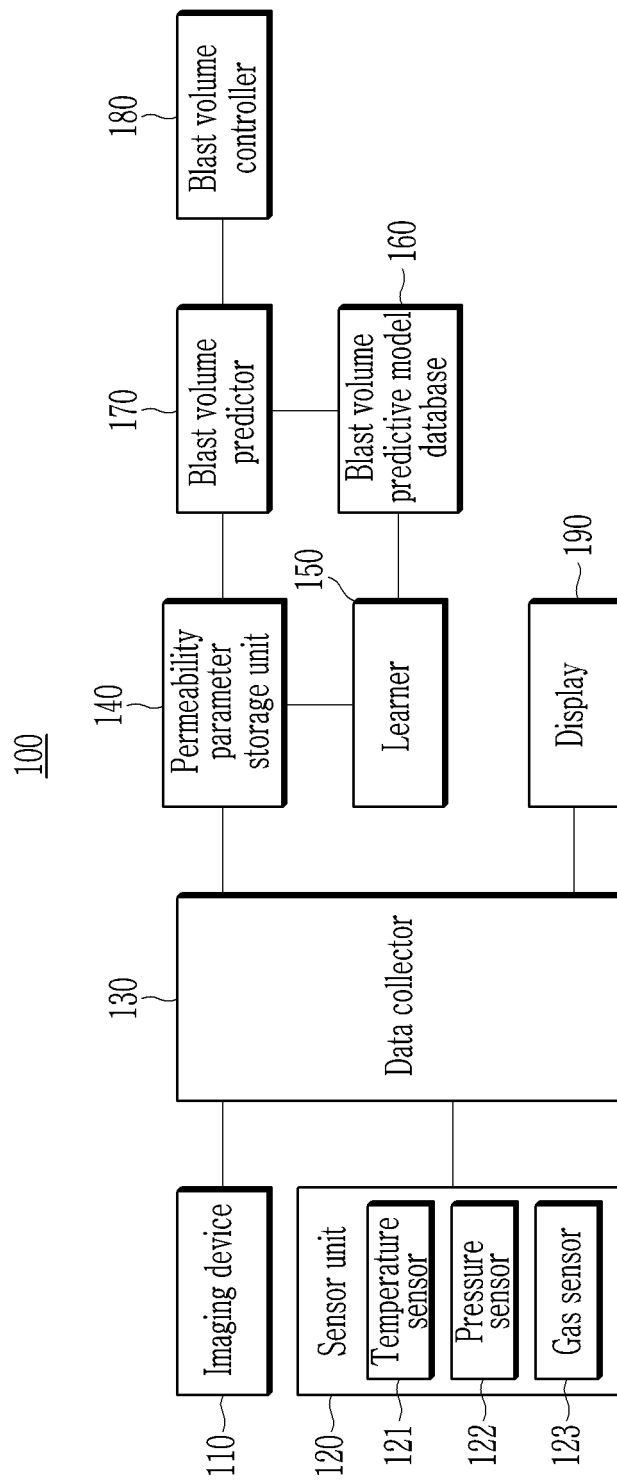
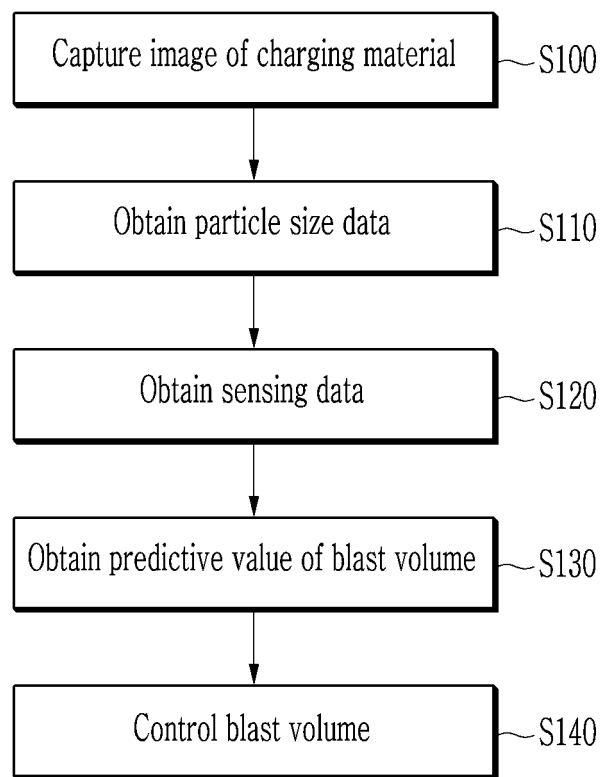


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2018/007588

A. CLASSIFICATION OF SUBJECT MATTER

C21B 7/24(2006.01)i, C21B 7/16(2006.01)i

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)

C21B 7/24; C21B 5/00; C21B 9/00; G01M 99/00; C21B 7/16

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

Korean Utility models and applications for Utility models: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: charging material, image, camera, particle size, permeability and air blow rate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2013-0013653 A (HYUNDAI STEEL COMPANY) 06 February 2013 See paragraphs [0016]-[0056]; claim 1; and figures 1-2.	1-4,8-12,16
A		5-7,13-15
Y	JP 6044536 B2 (JFE STEEL CORP.) 14 December 2016 See paragraphs [0010]-[0014] and figure 1.	1-4,8-12,16
Y	KR 10-1466499 B1 (HYUNDAI STEEL COMPANY) 28 November 2014 See paragraph [0023] and figure 2.	3,4,11,12
A	JP 2008-163381 A (NIPPON STEEL CORP.) 17 July 2008 See claim 1 and figure 1.	1-16
A	KR 10-2011-0071310 A (POSCO) 29 June 2011 See claim 1 and figure 2.	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

24 OCTOBER 2018 (24.10.2018)

Date of mailing of the international search report

24 OCTOBER 2018 (24.10.2018)

Name and mailing address of the ISA/KR

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EP 3 712 281 A1

INTERNATIONAL SEARCH REPORT Information on patent family members

International application No.

PCT/KR2018/007588

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