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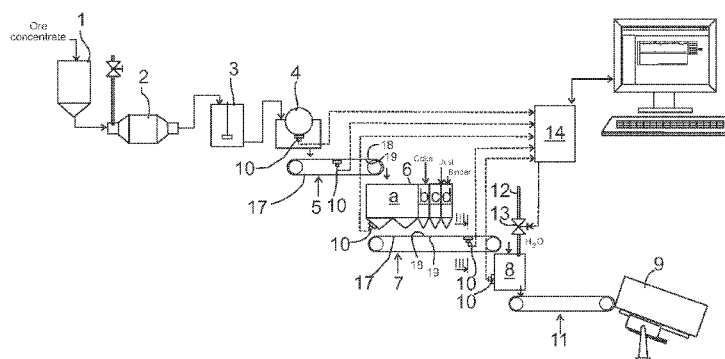


Fig. 1

(57) **Abstract:** A method and equipment for preparing ore concentrate for pelletizing. The method comprises a) feeding the concentrate to a grinder (2); b) grinding the concentrate in a grinder (2) together with an amount of water, if needed, and possibly added additives to obtain a mixture; c) mixing the mixture in a slurry mixer (3); d) filtering the mixture in a filter (4); e) conveying the mixture on a first conveyor (5) from the filter (4) to a buffer bin (6a); f) buffer storing the mixture in the buffer bin (6a); g) conveying the mixture on a second conveyor (7) while adding additives from additive bins (6b, c, d), to a mixer (8); h) mixing the mixture and the additives in the mixer (8); i) if needed, feeding an amount of water to the mixer (8); j) transferring the mixture to a pelletizing device (9); and k) pelletizing the mixture in a pelletizing device (9) to form green pellets. The moisture content of the mixture is continuously measured by an online measurement method with sensors (10) during at least one of the method steps d) to j), and the amount of water to be fed into the mixer (8) in the mixing step h) is continuously regulated by a control unit (14) on the basis of said measured moisture content value to ensure that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or strength.

METHOD AND EQUIPMENT FOR PREPARING ORE CONCENTRATE FOR PELLETIZING

FIELD OF THE INVENTION

5 The present invention relates to a method and equipment for preparing ore concentrate for pelletizing.

BACKGROUND OF THE INVENTION

10 In prior art there is known, e.g. from publication WO2012/172174 A1, a method and equipment for preparing ore concentrate for pelletizing. The raw material is obtained from a mine. The ore concentrate is stored and initially fed to the process from a concentrate bin. Typically at this stage the ore concentrate has
15 moisture content more than 1 w-%. In the method the concentrate is fed from a concentrate bin to a grinder. In the grinder the concentrate is ground to a predetermined grain size together with an amount of water and possibly added additives to obtain a mixture
20 thereof. The mixture is mixed in a slurry mixer. Thereafter the mixture is led to a filter for filtering the mixture to form a dewatered mixture. From the filter the dewatered mixture is then conveyed on a first conveyor to a buffer bin wherein the mixture is
25 buffer stored. From the buffer bin the mixture is conveyed to a mixer on a second conveyor while adding additives from additive bins. In the mixer the mixture and the additives are mixed. If needed, an amount of water is fed to the mixer. The water is fed to the
30 mixer via a pipeline having a control valve by which the amount of water to be fed can be regulated. A transfer means transfers the mixture from the mixer to a pelletizing device wherein the mixture is pelletized to form green pellets for subsequent indurating which
35 can be made by a sintering/indurating process.

In the pelletizing device, the type of which can be a rotating drum or table, the green pellets are formed gradually by a snow-ball effect wherein the concentrate particles are bound together by the moisture residing between the particles holding them together. The size and strength of the green pellets mainly depends on the grain size and the moisture content of the mixture from which the green pellets are formed of. The grain size is normally adjusted to constant in the grinder. Thereafter the pellet size can only be regulated by regulating the moisture content of the mixture. If the moisture content of the mixture is too low, the green pellets are not formed properly or their size is too small. If the moisture content of the mixture is too high, the size of the green pellets will be too large. It is known that the optimal moisture content to obtain an optimal pellet size and strength for example for chromite concentrate mixture before pelletizing is 9 - 10 w-% by which the optimal pellet diameter about 12 mm can be obtained.

Conventionally the method of regulating the moisture content of the mixture before pelletizing is based on manual sampling of the mixture and measurement of the moisture content of the sample is performed in a laboratory. A sample has been taken from the same place from the pelletizing feed. The amount of water to be fed to the mixer has been regulated on the basis of these results obtained in the laboratory analysis. The interval between consecutive samplings has typically been two hours and the laboratory analysis takes several minutes. The long response time for regulating the moisture content of the mixture causes problems and the moisture content of the mixture in the process can vary substantially within such a period before adjustment of the moisture content can take place. Manual sampling may lead to unreliable measurement results

due to dynamic nature of the process, long sampling intervals, disturbances and other failure. Sampled moisture data always includes some random variation, inaccuracy and errors that cannot be eliminated from the results. Manual sampling and laboratory analysis also requires costly human work input and working time of the process operators.

OBJECTIVE OF THE INVENTION

The objective of the invention is to alleviate the disadvantages mentioned above.

In particular, it is an objective of the present invention to provide a method and equipment by which the measurement of the moisture content can be made continuously and the measurement results can be immediately used to continuously regulate the moisture content of the mixture to ensure that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or strength.

SUMMARY OF THE INVENTION

According to a first aspect, the present invention provides a method for preparing ore concentrate for pelletizing, the method comprising

- a) feeding the concentrate from a concentrate bin to a grinder,
- b) grinding the concentrate in the grinder to a predetermined grain size together with an amount of water, if needed, and possibly added additives to obtain a mixture,
- c) mixing the mixture in a slurry mixer,
- d) filtering the mixture in a filter to form a dewatered mixture,
- e) conveying the dewatered mixture on a first conveyor from the filter to a buffer bin,

f) buffer storing the mixture in the buffer bin,

g) conveying the mixture from the buffer bin on a second conveyor to a mixer while adding additives
5 from additive bins,

h) mixing the mixture and the additives in the mixer,

i) if needed, feeding an amount of water to the mixer,

10 j) transferring the mixture from the mixer to a pelletizing device, and

k) pelletizing the mixture in a pelletizing device to form green pellets for subsequent indurating or sintering.

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According to the invention, in the method, the moisture content of the mixture is continuously measured by an online measurement method during at least one of said method steps d) to j), and the amount of water to
20 be fed into the mixer (8) in the mixing step h) is continuously regulated on the basis of said measured moisture content value to ensure that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or
25 strength.

The moisture content to be measured includes the water on the surface of the concentrate particles and between the particles, hygroscopic water, capillary water,
30 ter, pore water and added water. In fact, measurement of the moisture content means measuring of the content of residual water and added water.

According to a second aspect, the present invention
35 provides an equipment to prepare ore concentrate for pelletizing, the equipment comprising

- a concentrate bin for feeding the concentrate,
- a grinder to receive the concentrate from the concentrate bin and for grinding the concentrate to a predetermined grain size together with an amount of water, if needed, and possibly added additives to a mixture,
- a slurry mixer to receive the mixture from the grinder for mixing the mixture,
- a filter to receive the mixture from the slurry mixer for filtering the mixture to a dewatered mixture,
- a first conveyor to receive the dewatered mixture from the filter for conveying,
- a buffer bin to receive the mixture from the first conveyor for buffer storing of the mixture,
- additive bins to store and feed additives,
- a second conveyor to receive the mixture from the buffer bin and additives from additive bins for conveying the mixture and additives,
- a mixer to receive the mixture and additives from the second conveyor for mixing,
- a first pipeline for feeding water to the mixer,
- a first control valve in the first pipeline for regulating of the amount of water to be fed to the mixer,
- a transfer means to receive the mixture from the mixer for transferring, and
- a pelletizing device to receive the mixture from the transfer device for pelletizing the mixture to green pellets.

According to the invention the equipment comprises one or more online moisture content sensors arranged to measure moisture content of the mixture, said sensor being disposed in connection with one or more of

the devices including the filter, the first conveyor, the buffer bin, the second conveyor, the mixer and/or the transfer means; and a control unit arranged to continuously control the first control valve to regulate the amount of water to be fed to the mixer on the basis of the moisture content measurement results obtained from the one or more online moisture content sensors to ensure that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or strength.

The invention has many advantages. The process for preparing ore concentrate for pelletizing can be monitored online and adjusted in real time. The measurement of the moisture content can be made continuously and the measurement results can be immediately used as a feedback to continuously regulate the moisture content of the mixture to ensure that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or strength. The response time to control the process is remarkably shortened. Proper moisture control further produces significant cost savings; for instance pelletizing (agglomeration) process becomes more stable and thus good green pellet quality is secured. In addition, process operator will have more time for performing other tasks when moisture content is controlled automatically. Manual sampling can be reduced or even avoided.

In an embodiment of the method, the moisture content of the concentrate is measured in at least one of the method steps a) to b), and that the an amount of water to be fed to the grinder is regulated continuously on the basis of said measured moisture content value.

In an embodiment of the method, the moisture content of the concentrate and/or the mixture is measured by a high-frequency capacitive measurement method.

- 5 In an embodiment of the method, the moisture content of the concentrate and/or the mixture is measured by a non-contact high-frequency capacitive measurement sensor which has no direct contact to the material subject to measurement.

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- In an embodiment of the method, the amount of water to be fed into the mixer in the mixing step h) is calculated by the difference between the measured moisture content value and a target value known to produce optimal size and/or strength for the green pellets.
- 15

- In an embodiment of the method, if the measured moisture content value is smaller than the predetermined target value, a calculated amount of water is fed into the mixer in the mixing step h), and if the measured moisture content value is the same or greater than the predetermined target value, no water is fed into the mixer in the mixing step g).
- 20

- 25 In an embodiment of the method, the moisture content of the concentrate is measured with a moisture content sensor placed in and/or after the filter.

- In an embodiment of the method, the filtration effect of the filter is regulated on the basis of said measured moisture content value.
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- In an embodiment of the method, the moisture content of the mixture is measured during conveying the concentrate on the conveyor.
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In an embodiment of the method, the first conveyor and/or the second conveyor being a belt conveyor having a moving belt on which the mixture is placed as a material bed the moisture content of the material bed
5 lying on the belt is measured in a contact or non-contact manner by a high-frequency capacitive measurement sensor which is placed above or underneath the moving belt.

10 In an embodiment of the method, a high-frequency capacitive measurement sensor being placed above the moving belt, the sensor is arranged to direct constant contact with the upper surface of the material bed.

15 In an embodiment of the method, the high-frequency capacitive measurement sensor being placed underneath the moving belt, the sensor is arranged to direct constant contact with the underside of the moving belt.

20 In an embodiment of the method, the moisture content of the mixture is measured while storing the concentrate in the intermediate bin.

In an embodiment of the method, the moisture content
25 of the mixture is measured in at least one measurement point located after the mixing step h) and before the pelletizing step k).

In an embodiment of the method, the moisture content
30 of the mixture is measured during the transferring step j).

In an embodiment of the method, an additional amount of water is fed to the mixture just before feeding the
35 mixture to the pelletizing device or directly to the pelletizing device if the measured moisture content value of the mixture is below the target value, and

the amount of additional water to be fed is regulated on the basis of said moisture content value of the mixture measured in said at least one measurement point located after the mixing step h) and before the pelletizing step k).

In an embodiment of the method, in the transferring step j) the moisture content of the mixture is measured during conveying the concentrate on a third conveyor.

In an embodiment of the method, the third conveyor is a belt conveyor having a moving belt on which the mixture is placed as a material bed; and the moisture content of the material bed lying on the belt is measured in a contact or non-contact manner by a high-frequency capacitive measurement sensor which is placed above or underneath the moving belt.

In an embodiment of the method, a high-frequency capacitive measurement sensor being placed above the moving belt, the sensor is arranged to direct constant contact with the upper surface of the material bed.

In an embodiment of the method, the high-frequency capacitive measurement sensor being placed underneath the moving belt, the sensor is arranged to direct constant contact with the underside of the moving belt.

In an embodiment of the method, the type of grinder in the grinding step b) being a ball mill, the amount of grinding media to be fed into the ball mill is regulated on the basis of the moisture measured in at least one of the method steps a) to b).

In an embodiment of the method, the ore concentrate is chromite or iron or manganese or ilmenite or nickel or niobium concentrate or any combination thereof.

- 5 In an embodiment of the equipment, the equipment comprises a second pipeline for feeding water to the grinder and a second control valve in the second pipeline for regulating of the amount of water to be fed to the grinder; that a moisture content sensor is disposed in the concentrate bin and/or in the grinder;
10 and that the control unit is arranged to continuously control the second control valve to regulate the amount of water to be fed to the grinder on the basis of the moisture content measurement results obtained
15 from said moisture content sensor disposed in the concentrate bin and/or in the grinder.

In an embodiment of the equipment, the first conveyor and/or the second conveyor is a belt conveyor including an endless moving belt having an upper side on
20 which the mixture is lying as a material bed and an underside.

In an embodiment of the equipment, the transfer device
25 is a third belt conveyor arranged between the mixer and the pelletizing device, said third belt conveyor having a moving belt having an upper side on which the mixture is lying as a material bed and an underside.

30 In an embodiment of the equipment, the equipment comprises a third pipeline for spraying water onto the mixture bed travelling on the third belt conveyor at a water spraying point, and a third control valve in the third pipeline for regulating of the amount of water;
35 and a moisture content sensor is disposed before and/or after said water spraying point; and that the control unit to control the first third control valve

to regulate the amount of water to be fed to the mixture bed.

In an embodiment of the equipment, the equipment comprises a fourth pipeline for feeding water to the pelletizing device, and a fourth control valve in the second pipeline for regulating of the amount of water to be fed to the pelletizing device; and that the control unit is arranged to continuously control the fourth control valve to regulate the amount of water to be fed into the pelletizing device on the basis of the moisture content measurement results obtained from a moisture content sensor disposed to measure the moisture content of the mixture bed travelling on the moving belt of the third belt conveyor.

In an embodiment of the equipment, the moisture content sensor is arranged to direct constant contact with the upper surface of the material bed travelling on the upper side of the moving belt.

In an embodiment of the equipment, the moisture content sensor is placed underneath the moving belt, and that the sensor is arranged to direct constant contact with the underside of the moving belt.

In an embodiment of the equipment, the moisture content sensor is a high-frequency capacitive measurement sensor which senses the dielectricity of the concentrate and/or mixture subject to measurement, and that the control unit is arranged to calculate the moisture content on the basis of the measured dielectricity.

In an embodiment of the equipment, the control unit is arranged to calculate the amount of water to be fed to the grinder and/or to the mixer and/or to the mixture material bed on the third conveyor and/or to the

pelletizing device by the difference between the measured moisture content and a target value, said target value being known to produce an optimal size or strength for the green pellets.

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In an embodiment of the equipment, the control unit is arranged to adjust the filtration effect of the filter for controlling the moisture content of the filtration cake on the basis of the moisture content value measured by said one or more moisture content sensors.

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In an embodiment of the equipment, the type of grinder is a ball mill, and that the control unit is arranged regulate the amount of grinding media to be fed into the ball mill on the basis of the moisture measured in the concentrate bin and/or in the ball mill.

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In an embodiment of the equipment, the equipment comprises

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- a mounting frame arranged below the moving belt, to which frame the moisture content sensor is mounted, and

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- an adjustment means for adjusting the height position of the sensor in relation to the moving belt and for pressing the sensor against the underside of the moving belt for non-contact measurement of the moisture content of the mixture travelling on the upper side of the moving belt.

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In an embodiment of the equipment, the equipment comprises a mechanical level control device, such as a ski, a scraper, a plough or like, which is disposed at a height above the moving belt and upstream in relation to the moisture content sensor to control the thickness of least the part of the material bed which passes the moisture content sensor.

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In an embodiment of the equipment, a moisture content sensor is connected to the mechanical level control device and arranged to direct contact with the upper surface of the mixture bed travelling on the moving
5 belt.

It is to be understood that the aspects and embodiments of the invention described above may be used in any combination with each other. Several of the as-
10 pects and embodiments may be combined together to form a further embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and constitute a part of this specification, illustrate embodiments of the invention and together with the description help to explain the principles of the invention. In the drawings:

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Figure 1 shows a schematic flow chart of a process and process equipment of a first embodiment of the invention for preparing ore concentrate for pelletizing,

25 Figure 2 shows a a schematic flow chart of a process and process equipment of a second embodiment of the invention for preparing ore concentrate for pelletizing

30 Figure 3 is a cross-section III - III of the second conveyor of the equipment of Figure 1,

Figure 4 is a cross-section IV - IV of Figure 3,

35 Figure 5 shows a first alternative embodiment for the embodiment of Figure 3,

Figure 6 shows a cross-section VI - VI of Figure 5,

Figure 7 shows a second alternative embodiment for the embodiment of Figure 3, and

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Figure 8 shows a cross-section VIII - VIII of Figure 7.

DETAILED DESCRIPTION OF THE INVENTION

10 Referring to Figure 1, the raw material is obtained from a mine. The raw material, coarse ore concentrate, is stored and initially fed to the process from a concentrate bin 1. The equipment and method is suitable for any ore concentrate such as chromite or iron or
15 manganese or ilmenite or nickel or niobium concentrate or any combination thereof.

The equipment further comprises a wet or dry grinder 2 for grinding the coarse ore concentrate to a suitable grain size. Dry grinder is a grinder which is more
20 closely disclosed in WO2012/172174 A1. The grinder 2 receives the concentrate from the concentrate bin 1 and grinds the concentrate to a predetermined grain size together with an amount of water and possibly
25 added additives to a mixture. The grinder 2 may be a ball mill, whereto the material to be ground is fed together with the addition of water if the grinder is a wet grinder. A ball mill 2 is a rotating drum which is partially filled with the material to be ground and
30 grinding medium. Different materials are used as grinding media, including ceramic balls, flint pebbles and steel balls. As the drum rotates the grinding media rise with the aid of centrifugal force along with the inner surface of the drum and eventually fall on
35 the material to be ground. Various factors, like the size of the grinding media and the rotation speed of the drum, affect to the degree of grinding.

The grinder 2 is followed by a slurry mixer 3 which is arranged to mix the slurry discharged from the grinder 2.

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The mixture mixed in the slurry mixer 3 is then led to a filter 4, which can be a pressure filter or a capillary-effect ceramic disc filter. The filter 4 is arranged to dewater the mixture by filtering to form a dewatered mixture.

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From the filter 4 the mixture is conveyed by a first conveyor 5 to a buffer bin 6a. Also other additives, solid fuel (coke fine which acts as a fuel in the subsequent sintering/indurating process), process dust and binding agent are stored in additive bins 6 b, c, d. The mixture from the buffer bin 6a and additives from the additive bins 6 b, c, d are distributed onto a second conveyor 7 which conveys these materials to a mixer 8.

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The mixer 8 mixes the mixture with solid fuel, process dust and binder to form a homogenous mixture of these.

An amount of water is added, if needed, via a first pipeline 12 and regulated by a control valve 13 into the mixer 8 to ensure that the mixture has predetermined moisture content for pelletizing.

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A third belt conveyor 11 receives the mixture from the mixer 8 for transferring it to a pelletizing device 9 for pelletizing the mixture to green pellets.

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One or more online moisture content sensors 10 are arranged to measure moisture content of the mixture. The sensor 10 or sensors 10 is/are disposed in connection with one or more of the devices including the filter

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4, the first conveyor 5, the buffer bin 6a, the second conveyor 7, and/or the mixer 8. The equipment comprises a control unit 14. The control unit 14 is arranged to continuously control the first control valve 13 to regulate the amount of water to be fed to the mixer 8 on the basis of the moisture content measurement results obtained from the one or more online moisture content sensors 10. The control unit 14 calculates the amount of water to be fed into the mixer 8 by the difference between the measured moisture content value and a target value known to produce optimal size and/or strength for the green pellets. If the measured moisture content value is smaller than the predetermined target value, the control unit 14 controls the first control valve 13 to feed a calculated amount of water into the mixer 8. If the measured moisture content value is the same or greater than predetermined target value, the control unit 14 shuts off the first control valve 13, so that no water is fed into the mixer 8. This ensures that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or strength.

Although Figure 1 shows an embodiment which is shown to include all the above-mentioned moisture content sensors 10, it should be understood that less or more sensors 10 (but at least one sensor 10) may be used in other embodiments.

The moisture content of the mixture is continuously measured by an online measurement method during

- during or after filtering the mixture in a filter 4 to form a dewatered mixture, and/or
- during or after conveying the dewatered mixture on a first conveyor 5 from the filter 4 to a buffer bin 6a, and/or

- during or after buffer storing the mixture in the buffer bin 6a, and/or

- during or after conveying the mixture from the buffer bin 6a on a second conveyor 7 while adding
5 additives from additive bins 6b,c, d, to a mixer 8, and/or

- during mixing the mixture and the additives in the mixer (8). The amount of water to be fed into the mixer 8 via the first pipeline 12 during mixing in
10 the mixer 8 is continuously regulated on the basis of said measured moisture content. This is to ensure that the mixture has a predetermined moisture content to produce green pellets having a predetermined pellet size and/or strength.

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The first conveyor 5 and the second conveyor 7 are belt conveyors including an endless moving belt 17 having an upper side 18 on which the mixture is lying as a material bed and an underside 19. Also the transfer device 11 between the mixer 8 and the pelletizing
20 device 9 is a third belt conveyor 11. The third belt conveyor 11 also has a moving belt 17 having an upper side 18 on which the mixture is lying as a material bed and an underside 19. The arrangement of moisture
25 content sensors 10 in connection with the belt conveyors is more closely disclosed in connection with Figures 3 - 9.

Figure 2 shows a further modification of the equipment
30 shown in Figure 1 having the common features as disclosed in connection with Figure 1.

Referring to Figure 2, it shows that the moisture content of the concentrate can be measured during feeding
35 the concentrate from a concentrate bin 1 to a grinder 2, and/or during grinding the concentrate in the grinder 2, and that the an amount of water to be fed

to the grinder 2 can be regulated continuously on the basis of said measured moisture content value. For this purpose the equipment comprises a second pipeline 15 for feeding water to the grinder 2 and a second control valve 16 in the second pipeline for regulating of the amount of water to be fed to the grinder 2. One or more moisture content sensors 10 are disposed in the concentrate bin 1 and/or in the grinder 2. The control unit 14 is arranged to continuously control the second control valve 16 to regulate the amount of water to be fed to the grinder 2 on the basis of the moisture content measurement results obtained from said moisture content sensor 10 disposed in the concentrate bin 1 and/or in the grinder 2.

Figure 2 also schematically shows that the filtration effect of the filter 4 can be regulated by the control unit 14 on the basis of a moisture content value measured by a moisture content sensor 10 arranged in or after the filter 4.

Further, Figure 2 shows that the equipment may comprise a third pipeline 20 for spraying water onto the mixture bed travelling on the third belt conveyor 11 at a water spraying point, and a third control valve 21 in the third pipeline for regulating of the amount of water. The moisture content sensor 10 is disposed before and after said water spraying point. Then control unit 14 controls the first third control valve 21 to regulate the amount of water to be fed to the mixture bed.

Further Figure 2 shows that the equipment may comprise a fourth pipeline 22 for feeding water to the pelletizing device 9. A fourth control valve 23 is in the second pipeline 22 for regulating of the amount of water to be fed to the pelletizing device 9, The con-

trol unit 14 is arranged to continuously control the fourth control valve 23 to regulate the amount of water to be fed into the pelletizing device 9 on the basis of the moisture content measurement results obtained from a moisture content sensor 10 disposed to measure the moisture content of the mixture bed travelling on the moving belt 17 of the third belt conveyor 11.

10 The type of grinder 2 being a ball mill, the control unit 14 may also regulate the amount of grinding media to be fed into the ball mill on the basis of the moisture measured in the concentrate bin 1 and/or in the ball mill 2. By this way also the grain size of the concentrate may be adjusted.

The additional moisture content measuring sensors 10 arranged in the concentrate bin 1, in the grinder 2 and in connection with the third belt conveyor 11 may be used separately in different embodiments or in combination in one embodiment. Likewise the additional water feeding to the grinder 2, on the third belt conveyor 11 or into the pelletizing drum 9 may be used separately in different embodiments or in combination in one embodiment.

Figures 3 to 6 show two alternative embodiments of arranging the moisture content sensor 10 in connection with a conveyor belt when the sensor 10 is placed underneath the moving belt 17 of the conveyor. The sensor 10 is arranged to direct constant contact with the underside 19 of the moving belt 17. The moving belt 17 is typically an endless loop of rubber belt. This kind of arrangement wherein the sensor 10 is out of contact to the mixture to be measured is especially advantageous when the particles in the material to be measured are very hard, sharp-edged and abrasive, like in

the case of chromite concentrate. In this kind of case the moisture content sensor 10 cannot be arranged to direct constant contact with the material bed travelling on the moving belt since the particles tend to adhere rapidly to the sensor 10 and the mechanical level control device 26. The abrasive material also causes rapid wear of the sensor head.

The moisture content sensor 10 is preferably a high-frequency capacitive measurement sensor which senses the dielectricity of the concentrate and/or mixture subject to measurement. In that case the control unit 14 is arranged to calculate the moisture content on the basis of the measured dielectricity. A mounting frame 24 is arranged below the moving belt 17. The high-frequency capacitive measurement sensor 10 is mounted to the frame 24. An adjustment means 25 is arranged for adjusting the height position of the sensor 10 in relation to the moving belt 17 and for pressing the sensor 10 against the underside 19 of the moving belt for non-contact measurement of the moisture content of the mixture travelling on the upper side 18 of the moving belt. A mechanical level control device 26, such as a ski, a scraper, a plough or like, is disposed at a height above the moving belt 17 and upstream in relation to the moisture content sensor 10 to control the thickness s of at least the part of the material bed which passes the moisture content sensor 10.

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In Figures 3 and 4 the adjustment means 25 is mechanical and implemented with springs to produce the pressing effect.

35 In figures 5 and 6 desired action of the adjustment means 25 is implemented with a parallelogram and a hydraulic cylinder.

Figures 8 and 9 show that the moisture content sensor 10 may be arranged to direct constant contact with the upper surface of the material bed travelling on the upper side 18 of the moving belt 17. A mechanical level control device 26, such as a ski, a scraper, a plough or like, is disposed at a height above the moving belt 17 and upstream in relation to the moisture content sensor 10 to control the thickness of least the part of the material bed which passes the moisture content sensor 10. The moisture content sensor 10 is connected to the mechanical level control device 26, such as a ski, arranged to direct contact with the upper surface of the mixture bed travelling on the moving belt 17.

Although the invention has been described in conjunction with a certain type of process equipment, it should be understood that the invention is not limited to any certain type of process equipment. While the present invention has been described in connection with a number of exemplary embodiments, and implementations, the present inventions are not so limited, but rather cover various modifications, and equivalent arrangements, which fall within the purview of prospective claims.

CLAIMS

1. A method for preparing ore concentrate for pelletizing, the method comprising
- 5 a) feeding the concentrate from a concentrate bin (1) to a grinder (2),
- b) grinding the concentrate in the grinder (2) to a predetermined grain size together with an amount of water, if needed, and possibly added additives to obtain a mixture,
- 10 c) mixing the mixture in a slurry mixer (3),
- d) filtering the mixture in a filter (4) to form a dewatered mixture,
- e) conveying the dewatered mixture on a first
- 15 conveyor (5) from the filter (4) to a buffer bin (6a),
- f) buffer storing the mixture in the buffer bin (6a),
- g) conveying the mixture from the buffer bin (6a) on a second conveyor (7) while adding additives
- 20 from additive bins (6b,c, d), to a mixer (8),
- h) mixing the mixture and the additives in the mixer (8),
- i) if needed, feeding an amount of water to the mixer (8),
- 25 j) transferring the mixture from the mixer to a pelletizing device (9), and
- k) pelletizing the mixture in a pelletizing device (9) to form green pellets, characterized in that the moisture content of the mixture is
- 30 continuously measured by an online measurement method during at least one of said method steps d) to j), and the amount of water to be fed into the mixer (8) in the mixing step h) is continuously regulated on the basis of said measured moisture content value to ensure that the mixture has a predetermined moisture
- 35 content to produce green pellets having a predetermined pellet size and/or strength.

2. The method according to claim 1, characterized in that the moisture content of the concentrate is measured in at least one of the method steps
5 a) to b), and that the an amount of water to be fed to the grinder (2) is regulated continuously on the basis of said measured moisture content value.

3. The method according to claim 1 or 2, characterized in that the moisture content of the concentrate and/or the mixture is measured by a high-frequency capacitive measurement method.
10

4. The method according to any one of claims 1 to 3, characterized in that the moisture content of the concentrate and/or the mixture is measured by a non-contact high-frequency capacitive measurement sensor (10) which has no direct contact to the material subject to measurement.
15

5. The method according to any one of claims 1 to 4, characterized in that the amount of water to be fed into the mixer (8) in the mixing step h) is calculated by the difference between the measured
20 moisture content value and a target value known to produce optimal size and/or strength for the green pellets.
25

6. The method according to claim 5, characterized in that if the measured moisture content value is smaller than the predetermined target value, a calculated amount of water is fed into the mixer (8) in the mixing step h), and if the measured moisture content value is the same or greater than the predetermined target value, no water is fed into the mixer (8)
30 in the mixing step g).
35

7. The method according to any one of claims 1 to 6, characterized in that the moisture content of the concentrate is measured with a moisture content sensor (10) placed in and/or after the filter (4).

5

8. The method according to any one of the claims 1 to 7, characterized in that the filtration effect of the filter (4) is regulated on the basis of said measured moisture content value.

10

9. The method according to any one of claims 1 to 8, characterized in that the moisture content of the mixture is measured during conveying the concentrate on the conveyor (5, 7).

15

10. The method according to any one of claims 1 to 9, characterized in that the first conveyor (5) and/or the second conveyor (7) being a belt conveyor having a moving belt (17) on which the mixture is placed as a material bed the moisture content of the material bed lying on the belt is measured in a contact or non-contact manner by a high-frequency capacitive measurement sensor (10) which is placed above or underneath the moving belt.

25

11. The method according to claim 10, characterized in that a high-frequency capacitive measurement sensor (10) being placed above the moving belt (17), the sensor is arranged to direct constant contact with the upper surface of the material bed.

30

12. The method according to claim 10, characterized in that the high-frequency capacitive measurement sensor (10) being placed underneath the moving belt (17), the sensor is arranged to direct constant contact with the underside (19) of the moving belt.

35

13. The method according to any one of claims 1 to 10,
c h a r a c t e r i z e d in that the moisture content of
the mixture is measured while storing the concentrate
5 in the intermediate bin (6a).

14. The method according to any one of claims 1 to 13,
c h a r a c t e r i z e d in that the moisture content of
the mixture is measured in at least one measurement
10 point located after the mixing step h) and before the
pelletizing step k).

15. The method according to claim 14, c h a r a c -
t e r i z e d in that the moisture content of the mix-
15 ture is measured during the transferring step j).

16. The method according to claim 14 or 15, c h a r -
a c t e r i z e d in that an additional amount of water
is fed to the mixture just before feeding the mixture
20 to the pelletizing device (9) or directly to the
pelletizing device if the measured moisture content
value of the mixture is below the target value, and
the amount of additional water to be fed is regulated
on the basis of said moisture content value of the
25 mixture measured in said at least one measurement
point located after the mixing step h) and before the
pelletizing step k).

17. The method according to any one of the claims 1 to
30 16, c h a r a c t e r i z e d in that in the transferring
step j) the moisture content of the mixture is meas-
ured during conveying the concentrate on a third con-
veyor (11).

35 18. The method according to claim 17, c h a r a c -
t e r i z e d in that the third conveyor (11) is a belt
conveyor having a moving belt (17) on which the mix-

ture is placed as a material bed; and the moisture content of the material bed lying on the belt is measured in a contact or non-contact manner by a high-frequency capacitive measurement sensor (10) which is placed above or underneath the moving belt.

19. The method according to claim 18, characterized in that a high-frequency capacitive measurement sensor (10) being placed above the moving belt (17), the sensor is arranged to direct constant contact with the upper surface of the material bed.

20. The method according to claim 18, characterized in that the high-frequency capacitive measurement sensor (10) being placed underneath the moving belt, the sensor is arranged to direct constant contact with the underside of the moving belt.

21. The method according to any one of claims 1 to 20, characterized in that the ore concentrate is chromite or iron or manganese or ilmenite or nickel or niobium concentrate or any combination thereof.

22. An equipment to prepare ore concentrate for pelletizing, the equipment comprising

- a concentrate bin (1) for feeding the concentrate,
- a grinder (2) to receive the concentrate from the concentrate bin and for grinding the concentrate to a predetermined grain size together with an amount of water, if needed, and possibly added additives to a mixture,
- a slurry mixer (3) to receive the mixture from the grinder (2) for mixing the mixture,
- a filter (4) to receive the mixture from the slurry mixer (3) for filtering the mixture to a dewatered mixture,

- a first conveyor (5) to receive the de-watered mixture from the filter (4) for conveying,
- a buffer bin (6a) to receive the mixture from the first conveyor (5) for buffer storing of the mixture,
- additive bins (6b, c, d) to store and feed additives,
- a second conveyor (7) to receive the mixture from the buffer bin (6a) and additives from additive bins (6b, c, d) for conveying the mixture and additives,
- a mixer (8) to receive the mixture and additives from the second conveyor (7) for mixing,
- a first pipeline (12) for feeding water to the mixer (8),
- a first control valve (13) in the first pipeline (12) for regulating of the amount of water to be fed to the mixer (8),
- a transfer means (11) to receive the mixture from the mixer (8) for transferring, and
- a pelletizing device (9) to receive the mixture from the transfer device (11) for pelletizing the mixture to green pellets, characterized in that the equipment comprises
 - one or more online moisture content sensors (10) arranged to measure moisture content of the mixture, said sensor (10) being disposed in connection with one or more of the devices including the filter (4), the first conveyor (5), the buffer bin (6a), the second conveyor (7), the mixer (8) and/or the transfer means (11); and
 - a control unit (14) arranged to continuously control the first control valve (13) to regulate the amount of water to be fed to the mixer (8) on the basis of the moisture content measurement results obtained from the one or more online moisture content sensors (10) to ensure that the mixture has a prede-

terminated moisture content to produce green pellets having a predetermined pellet size and/or strength.

23. The equipment according to claim 22, characterized in that the equipment comprises a second pipeline (15) for feeding water to the grinder (2) and a second control valve (16) in the second pipeline for regulating of the amount of water to be fed to the grinder; that a moisture content sensor (10) is disposed in the concentrate bin (1) and/or in the grinder (2); and that the control unit (14) is arranged to continuously control the second control valve (16) to regulate the amount of water to be fed to the grinder on the basis of the moisture content measurement results obtained from said moisture content sensor (10) disposed in the concentrate bin and/or in the grinder.

24. The equipment according to claim 22 or 23, characterized in that the first conveyor (5) and/or the second conveyor (7) is a belt conveyor including an endless moving belt (17) having an upper side (18) on which the mixture is lying as a material bed and an underside (19).

25. The equipment according to any one of the claims 22 to 24, characterized in that the transfer device (11) is a third belt conveyor (11) arranged between the mixer (8) and the pelletizing device (9), said third belt conveyor (11) having a moving belt (17) having an upper side (18) on which the mixture is lying as a material bed and an underside (19).

26. The equipment according to claim 25, characterized in that the equipment comprises a third pipeline (20) for spraying water onto the mixture bed travelling on the third belt conveyor (11) at a water spraying point, and a third control valve (21) in the

third pipeline for regulating of the amount of water;
and a moisture content sensor (10) is disposed before
and/or after said water spraying point; and that the
control unit (14) to control the first third control
5 valve (21) to regulate the amount of water to be fed
to the mixture bed.

27. The equipment according to claim 25 or 26,
c h a r a c t e r i z e d in that the equipment comprises
10 a fourth pipeline (22) for feeding water to the
pelletizing device (9), and a fourth control valve
(23) in the second pipeline for regulating of the
amount of water to be fed to the pelletizing device;
and that the control unit (14) is arranged to continu-
15 ously control the fourth control valve (23) to regu-
late the amount of water to be fed into the pelletiz-
ing device (9) on the basis of the moisture content
measurement results obtained from a moisture content
sensor (10) disposed to measure the moisture content
20 of the mixture bed travelling on the moving belt (17)
of the third belt conveyor (11).

28. The equipment according to any one of the claims
24 to 27, c h a r a c t e r i z e d in that the moisture
25 content sensor (10) is arranged to direct constant
contact with the upper surface of the material bed
travelling on the upper side (18) of the moving belt
(17).

30 29. The equipment according to any one of the claims
24 to 28, c h a r a c t e r i z e d in that the moisture
content sensor (10) is placed underneath the moving
belt (17), and that the sensor (10) is arranged to di-
rect constant contact with the underside (19) of the
35 moving belt (17).

30. The equipment according to any one of the claims 22 to 29, characterized in that the moisture content sensor (10) is a high-frequency capacitive measurement sensor which senses the dielectricity of the concentrate and/or mixture subject to measurement, and that the control unit (14) is arranged to calculate the moisture content on the basis of the measured dielectricity.

31. The equipment according to any one of the claims 22 to 30, characterized in that the control unit (14) is arranged to calculate the amount of water to be fed to the grinder (2) and/or to the mixer (8) and/or to the mixture material bed on the third conveyor (11) and/or to the pelletizing device (9) by the difference between the measured moisture content and a target value, said target value being known to produce an optimal size or strength for the green pellets.

32. The equipment according to any one of claims 22 to 31, characterized in that the control unit (14) is arranged to adjust the filtration effect of the filter (4) for controlling the moisture content of the filtration cake on the basis of the moisture content value measured by said one or more moisture content sensors (10).

33. The equipment according to claim 29 to 32, characterized in that the equipment comprises
- a mounting frame (24) arranged below the moving belt (17), to which frame the moisture content sensor (10) is mounted, and

- an adjustment means (25) for adjusting the height position of the sensor (10) in relation to the moving belt (17) and for pressing the sensor (10) against the underside (19) of the moving belt for non-contact measurement of the moisture content of the

mixture travelling on the upper side (18) of the moving belt.

34. The equipment according to any one of the claims
5 22 to 33, characterized in that the equipment
comprises a mechanical level control device (26), such
as a ski, a scraper, a plough or like, which is dis-
posed at a height above the moving belt (17) and up-
stream in relation to the moisture content sensor (10)
10 to control the thickness (s) of least the part of the
material bed which passes the moisture content sensor
(10).

35. The equipment according to claim 34, characterized
in that a moisture content sensor (10) is
connected to the mechanical level control device (26)
and arranged to direct contact with the upper surface
of the mixture bed travelling on the moving belt (17).

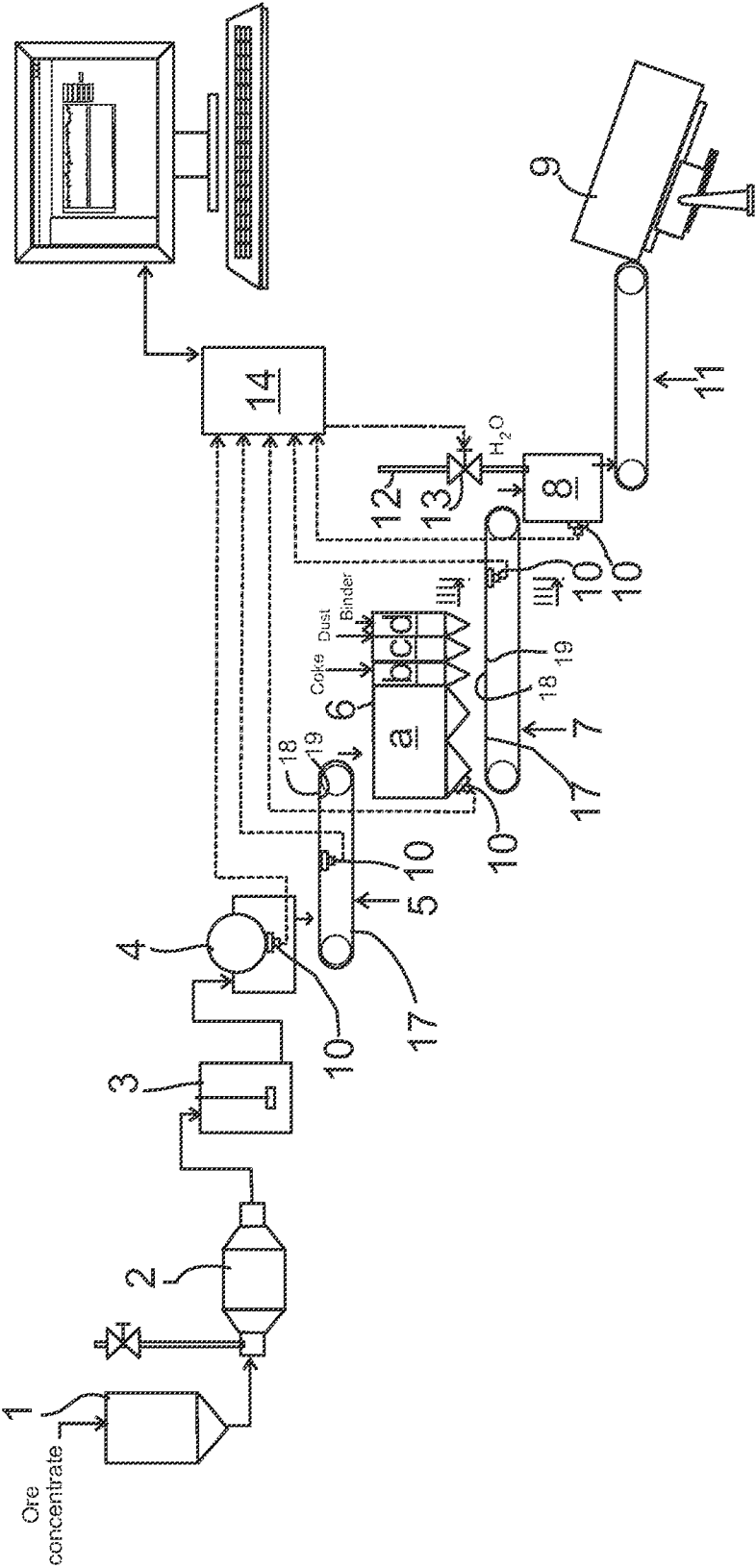


Fig. 1

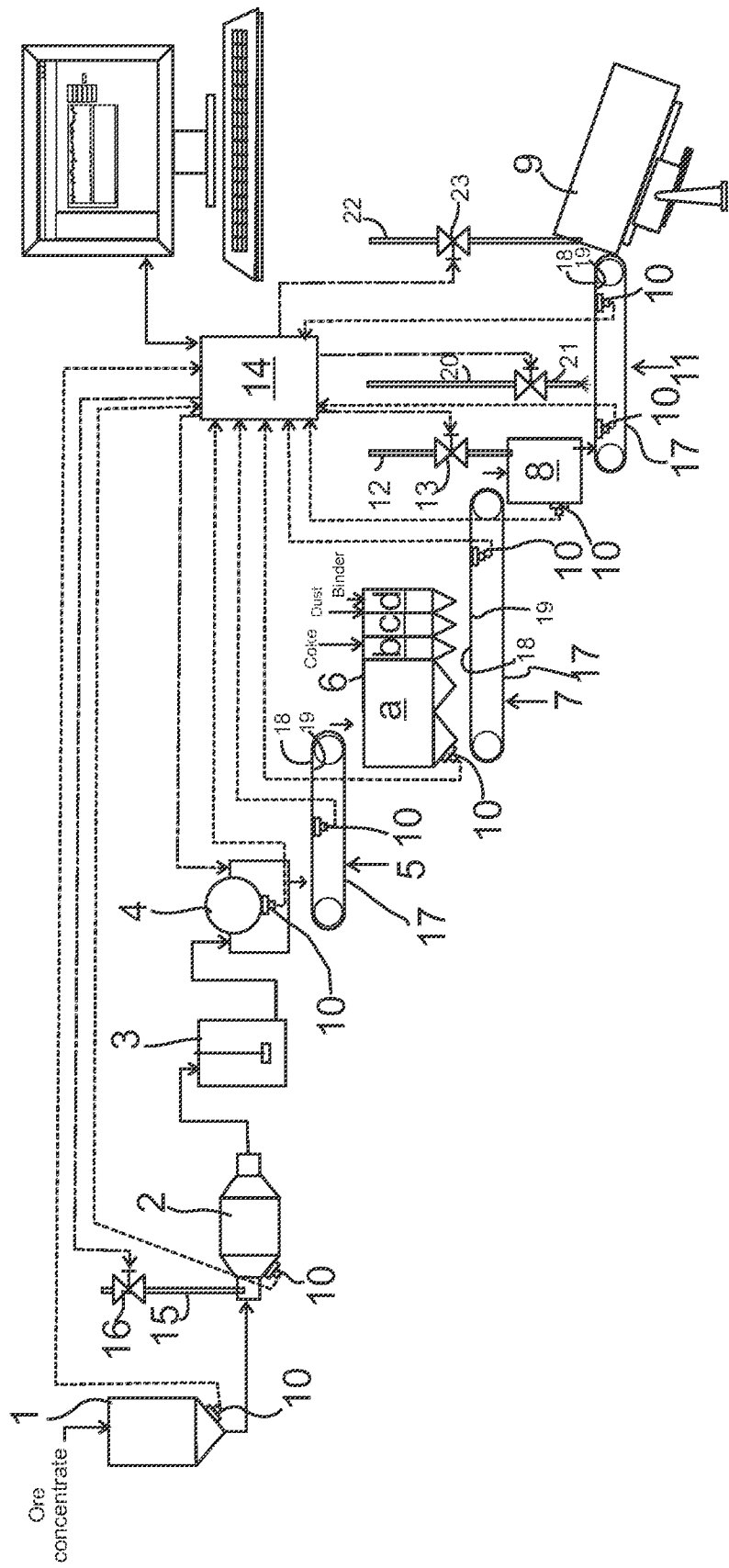


Fig. 2

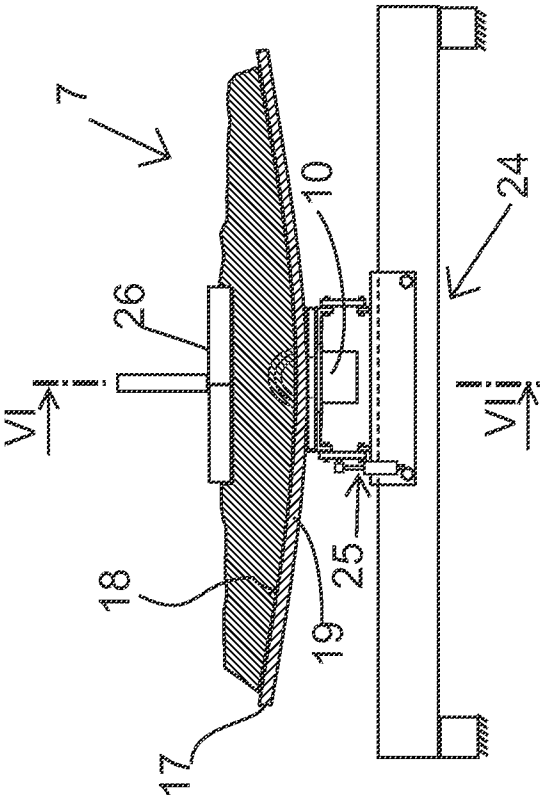


Fig. 5

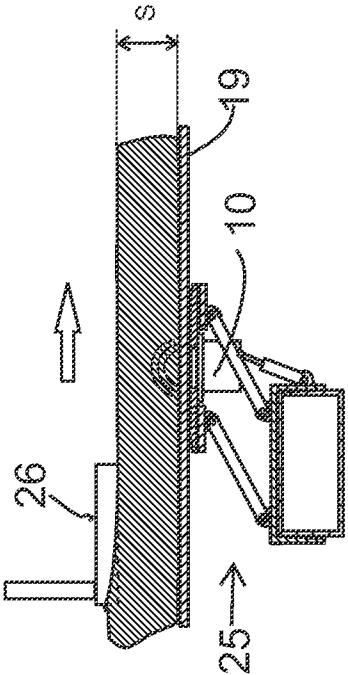


Fig. 6

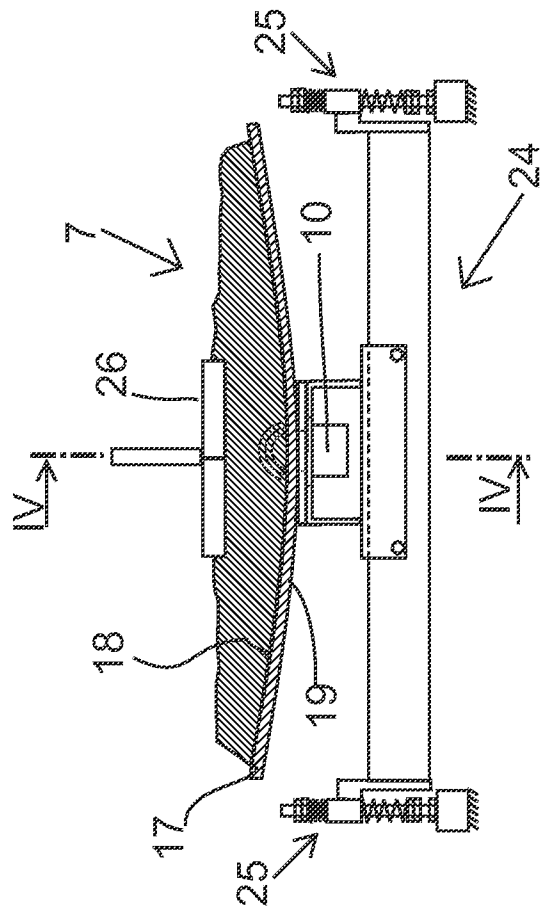


Fig. 3

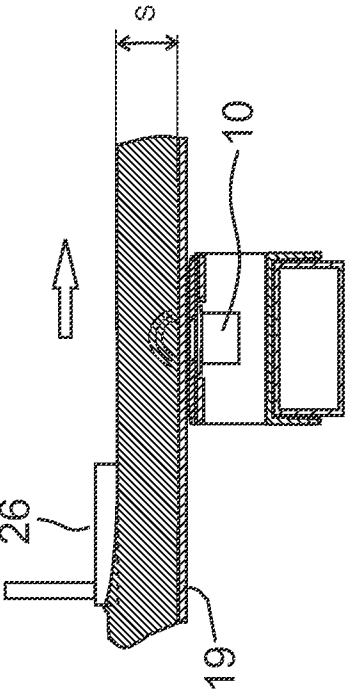


Fig. 4

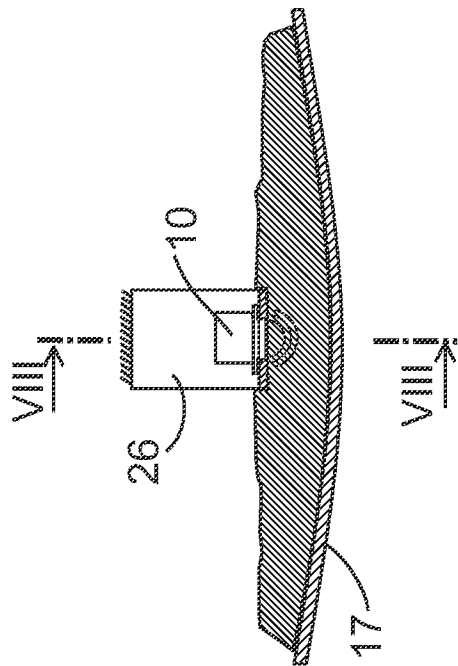


Fig. 7

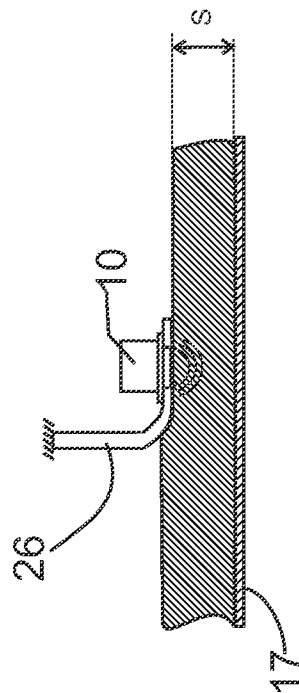


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2014/051013

A. CLASSIFICATION OF SUBJECT MATTER
INV. C22B1/24
ADD.

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)
C22B

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

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

EPO-Internal, COMPENDEX, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 148 971 A (SOMERLED MACDONALD ET AL) 15 September 1964 (1964-09-15) the whole document	1-35
Y	US 3 864 118 A (SCHUMACHER CHARLES R ET AL) 4 February 1975 (1975-02-04) column 10, line 56 - column 12, line 5; figure 1	1-35
Y	WO 2012/172174 A1 (OUTOTEC OYJ [FI]; PALANDER MARKO [FI]) 20 December 2012 (2012-12-20) cited in the application figures 1,2	1-35



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

16 March 2015

Date of mailing of the international search report

26/03/2015

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INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2014/051013

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	MILJAK D G ET AL: "On-Line Microwave Moisture Measurement of Iron Ore and Mineral Concentrates in Conveyor Applications", IEEE INSTRUMENTATION AND MEASUREMENT TECHNOLOGY CONFERENCE (IEEE CAT. NO. 06CH37714C)IMTC, IEEE, 1 April 2006 (2006-04-01), pages 183-186, XP031056700, ISBN: 978-0-7803-9359-2 page 183 -----	1-35
Y	SU 800 219 A1 (N PROIZV OB TULATSCHERMET [SU]) 30 January 1981 (1981-01-30) claim 1; figure 1 -----	1-35
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Y	JP 2011 111662 A (JFE STEEL CORP) 9 June 2011 (2011-06-09) Patent Abstracts of Japan; figure 1 -----	1-35

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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