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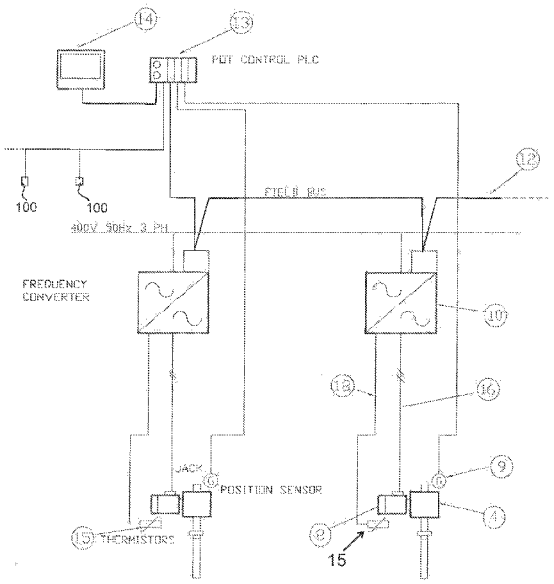


Fig 2

(57) Abstract: The invention relates to an adjustment device mechanism for anodes of an aluminium smelter and to a corresponding adjustment method. An aluminium production cell used in the smelter comprises a cathode (2) forming the bottom of the production tank, and anodes (1) that are held at a suitable distance from the cathode by lifting and lowering the anodes. The adjustment device mechanism comprises a control device (3) having an algorithm. Each of the anodes (1) has their own adjustment device (4) that is independent of the other anodes and that includes its own power unit (8), arranged to control the power unit (8) with the algorithm of the control device (13) in order to adjust the distance of the anode from the cathode independently of the other anodes or synchronously with the other anodes. The adjustment device mechanism comprises a sensor (9) for monitoring the movement or position of the anode (1) or of a part that is proportional to its movement, and current measuring means (100) for individually measuring the current of each of the anodes. The algorithm of the control device (13) is arranged to select, based on the movement and position monitored by the sensor (9) and the current of the anode measured by the current measuring means (100), in connection with lifting and lowering said anode, an optimal mode of adjusting the acceleration for starting or stopping the movement.

ADJUSTMENT DEVICE MECHANISM FOR ANODES OF AN ALUMINIUM SMELTER AND METHOD FOR ADJUSTING ANODES OF AN ALUMINIUM SMELTER

FIELD OF THE INVENTION

The invention relates to an adjustment device mechanism for anodes of an aluminium smelter, and to a corresponding method for adjusting anodes of an aluminium smelter.

BACKGROUND OF THE INVENTION

This invention relates to an anode-cathode electrolysis cell typically used in a Hall-Heroult process for the production of aluminium, comprising a bottom of a tank serving as the cathode, and anodes suspended at a suitable distance from it, the anodes being adjusted by an adjustment apparatus. In the apparatus, each one of the anodes is provided with their own adjustment device for adjusting the anode independently of the other anodes. As the anodes are consumed during the process, they are adjusted lower so that the distance to the cathode remains suitable. In one electrolysis cell there may be 20-40 anodes through which high electric current is conducted.

A common method of adjusting the anodes has been to fix them to an anode bridge transmitting the electric current, the bridge being then moved such that the anodes move together. The anodes are intended to be arranged such that the system is formed by anodes consumed to different degrees, so that when one of them is consumed completely, they can be replaced one anode at a time, hindering the process as little as possible. When replacing an anode, the new anode is locked

to the anode bridge so that the distance to the cathode is suitable, and the base of the anode is at the same level with the other anodes. Thus, the point of attachment of the anode is higher than the other ones. The consumption margin of the anodes is typically 2-3 fold compared to the movement range of the adjustment system moving the anode bridge. When the adjustment has proceeded to the lowest position of the movement range, the anodes are locked to be immovable with a separate locking device, and their locking to the anode bridge is opened, and the bridge is raised to the upper position with the adjustment apparatus, after which the anodes are again locked to the anode bridge and the next cycle begins. These operations hinder continuous efficient driving and adjustment of the production cell. Thus, solutions for adjusting the anodes separately have been developed.

One solution for separate adjustment has been described in patent US 4414070, where one motor may be used for driving separate lifting stages collectively or separately by connecting them to or disconnecting them from the motor via a multiple-branch shaft system and separate clutches. This type of structure is complicated to control and includes several components that are prone to malfunction, which may diminish the reliability of the system.

Typical anode adjustment is carried out by driving all of them together, whereby it is important to keep them synchronized. The difficulty of synchronization is due to the fact that the typical lifting device based on a screw jack and a worm gear is in practice an individual. The lifting device is intended to be manufactured

with low efficiency in order to be self-locking, so that it prevents back-rotation, i.e. the position of the anode does not change even if the device was not specifically braked.

In practice, the efficiency of lifting devices varies, and their efficiency is also improved with breaking in. As a result, when adjusting the anodes with seemingly similar motors, their moving speeds and stopping distances may be slightly different. When the typical adjustment cycle comprises several short adjustments one after the other, the inaccuracies caused by frictional differences begin to accumulate. The adjusting accuracy may be improved by an apparatus that measures the position of the lifting devices, and by a supporting control system. Motor control carried out in the normal way, however, results in a situation where, with slightly longer adjustments, the above-mentioned frictional differences cause deviation in the stopping positions, and a need for back-and-forth adjustment.

The motor power in anode systems is typically between 5-15 kW when one motor is used for adjusting all anodes at the same time. In the separate motor drive, each of the motors is considerably smaller, depending on the lower load, ranging between 0.3-1 kW. The preferred induction motor typically used as the drive device moves at different speeds depending on the load. This is due to the slip that is inherent in the motor type. For example, the nominal speed of a 4-pole induction motor is 1500 rpm / 50 Hz, but with a nominal load it is typically 1425-1475 rpm when the motor size is 4-10 kW. The speed varies according to load, being lower than the nominal speed at overload, and

vice versa when operating at part load. With small motors, such as the motors of less than 1 kW in the separate drive system, this difference is even greater, and the speed under load may drop to a level of 1350 rpm. This problem increases the difficulty of synchronization in separate adjustment.

Overload protection is needed for the lifting devices in case of various disruptions. In collective motor systems, this is typically implemented with a current-based overload protector. This works in a satisfactory manner, even if the thermal relay does not react to the load of an individual anode. This is because the collective motor sized for driving all the lifting devices and anodes together operates at a relatively high loading range, which is 50-80% of the nominal load. Thus, the increase of electric current in the motor is quite linear, and overload situations can be easily estimated from it.

This is not the case in the system according to patent US 4414070, where a large collective motor may be used for driving a single adjustment device if needed. Thus, the motor operates even at a load of less than 5%, such that measuring the motor current relative to the torque is quite inaccurate and nonlinear. Thus, the increase of electric current caused by overloading of one of the adjustment devices is impossible to detect, and a motor that is 20 times larger than required may easily damage the system if the overload situation is not responded to.

In the aluminium production process, it happens from time to time that the concentration of alumina in the

electrolyte drops to a level where fluoride salts start to disintegrate, forming gaseous fluorine compounds, forming electrically insulating gas bubbles and a gas film at the lower surface of the anode. This is known as an anode effect. Normally, when their amount over the whole cell is such that the voltage drop exceeds a specific limit, all anodes are lifted at the same time, and other bubble-removing operations are carried out in the bath.

OBJECT OF THE INVENTION

This invention intends to remedy the above-described defects of the prior art, and introduce additional features by means of which the adjustability of the electrolysis process may further be enhanced.

Specifically, the object of the invention is to disclose an anode adjustment device mechanism and method that enable the anode effect to be removed as efficiently as possible.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, an adjustment device mechanism for anodes of an aluminium smelter is disclosed, wherein an aluminium production cell used in the smelter comprises a cathode forming the bottom of the production tank, and anodes that are held at a suitable distance from the cathode by lifting and lowering the anodes, the adjustment device mechanism comprising a control device having an algorithm, and for each of the anodes their own adjustment device that is independent of the other anodes and that includes its own power unit, arranged to control the power unit with the algorithm of the control de-

vice in order to adjust the distance of the anode from the cathode independently of the other anodes or synchronously with the other anodes, and the adjustment device mechanism comprising a sensor for monitoring the movement or position of the anode or of a part that is proportional to its movement, and current measuring means for individually measuring the current of each of the anodes, and that the algorithm of the control device is arranged to select, based on the movement and position monitored by the sensor and the current of the anode measured by the current measuring means, in connection with lifting and lowering said anode, an optimal mode of adjusting the acceleration for starting and stopping the movement.

Further, the invention relates to a method for adjusting anodes of an aluminium smelter. According to a second aspect of the invention, a method for adjusting anodes of an aluminium smelter is disclosed, wherein an aluminium production cell used in the smelter comprises a cathode forming the bottom of the production tank, and anodes that are held at a suitable distance from the cathode by lifting and lowering the anodes, and an adjustment device mechanism comprising a control device having an algorithm, and for each of the anodes their own adjustment device that is independent of the other anodes and that includes its own power unit, for controlling the power unit with the algorithm of the control device in order to adjust the distance of the anode from the cathode independently of the other anodes or synchronously with the other anodes, in which method the position and speed of the anode or of a part that is proportional to its movement are monitored by a sensor, the current of each of

the anodes is individually measured by current measuring means, and by the algorithm of the control device, based on the measured current of the anode, in connection with lifting and lowering said anode, an optimal mode of adjusting the acceleration for starting and stopping the movement is selected, so as to provide a transversal flow in the electrolyte, so that the optimal operation of the whole production cell is disturbed as little as possible.

Different embodiments and alternative detailed different structural solutions and operations of the method of the invention are disclosed in the following description and in the dependent claims presented herein.

The invention relates to a method for driving an adjustment device mechanism for anodes of an electrolysis process separately for each of the anodes in aluminium production, such that each individual anode is controlled by its own adjustment device having its own driving device for moving the anode up or down independently of the other anodes. The corresponding apparatus is provided with technology enabling speed adjustment of the driving device, for example with a frequency converter in connection with an electric motor. By monitoring the moving speed, and according to the features of individual driving devices, the control system may learn suitable drive control so as to compensate for differences in the mechanical efficiency of the adjustment devices due to manufacturing, such that the adjustment is accurate, and positioning adjustments back and forth can be minimized.

The object of the invention is possible to be carried out by providing each of the anode driving devices or motors with control by means of which the moving speed and the acceleration and deceleration ramps of the anode may be adjusted. One such device is for example a frequency converter when the driving device an electric motor. In order to take full advantage of the possibility to adjust the above-mentioned parameters, the method may be provided, according to the invention, with control measuring the moving speed of each individual by means of a position sensor. These data may be proportioned to the driving load that depends on the degree of consumption and moving direction of the anode. Based on these parameters, specific efficiency for different loads is calculated for the lifting device. Using these data, the adjustment is carried out such that an anode moving more heavily is driven, in case of a frequency converter, at a higher frequency, whereby the real moving speed remains as constant as possible. Frequency converters also enable acceleration and deceleration ramps to be programmed, and they may be adjusted to further increase the positioning accuracy. This kind of self-learning mode of control substantially reduces the need of additional back-and-forth adjustment in the positioning.

The advantages of using frequency converters may also be utilized more widely. Many times the need of adjustment is very short, such that by using a short control pulse, the anodes are intended to be slightly twitched to a desired direction. When short controls are used in a situation where the movement has not yet reached full speed, the kinetic frictions are very nonlinear. This is seen such that when reaching for

adjustment of 0.5 mm with a control pulse of 0.3 s, the real movement may be 0.3 mm, but when reaching for adjustment of 1 mm with a control pulse of 0.6 s, the movement may be up to 1.5 mm. With adjustment by frequency converters based on position measurement, short adjustment needs may be accurately fulfilled in a controlled manner at a slow speed, such that the reduced kinetic frictions of the adjustment device after reaching full speed are not able to diminish the accuracy.

Using separate motors also enables reliable load measurement for the actuator based on the motor current, because each motor is sized to be suitable for the lifting device. Thus, the current range is more linear, and load estimation from it is sufficiently accurate. A suitable motor is furthermore not able to overload and damage the lifting device. Using a frequency converter introduces automatic load measurement, and there is no need for a separate thermal fuse. The load may also be monitored remotely during driving with reasonable accuracy, taking into consideration the limitations imposed by the low efficiency (approximately 20%) of the lifting devices. Thus, timely alerts may be obtained for a malfunctioning device that is expected to be damaged. Load measurement using a weighing sensor is an expensive and unreliable method due to the special conditions of the aluminium production cell, high temperature and magnetic field. And it may not be used for detecting the condition of the lifting device seen as change of efficiency. Using a self-learning frequency converter thus enables overload protection of the device, accurate positioning

and condition monitoring based on monitoring of the development of specific efficiency.

Typically, the adaptive adjustment apparatus according to the invention operates in the following way. The position of each of the adjustment devices adjusting the position of the anode is measured by their own position sensor, typically an absolute rotating position sensor connected to any of the rotating shafts of the adjustment device. The resolution of the sensor is selected such that the accuracy is better than the required anode positioning accuracy, which is typically +- 0.5 mm. The position data given by the sensor are read to the anode cell control unit. The anode control is primarily based on the position data given by the sensor and on a command given by the control unit for the desired change of position, which provides a new target value for the position of the adjustment device. A position adjustment algorithm is programmed for the control unit for starting the motor in the desired direction and stopping it at the given position target address. Because there are differences in the adjustment devices due to mechanical qualities and the anode load, the preferred typically used induction motor is not able to drive the devices at the same speed due to the slip varying according to load, and thus due to the rotating speed.

In the apparatus and method according to the invention it is the object to improve the accuracy of adjustment described above by means of a self-learning control logic using the measured position data and the real speed calculated from it, and if necessary, the motor loading torque measured with the frequency converter.

Based on these values, correction factors for the speed command are calculated for up and down driving separately for each of the devices and loads. These data may also be updated at a suitable delay in order to compensate, for example, for the sensitization due to breaking in of the adjustment device. The position measurement data may also include calculation of the stopping speed of the device in various situations, based on which a suitable deceleration ramp is defined for the frequency converter for stopping the devices as accurately as possible at a desired distance after the stopping command. Stopping accuracy may also be improved with a creeping drive before stopping, during which the final precise adaptation of the positions may be carried out in a controlled manner. Depending on the length of the change of position command, the positioning may also be carried out as a creeping drive alone with short adjusting movements.

In some situations, such as in case of the so-called anode effect, a quick and longer back-and-forth adjustment may be needed for a short time. This may be done by means of the frequency converters with a quicker-than-normal driving movement by changing the speed command. The adaptive separate adjustment according to the invention also enables fine tuning separately for each of the anodes according to how the electric current measured for each of the anodes separately deviates from the average value. This may be due to abnormal consumption of the anode or a local anode effect where undesirable gas bubbles insulating the electric current are formed at the lower surface of the anode. Normally, when they are present over the whole cell to such extent that the voltage drop ex-

ceeds a specific limit, all anodes are lifted at the same time, and other bubble-removing operations are carried out in the bath. By means of separate adjustment and separate measurement, the removal of the bubbles may be carried out locally at an earlier stage, thus increasing the efficiency of aluminium production.

In the system according to the invention the control device gives a problematic anode a command for a new position, for example at a higher-than-normal speed, so as to increase a transversal flow of the electrolysis bath below the rising anode, forcing gas bubbles away. The separate adjustment also enables another anode to be lowered at the same time, such that the level of the bath remains the same, and the process is disturbed as little as possible.

In one embodiment of the adjustment mechanism the power unit is an electric motor arranged to have adjustable speed and torque.

In one embodiment of the adjustment mechanism the electric motor is an induction motor arranged to be controlled by a frequency converter.

In one embodiment of the adjustment mechanism the sensor is an encoder measuring the rotation and/or position of a part.

In one embodiment of the adjustment mechanism the sensor is a linear potentiometer measuring the position of a part of a structure moving with the anode in a vertical direction.

In one embodiment of the method the quantity of electric current of an individual anode is measured, and the distance of the anode from the cathode is controlled based on the measurement.

In one embodiment of the method the adjustment is carried out by adjusting the speed and torque of the electric motor serving as the power unit.

In one embodiment of the method the position and movement of the anode are measured by measuring the movement and position of the adjustment device by one or more sensors.

In one embodiment of the method, parameters representing the real movement are determined for the lifting device based on the current of the motor, the position and moving speed measured and calculated from the sensor, and the weight to be lifted according to the position of the anode.

In one embodiment of the method, the driving parameters of movement control are corrected based on the real movement values, so that the following runs will be more accurate.

In one embodiment of the method, the anode effect is removed by lifting one or more anodes and correspondingly lowering one or more anodes at variable speeds to enhance the discharge flow of the gas bubbles in order to reduce the anode effect.

In one embodiment of the method the anode effect is detected by measuring the electric current separately for each of the anodes.

In one embodiment of the method, the control device is used for verifying individual moving properties of individual adjustment devices and predictively adapting the control parameters according to these properties, such that the separate adjustment devices substantially move at the same speed and substantially stop at the same position when the anodes need to move in a synchronized manner.

SHORT DESCRIPTION OF THE DRAWINGS

The invention will now be described in detail with reference to the accompanying drawings, in which

Fig. 1 illustrates one aluminium production cell according to the invention, and

Fig. 2 shows an electric control diagram relating to the invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 illustrates a simplified version of an electrolytic aluminium production cell with only three anodes. This version comprises a cathode 2 serving as the bottom of the cell, and anodes 1 supported by an anode adjustment device 4 at a suitable distance from the cathode, depending on the thickness of a molten aluminium layer on the bottom. The structure also comprises a busbar 3 supplying current to the anodes 1, and flexible current supply cables 5 connected to a central bar 6 of the anodes from the busbar. The cur-

rent supply cables are typically made from several thin aluminium strips having good flexibility and allowing the movement of the anode while conducting electric current through the anodes. The adjustment devices 4 are connected to a frame 7 of the machine that stands on the floor. Each of the anode adjustment devices 4 includes its own electric motor 8 and a sensor 9 monitoring the position of the device, which may typically be an encoder measuring the rotation and position of a part, or a linear potentiometer measuring the position of a part of a structure moving with the anode in a vertical direction.

Fig. 2 shows a typical electric control diagram of the system. In the diagram, the electric motor 8 driving the adjustment device 4 is connected with a cable 16 to a frequency converter 10. The motor 8 also has typically built-in thermistors 15 that protect the motor from overheating and are electrically connected via a cable 18 to the frequency converter 10. The frequency converters 10 are controlled according to commands given by an algorithm of a control device 13. The control device 13 is a control logic 13 having an algorithm. All of the frequency converters may be connected to a same electric control bus 12, which is in turn connected to the control logic 13. Further, the control logic 13 is connected to current measuring means 100 that individually measure the current of each of the anodes. An I/O device 14 is connected to the control logic 13 for monitoring the state of the system and changing the settings as needed. Also, manual adjustment of individual anodes or programmed automatic driving may be switched on from the I/O device 14. The I/O device is typically an industrial PC comprising a

display, a central processing unit and an input device. A sensor 9 measuring the position of the adjustment is also connected to the adjustment device 4 for transmitting real-time data to the control logic 13 of the position of the adjustment. The control logic 13 also calculates a speed on this basis and compares the value to other simultaneously moving anode adjustment devices 4 and, if necessary, gives the frequency converter 10 a different speed command so that the real speeds of the adjustment devices 4 moving at different speeds would correspond to each other. These data are stored for each of the adjustment devices in a table of the control logic 13 separately for different types of driving situations. Thus, by using the corrected value further on, the devices will move more accurately at the same speed.

The invention has been described above in detail with reference to its embodiments illustrated in the drawings; however, different embodiments of the invention are possible within the scope defined by the accompanying claims.

CLAIMS

1. An adjustment device mechanism for anodes of an aluminium smelter, wherein an aluminium production cell used in the smelter comprises a cathode (2) forming the bottom of the production tank, and anodes (1) that are held at a suitable distance from the cathode by lifting and lowering the anodes, the adjustment device mechanism comprising a control device (3) having an algorithm, and for each of the anodes (1) their own adjustment device (4) that is independent of the other anodes and that includes its own power unit (8), arranged to control the power unit (8) with the algorithm of the control device (13) in order to adjust the distance of the anode from the cathode independently of the other anodes or synchronously with the other anodes, and the adjustment device mechanism comprising a sensor (9) for monitoring the movement or position of the anode (1) or of a part that is proportional to its movement, and current measuring means (100) for individually measuring the current of each of the anodes, and that the algorithm of the control device (13) is arranged to select, based on the movement and position monitored by the sensor (9) and the current of the anode measured by the current measuring means (100), in connection with lifting and lowering said anode, an optimal mode of adjusting the acceleration for starting and stopping the movement.

2. The adjustment device mechanism according to claim 1, c h a r a c t e r i z e d in that the power unit (8) is an electric motor arranged to have adjustable speed and torque.

3. The adjustment device mechanism according to claim 2, characterized in that the electric motor (8) is an induction motor arranged to be controlled by a frequency converter (10).

4. The adjustment device mechanism according to any one of claims 1-3, characterized in that the sensor (9) is an encoder measuring the rotation and/or position of a part.

5. The adjustment device mechanism according to any one of claims 1-3, characterized in that the sensor (9) is a linear potentiometer measuring the position of a part of a structure moving with the anode (1) in a vertical direction.

6. A method for adjusting anodes of an aluminium smelter, wherein an aluminium production cell used in the smelter comprises a cathode (2) forming the bottom of the production tank, and anodes (1) that are held at a suitable distance from the cathode by lifting and lowering the anodes, and an adjustment device mechanism comprising a control device (3) having an algorithm, and for each of the anodes (1) their own adjustment device (4) that is independent of the other anodes and that includes its own power unit (8), for controlling the power unit (8) with the algorithm of the control device (13) in order to adjust the distance of the anode from the cathode independently of the other anodes or synchronously with the other anodes, in which method the position and speed of the anode or of a part that is proportional to its movement are monitored by a sensor (9), the current of each of the anodes (1) is individually measured by current measuring means

(100), and by the algorithm of the control device (13), based on the measured current of the anode, in connection with lifting and lowering said anode, an optimal mode of adjusting the acceleration for starting and stopping the movement is selected, so as to provide a transversal flow in the electrolyte, so that the optimal operation of the whole production cell is disturbed as little as possible.

7. The method according to claim 6, characterized in that the quantity of electric current of an individual anode (1) is measured, and the distance of the anode (1) from the cathode (2) is controlled based on the measurement.

8. The method according to claim 6 or 7, characterized in that the adjustment is carried out by adjusting the speed and torque of the electric motor (8) serving as the power unit.

9. The method according to any one of claims 6 - 8, characterized in that the position and movement of the anode are measured by measuring the movement and position of the adjustment device (4) by one or more sensors (9).

10. The method according to any one of claims 6 - 9, characterized in that parameters representing the real movement are determined for the lifting device based on the current of the motor (8), the position and moving speed measured and calculated from the sensor (9), and the weight to be lifted according to the position of the anode (1).

11. The method according to claim 10, characterized in that the driving parameters of movement control are corrected based on the real movement values, so that the following runs will be more accurate.

12. The method according to any one of claims 6 - 11, characterized in that the anode effect is removed by lifting one or more anodes and correspondingly lowering one or more anodes at variable speeds to enhance the discharge flow of the gas bubbles in order to reduce the anode effect.

13. The method according to claim 12, characterized in that the anode effect is detected by measuring the electric current separately for each of the anodes.

14. The method according to any one of claims 6 - 13, characterized in that the control device is used for verifying individual moving properties of individual adjustment devices and predictively adapting the control parameters according to these properties, such that the separate adjustment devices substantially move at the same speed and substantially stop at the same position when the anodes need to move in a synchronized manner.

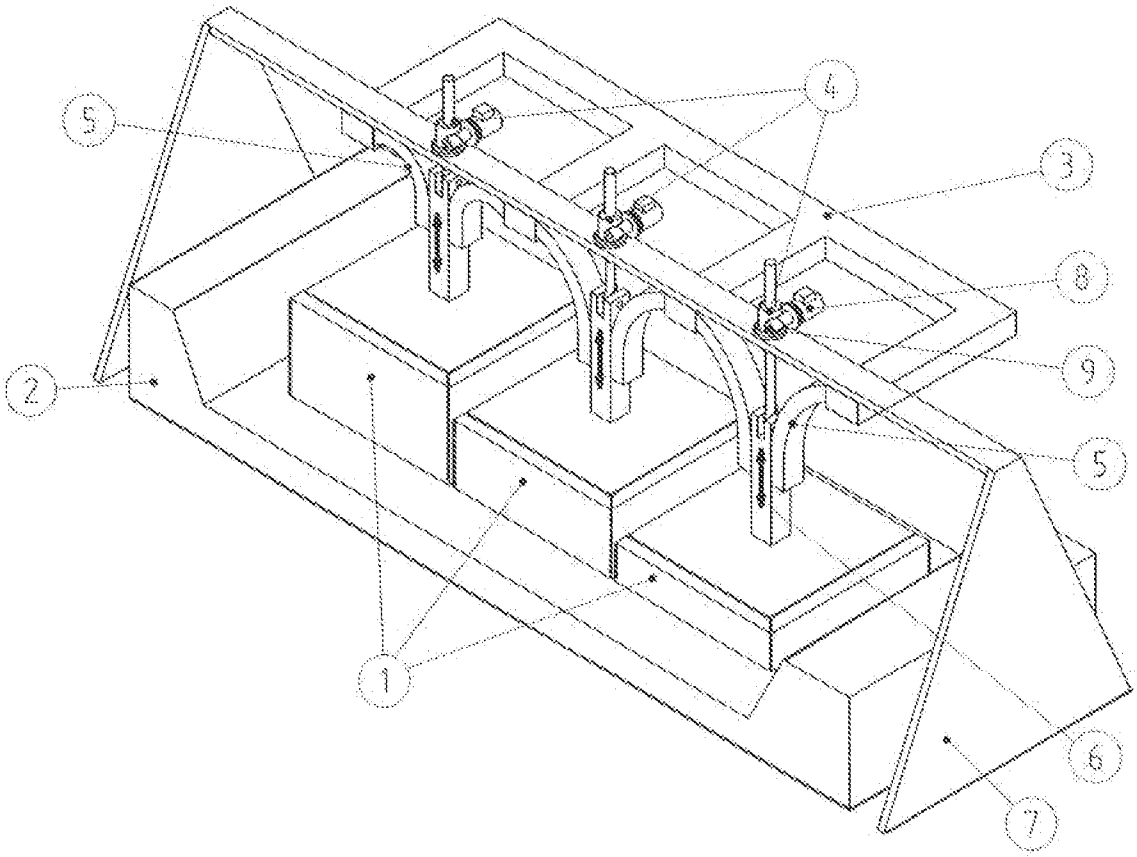


Fig 1

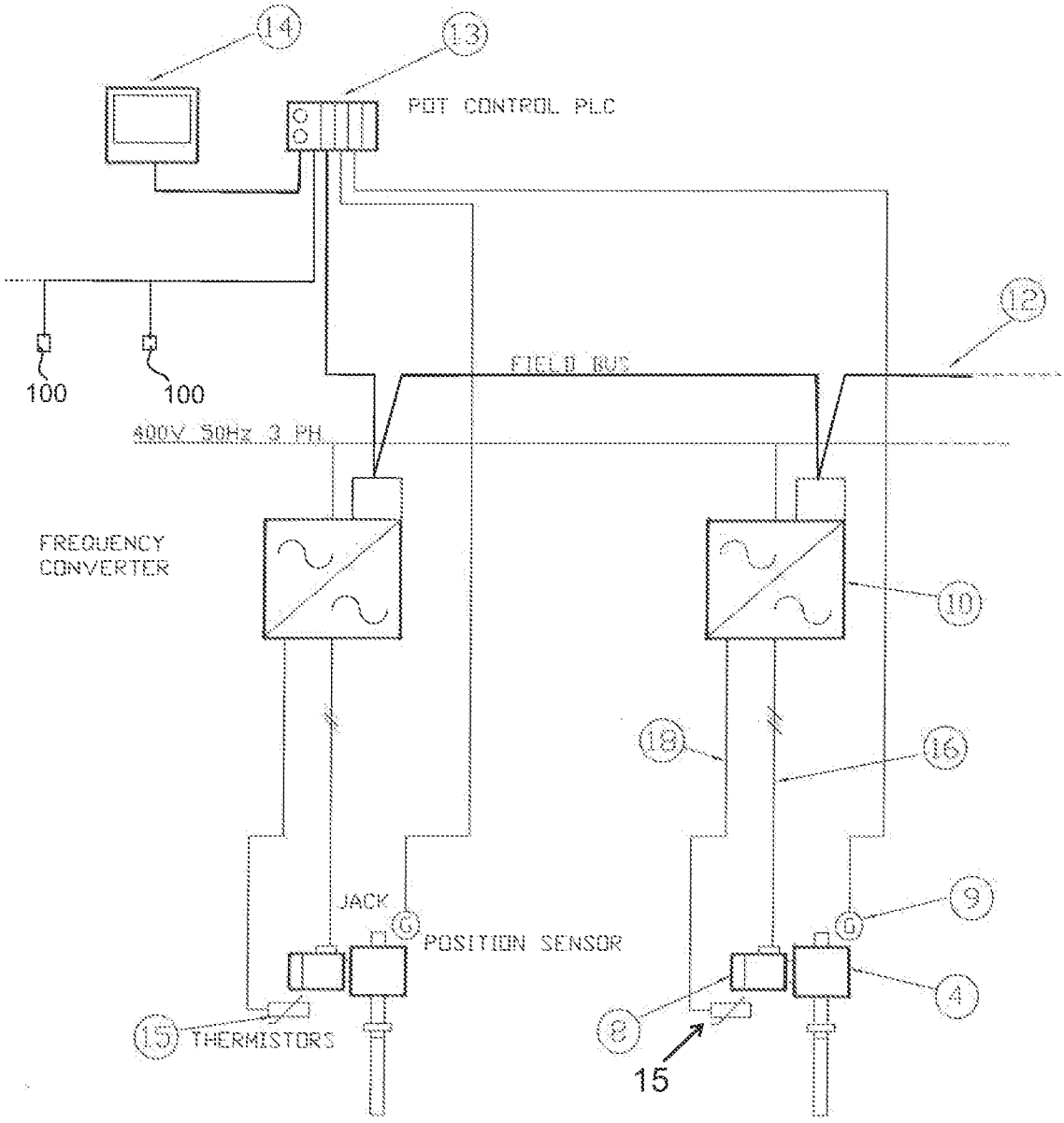

14
13
POT CONTROL PLC
12
100
100
FIELD BUS
400V 50Hz 3 PH
FREQUENCY CONVERTER
10
18
16
9
JACK
6
POSITION SENSOR
4
15
THERMISTORS
8
15

Fig 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2018/050212

A. **CLASSIFICATION OF SUBJECT MATTER**

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: C25C, H02P

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

FI, SE, NO, DK

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

EPODOC, WPIAP, EPO-Internal full-text databases, Full-text translation databases from Asian languages, PRH-Internal, NPL, BIOSIS, COMPDX, EMBASE, INSPEC, MEDLINE, TDB, XP3GPP, XPAIP, XPESP, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPMISC, XPOAC, XPRD, XPTK

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2111082 A (PECHINEY ALUMINIUM) 29 June 1983 (29.06.1983) abstract; page 1 lines 1-38, page 1 lines 58-71, page 1 line 101 – page 2 line 79, page 3 line 29 – page 4 line 67, page 5 lines 17-59; claims 1-6, 11, 12; and figures 1, 2	1 – 14
X	AU 2015208855 A1 (RIO TINTO ALCAN INT LTD) 28 July 2016 (28.07.2016) abstract; page 1 lines 12-17, page 1 line 24 – page 2 line 1, page 2 lines 9-18, page 3 lines 26-28, page 5 lines 13-19, page 7 lines 20-23, page 8 line 19 – page 9 line 9, page 10 lines 1-16, page 13 lines 6-12; claims 1, 5-7, 9, and figures 1, 2	1 – 14

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

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2018/050212

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 0131086 A1 (MOLTECH INVENT SA [LU]) 03 May 2001 (03.05.2001) abstract; page 6 lines 21-29, page 8 line 35 – page 9 line 32, page 12 lines 20-26, page 14 lines 16-21, page 14 line 31 – page 15 line 3, page 15 lines 10-17, page 17 line 9 – page 18 line 9; claims 1, 23-26; and figures 1, 2	1 – 14
A	ABB Oy, ACSM1 Motion Control Program Firmware Manual, 3AFE68848270 REV H, [online]. 2015-06-30 [retrieved on 2018-06-01]. Retrieved from <ABB's website, http://www.abb.com/abblibrary/downloadcenter/>. pages 15, 26, 29, 35-40, 50-53, 59-82, 145-177, 218-254, and 502-507	1 – 14

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International application No.
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CLASSIFICATION OF SUBJECT MATTER

IPC
C25C 3/08 (2006.01)
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