

(19)



(11)

EP 2 403 980 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
13.07.2016 Bulletin 2016/28

(51) Int Cl.:
C25C 7/06 (2006.01) **C25C 7/04** (2006.01)
C25C 1/08 (2006.01)

(21) Application number: **10738243.4**

(86) International application number:
PCT/FI2010/050058

(22) Date of filing: **02.02.2010**

(87) International publication number:
WO 2010/089452 (12.08.2010 Gazette 2010/32)

(54) METHOD OF ELECTROWINNING A METAL AND AN ELECTROLYSIS SYSTEM

VERFAHREN ZUR ELEKTROLYTISCHEN GEWINNUNG EINES METALLS UND
ELEKTROLYSESYSTEM

PROCÉDÉ D'EXTRACTION ÉLECTROLYTIQUE D'UN MÉTAL ET SYSTÈME D'ÉLECTROLYSE

(84) Designated Contracting States:
**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 SE SI SK SM TR**

(30) Priority: **03.02.2009 FI 20095094**

(43) Date of publication of application:
11.01.2012 Bulletin 2012/02

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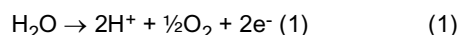
Description**FIELD OF THE INVENTION**

5 **[0001]** The invention relates to a method defined in the preamble of Claim 1.

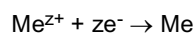
BACKGROUND OF THE INVENTION

10 **[0002]** In electrolysis, a metal that is dissolved in an electrolyte is electrowon. Electrowinning takes place in an electrolytic tank that contains a number of anodes and a number of cathodes that are arranged in an alternating manner. When an electric current is conducted to the system in sulphate-based electrolysis, metal is precipitated on the surface of the cathode and, when the water decomposes, acid and oxygen are formed on the anodes, according to the reaction equations (1) and (2):

15 Anodic reaction:



20 Cathodic reaction:



25 Me = metal, such as Ni, Co, Mn or Cu
wherein z = the charge of a metal ion

[0003] US 4,288,305, US 4,201,653 and US 2004/0007477 disclose electrowinning cells and processes.

30 **[0004]** A diaphragm technique is used in electrowinning metals, which in the electrochemical series are more ignoble than hydrogen. The overpotential of the reduction of these metals, which include for example nickel, cobalt and manganese, is higher than that of hydrogen, which is why the development of hydrogen at a low pH should be avoided by separating the anolyte and the catholyte from each other by a material that permeates the electrolyte in a controlled manner, such as a diaphragm fabric, and the electrolyte should flow from the catholyte space to the anolyte space. Generally, the cathodes in the sulphate-based electrolysis are placed in a diaphragm space.

35 **[0005]** When using anode bags, each anode is arranged inside an anode bag that is made of the material that permeates the electrolyte in a controlled manner. The anode bag defines an anodic space in its inside and the cathodes are in the free cathodic space that surrounds the anode bags. Due to the formation of acid, the pH of the anolyte in the anode bag is lower (in the order of pH 1 or lower) than the pH of the catholyte in the cathodic space (in the order of pH 3-4). The electrolyte flows continuously from the cathodic space into the anodic space inside the anode bag. The anolyte is an electrolyte that surrounds the anode and the catholyte is an electrolyte that surrounds the cathode. The electrolyte is fed into the cathodic space and removed by overflow. The anolyte is continuously removed from each anode bag. The flow of electrolyte is provided by means of a pressure difference between the anodic and cathodic spaces, including a hydrostatic pressure (caused by the difference of height between the anolyte and catholyte surfaces), and this prevents the back diffusion of protons into the catholyte space.

45 **[0006]** Even though the anode bag technique has been used commercially for a short time in the Cawse Nickel Refinery in Australia, the electrowinning process of nickel used therein is no longer in operation.

50 **[0007]** The Anglo Platinum Base Metal Refinery, which is located in South Africa, has tested the anode bag technique ["Nickel Electrowinning Tankhouse Developments at Anglo Platinum Base Metal Refinery", Authors: LJ Bryson, NJ Graham, EP Bogosi, DL Erasmus proceedings of ALTA 2008 - Nickel/Cobalt, Copper & Uranium Conference, June 16-18 2008]. According to this article, the process criteria regarding the anolyte acid concentration were the main stumbling stones in the implementation. The anode bags functioned under low pressure, which was needed to remove both aerosols and anolyte from the anode bag, resulting in pulling a low acid concentration through the anode bags, which further caused a significant addition in the amount of nickel electrolyte that was circulated. In other words, due to the low anolyte acid concentration, the anode bag technique tested in the Anglo Platinum Base Metal Refinery was not economically attractive.

55 **[0008]** Production of nickel is more economic, if a higher acid concentration of the anolyte than before is achieved in the electrowinning process of nickel. The high acid content of the anolyte is useful in dissolution. The high anolyte acid concentration can be provided by a suitable selection of a diaphragm fabric and by controlling the process parameters, namely the viscosity of the electrolyte and the permeability of the wall of the anode bag that is formed from the diaphragm

fabric that permeates the electrolyte in a controlled manner, the permeability depending on the viscosity of the electrolyte.

[0009] The problem is that it is difficult to select the correct diaphragm fabric of the anode bag, since manufacturers offer fabrics that have different gradual permeabilities and they express the permeability of the fabric in permeability of water only (a specific viscosity) and at one specific pressure difference (a specific height of a water column). When a high anolyte acid content is to be achieved, it is impossible to select the correct fabric on the basis of the above information, as it is not known, what the permeability of the fabric to the electrolyte is and how the viscosity of the electrolyte and the pressure difference on the different sides of the fabric influence the permeability.

OBJECT OF THE INVENTION

[0010] The object of the invention is to eliminate the disadvantages mentioned above.

[0011] In particular, the purpose of the invention is to disclose a method and a system, which enable the selection of the diaphragm fabric of the anode bag and the adjustment of process parameters, which is made on the basis of the selected fabric, so that a desired degree of anolyte acid concentration is obtained in the anodic space, which makes the electrowinning of metal a profitable business.

SUMMARY OF THE INVENTION

[0012] The method according to the invention is characterized in that, which is disclosed in Claim 1.

[0013] According to the invention, the dependences of the permeability of the diaphragm fabric on the viscosity of the catholyte and the pressure difference used are determined, and on the basis of the determined dependences, the exit velocity of the anolyte from the anode bag is adjusted by means of the current density used, the pressure difference and the viscosity of the catholyte, so that an acid content of the anolyte of at least 122 g/l is obtained. The concentration of nickel sulphate in the catholyte and/or the viscosity of the catholyte are measured, and the circulation speed of the catholyte is increased, if the nickel sulphate concentration in the catholyte and/or the viscosity of the catholyte exceed a predefined limit value, and the circulation speed of the catholyte is reduced, if the nickel sulphate concentration in the catholyte and/or the viscosity of the catholyte are below the predefined limit value.

[0014] It is essential for the invention that the flow can primarily be defined on the basis of the density of the fabric, i.e., the permeability of the electrolyte which, in addition to the properties of the fabric, is defined by the pressure difference and the viscosity.

[0015] The anolyte acid concentration can be controlled by using a tighter fabric for a less viscous electrolyte, which decreases the flow velocity from the cathodic space into the anodic space inside the anode bag, and vice versa, i.e., using a less tight fabric for a more viscous electrolyte. The viscosity of the electrolyte, in turn, can be adjusted to a minor degree by the concentration of the metallic salt in the catholyte, whilst the other parameters remain constant. This adjustment does not necessarily have significance for the process. For example, the variation of the Ni content in the process can be as little as about 10 g/l. The concentration of metallic salt in the catholyte, in turn, can be adjusted by adjusting the circulation speed of the catholyte. Fig. 1 shows the block flow chart of the process.

[0016] The acid concentration thus settles on a specific level, which depends on the exit velocity of the electrolyte (which is as high as the flow of electrolyte into the anode bag) and the flow used. E.g., in a process, wherein the total flow that is fed into one electrolytic tank is 16000 A and the flow of electrolyte into the anode bags totals 0.33 m³/h, the anolyte acid concentration is about 80 g/l.

[0017] In an application of the method, the pressure difference is adjusted by changing the difference of height between the fluid levels of the anolyte and the catholyte.

[0018] In an application of the method, the anolyte is removed from each anode bag by overflow so that, to provide a hydrostatic pressure, the level of the anolyte is kept lower than the level of the catholyte. This provides a sufficiently high hydrostatic pressure, which causes a flow of electrolyte from the catholyte side into the anode bags, preventing the migration of protons from the anolyte back to the catholyte side, i.e., from the anodic space into the cathodic space.

[0019] In an application of the method, the anolyte is removed from each anode bag by means of an overflow pipe, its head defining the level of the anolyte in the anode bag. The position of the overflow pipe head inside the anode bag very accurately defines the maximum level of anolyte in the anode bag. Damage of the anode bag is easy to observe, as the level of anolyte in the anode bag then rises higher than normal and the flow of anolyte to the overflow pipe increases to an exceptional degree, which is easy to observe and start the correcting measures accordingly.

[0020] In an application of the method, the anolyte is conveyed from the overflow pipes to a collector and further to a collecting tank.

[0021] In an application of the method, the anolyte is removed from each anode bag by means of a first suction pipe.

[0022] In an application of the method, oxygen and/or acid fog are sucked from the anode bag.

[0023] In an application of the method, the oxygen and/or acid fog are sucked from the anode bag through the first suction pipe, a second suction pipe and/or the overflow pipe.

LIST OF FIGURES

[0024] In the following, the invention is described in detail by means of application examples and with reference to the appended drawing, wherein

Fig. 1 shows the block flow chart of the process;

Fig. 2 shows schematically the cross section of part of the electrolytic tank that belongs to one application of the electrolysis system according to the invention;

Fig. 3 shows the cross section II-II of the tank of Fig. 1;

Figs. 4-6 show the permeability values that are measured at three different heights of the fluid levels (i.e., three different pressure differences) of a first diaphragm fabric (Fabric 1) at five different viscosity values of the catholyte, and the dependence graphs of the viscosity and permeability that are determined on the basis of the measured values;

Figs. 7-9 show the permeability values that are measured at three different heights of the fluid levels (i.e., three different pressure differences) of a second diaphragm fabric (Fabric 2) at five different viscosity values of the catholyte, and the dependence graphs of the viscosity and permeability that are determined on the basis of the measured values; and

Fig. 10 shows the effect of the difference of fluid levels (the pressure difference) on the permeability of Fabric 1 and Fabric 2.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Fig. 1 is a schematic general view of the electrolysis system that is suitable for electrowinning a metal, that is nickel, from an electrolyte that contains the sulphate salt of the said metal. The electrolyte is brought into the electrolytic tank from a circulation container and the catholyte is removed from the tank by overflow back to the circulation container. A rich electrolyte is added to the circulation container. Anolyte is removed from the electrolytic tank from inside the anode bags and conveyed further to dissolution. Oxygen and acid fog are removed from the anode bags to purification and the oxygen is further conducted to dissolution. In tanks, where permanent cathodes are used and on the surfaces of which a sufficient amount of metal to be electrowon has precipitated, the permanent cathodes are periodically removed from the electrolytic tank; metal is removed from the surface of the cathode and the permanent cathodes are returned to the tank again. In tanks, where starter sheets are used and on the surfaces of which a sufficient amount of metal to be electrowon has precipitated, the starter sheets are removed periodically from the electrolytic tank, and new starter sheets are placed in the tank.

[0026] Figs. 2 and 3 show part of an electrolytic tank 1. The tank 1 contains a number of anodes 2 and a number of cathodes 3 that are arranged alternately. The anodes 2 are lead anodes, alloys of lead, DSA anodes (Dimensionally Stable Anodes) or titanium anodes. The cathodes 3 are preferably either permanent cathodes, which are manufactured from acid-resistant special steel, titanium, or nickel starter sheets that are made for the purpose are used.

[0027] Referring to Fig. 3, the anodes 2 are inside anode bags 4 that permeate the electrolyte in a controlled manner. The cathodes 3 are freely inside the tank. The anode bag 4 defines an inner anodic space 5 inside of it and an outer free cathodic space 6 outside of it, where the cathodes 3 are. Metal is precipitated on the surface of the cathodes 3 and oxygen and acid are generated on the anodes 2.

[0028] The pH of the anolyte 7 in the anode bag 3 is lower ($\text{pH} \leq 1$) than that of the catholyte 8 (pH of about 3-4) in the cathodic space 6. The electrolyte flows continuously from the cathodic space to the anodic space inside the anode bag to constitute the anolyte. The system comprises a means of feeding the catholyte into the cathodic space and removing it from the tank by overflow or suction (not shown).

[0029] For removing the anolyte separately from each anode bag, an overflow pipe 9 is arranged for each anode bag 4, its head 10 opening in the area of the upper part of the anode bag 4. The position of the head 10 defines the level of the anolyte in the anode bag, so that the level of the anolyte is lower than the level of the catholyte by a distance H. The difference H of the levels of the catholyte and anolyte causes a pressure difference. The electrolyte flows through the diaphragm fabric at a flow rate, which depends on its permeation properties and which can be 1-100 l/m²/h.

[0030] Fig. 2 also shows that the anode bag 4 can include a first suction pipe 12 for removing the anolyte/oxygen/acid fog by suction. It can further include a second suction pipe 13 for removing the anolyte/oxygen/acid fog from the anode bag by suction. The bag may be sealed and impervious to gas above the fluid level.

[0031] To remove the anolyte, oxygen and acid fog from the anode bag, there can be three arrangements:

1) The anolyte is removed by overflow through the overflow pipe 9 and oxygen and acid fog are removed by the first suction pipe 12 or through the overflow pipe 9 as well;

2) The anolyte is removed by the second suction pipe 13, by which the oxygen and acid fog are also removed;

3) The anolyte is removed by the second suction pipe 13, and the first suction pipe 12 is used to remove both the anolyte and oxygen and acid fog.

[0032] For the process, the diaphragm fabric material of the anode bag is selected on the basis of an anolyte acid concentration of a desired degree, so that the permeability of the diaphragm fabric

$$X = f(\Delta p, \tau)$$

wherein

Δp is the pressure difference

τ is the viscosity of the catholyte

[0033] Correspondingly, the acid concentration of the anolyte

$$C = f(X, I)$$

wherein

I is the quantity of electric current used

[0034] For the process, a high anolyte acid concentration can be selected, and to achieve this, a suitable diaphragm fabric material can be selected. In the process, efforts are made to keep the viscosity of the catholyte the same by adjusting the circulation speed of the catholyte.

[0035] A desired permeability of the diaphragm fabric is achieved by a diaphragm fabric, which is made of polymer or microfibre, and by a correct selection of filaments, weave and coating. The permeability of the electrolyte can also be optimised by calendering. By selecting a suitable fabric, the desired acid content can be achieved; the high acid content cannot be achieved by other parameters, unless the fabric is dense enough.

EXAMPLE 1

[0036] To prove that a high anolyte acid concentration can be achieved, two bench-scale tests were conducted for the electrowinning of nickel by using anode bag fabrics, which had different permeabilities of the electrolyte. Two diaphragm fabrics A and B were used, which had the following permeabilities of the electrolyte: 280 ml/h for A and 2070 ml/h for B per anode bag for an electrolyte, which had a NiSO_4 concentration of about 70 g/l. Three anode bags (lead anodes) and two cathodes (starter sheets) were accommodated in a cell, the volume of which was 27 litres. The anolyte was removed by overflow and the overflow of the cathode was adjusted at the differences of height H of 30 and 20 mm, causing hydrostatic pressures, for the bag fabrics A and B, respectively. The catholyte was circulated and fresh electrolyte was added to the tank in an amount as large as the amount of anolyte that was removed from the anode bags. The temperature of the electrolyte was 57 °C. The current density was 200 A/m² and the cell current for A was 23 A, and for B, 22 A. The circulation speed of the catholyte was 6 l/h. For the electrolyte, the nickel concentration of which was 106 g/l, the total removal of anolyte from the cell during the test was 0.34 l/h for the bag fabric A and 3.4 l/h for the bag fabric B. The end result was that the anolyte acid concentrations were 122 g/l for A and 28 g/l for B at the end of the tests. The test shows that the high anolyte acid concentration can be reached by using correct process parameters.

[0037] Figs. 4-9 show, for the two different fabrics, Fabric 1 and Fabric 2 (which is not the same fabric as in the example above), the permeability values measured at three different heights of the fluid levels (i.e., three different pressure differences) at five different viscosity values of the catholyte, and the dependence graphs of viscosity and permeability determined on the basis of the measured values.

[0038] The graphs include the permeability of the electrolyte (litres per hour and square meter) as a function of viscosity (cP i.e., mPa/s). The graphs are adapted for a damping exponential function, which comprises three parameters y_0 , a and b :

$$f(X) = y_0 + ae^{-b\eta}$$

η is the viscosity or the X-axis and X is the permeability or the Y-axis.

[0039] In adjusting the parameters, the following values were obtained for them:

Fabric 1			
H (cm)	10	15	19
y_0	32.8	45.4	50.6
a	1183.7	1292.9	611.3
b	2.8	2.5	1.6

Fabric 2			
H (cm)	10	15	19
y_0	7.7	13.4	14.5
a	68.2	163.0	144.8
b	1.1	1.5	1.2

[0040] Fig. 10 shows the effect of the difference H of the fluid levels (i.e., the pressure difference) of Fabric 1 and Fabric 2 on the permeability at a specific viscosity value 2.73 cP, when the Ni content of the catholyte is 87 g/l.

Claims

1. A method of electrowinning nickel from an electrolyte that contains nickel sulphate in an electrolytic tank (1), which comprises a number of anodes (2) and a number of cathodes (3) that are arranged alternately, each anode (2) being arranged inside an anode bag (4), the anode bag consisting of a material that permeates the electrolyte in a controlled manner and defining inside it an anodic space (5) and outside it a free cathodic space, where the cathodes (3) are located, whereby nickel is precipitated on the surface of the cathode and acid and oxygen are generated on the anodes, and the hydrogen ions generated on the anode are prevented from entering through the diaphragm fabric by means of a pressure difference, so that the electrolyte flows constantly from the cathodic space into the anodic space inside the anode bag; and the catholyte is fed into the cathodic space of the electrolytic tank, removed therefrom as an overflow and recirculated back into the cathodic space, and the anolyte is removed separately from each anode bag as an overflow or by suction, and wherein as the material of the anode bag, a diaphragm fabric is selected from a group of diaphragm fabrics with different permeabilities, **characterised in that** the dependences of the permeability of the diaphragm fabric on the viscosity of the catholyte and the pressure difference used are determined and, on the basis of these determined dependences, the exit velocity of the anolyte from the anode bag is adjusted by the current density used, the pressure difference and the viscosity of the catholyte, so that an acid content of the anolyte of at least 122 g/l is obtained; and **in that** the concentration of nickel sulphate in the catholyte (8) and/or the viscosity of the catholyte are measured, and the circulation speed of the catholyte is increased, if the nickel sulphate concentration in the catholyte and/or the viscosity exceed a predefined limit value, and the circulation speed of the catholyte is reduced, if the nickel sulphate concentration in the catholyte and/or the viscosity of the catholyte are below the predefined limit value.
2. A method according to Claim 1, **characterised in that** the pressure difference is adjusted by changing the difference of height between the fluid levels of the anolyte and the catholyte.
3. A method according to any of Claims 1 or 2, **characterised in that** the anolyte (7) is removed from each anode bag (4) by overflow so that, to provide hydrostatic pressure, the level of the anolyte is kept lower than the level of the catholyte.
4. A method according to Claim 3, **characterised in that** the anolyte (7) is removed from each anode bag (4) by means of an overflow pipe (9), its head (10) defining the level of the anolyte in the anode bag.
5. A method according to Claim 4, **characterised in that** the anolyte (7) is conveyed from the overflow pipes (9) to a

collector (11).

6. A method according to any of Claims 1-5, **characterised in that** the anolyte (7) is removed from each anode bag (4) by means of a first suction pipe (12).
7. A method according to any of Claims 1-6, **characterised in that** oxygen and/or acid fog are sucked from the anode bag (4).
8. A method according to Claim 7, **characterised in that** the oxygen and/or acid fog are sucked from the anode bag (4) through the first suction pipe (12), a second suction pipe (13) and/or the overflow pipe (9).

Patentansprüche

1. Verfahren zur elektrolytischen Gewinnung von Nickel aus einem Elektrolyten, der Nickelsulfat enthält, in einem elektrolytischen Behälter (1), umfassend eine Reihe von Anoden (2) und eine Anzahl Kathoden (3), die abwechselnd angeordnet sind, wobei jede Anode (2) innerhalb einer Anodentasche (4) angeordnet ist, die Anodentasche aus einem Material besteht, das den Elektrolyt in einer kontrollierten Weise permeiert und die im Inneren einen anodischen Raum (5) definiert, und außerhalb einen freien kathodischen Raum aufweist, in dem die Kathoden (3) angeordnet sind, wobei Nickel auf der Oberfläche der Kathode präzipitiert und Säure und Sauerstoff an den Anoden erzeugt wird, und die Wasserstoffionen die an der Anode erzeugt werden, daran gehindert werden durch das Membrangewebe einzutreten mit Hilfe einer Druckdifferenz, so dass der Elektrolyt konstant aus dem kathodischen Raum in den anodischen Raum im Inneren des Anodenbeutels fließt; und der Katholyt in den kathodischen Raum des Elektrolytbehälters gespeist wird, daraus als Überlauf entfernt wird und in den kathodischen Raum zurück zirkuliert wird, und der Anolyt separat von jeder Anodentasche als Überlauf oder durch Absaugen entfernt wird, und wobei als das Material der Anodentasche ein Membrangewebe ausgewählt wird aus einer Gruppe von Membrangeweben mit unterschiedlichen Permeabilitäten,
dadurch gekennzeichnet, dass
die Abhängigkeiten der Durchlässigkeit des Membrangewebes von der Viskosität des Katholyten und der verwendeten Druckdifferenz ermittelt werden und, auf der Grundlage dieser ermittelten Abhängigkeiten, die Austrittsgeschwindigkeit des Anolyten aus der Anodentasche eingestellt wird durch die verwendete Stromdichte, die Druckdifferenz und der Viskosität des Katholyten, so dass ein Säuregehalt des Anolyten von mindestens 122 g / l erhalten wird; und dadurch, dass die Konzentration von Nickelsulfat in dem Katholyten (8) und / oder die Viskosität des Katholyten gemessen werden, und die Umlaufgeschwindigkeit des Katholyten erhöht wird, wenn die Nickelsulfatkonzentration im Katholyten und / oder die Viskosität einen vordefinierter Grenzwert überschreitet, und die Umlaufgeschwindigkeit des Katholyten verringert wird, wenn die Nickelsulfatkonzentration im Katholyten und / oder die Viskosität des Katholyten unter dem vordefinierter Grenzwert liegen.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Druckdifferenz durch Verändern der Höhendifferenz zwischen den Flüssigkeitspegeln des Anolyten und Katholyten eingestellt wird.
3. Verfahren nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** der Anolyt (7) von jeder Anodentasche (4) so durch Überlauf entfernt wird, um einen hydrostatischen Druck bereitzustellen, dass der Pegel des Anolyten niedriger gehalten wird als der Pegel des Katholyten.
4. Verfahren nach Anspruch 3, **dadurch gekennzeichnet, dass** der Anolyt (7) von jeder Anodentasche (4) mittels einer Überlaufleitung (9) entfernt wird, wobei dessen Kopf (10) den Pegel des Anolyten in der Anodentasche definiert.
5. Verfahren nach Anspruch 4, **dadurch gekennzeichnet, dass** der Anolyt (7) von der Überlaufleitungen (9) zu einem Sammler (11) befördert wird.
6. Verfahren nach einem der Ansprüche 1-5, **dadurch gekennzeichnet, dass** der Anolyt (7) von jeder Anodentasche (4) mittels einer ersten Saugleitung (12) entfernt wird.
7. Verfahren nach einem der Ansprüche 1-6, **dadurch gekennzeichnet, dass** Sauerstoff, und / oder Säurenebel aus dem Anodenbeutel (4) gesaugt wird.
8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** der Sauerstoff und / oder Säurenebel aus dem An-

odenbeutel (4) durch die erste Saugleitung (12), eine zweite Saugleitung (13) und / oder das Überlaufrohr (9) gesaugt werden.

5 Revendications

1. Procédé d'électrowinning de nickel à partir d'un électrolyte contenant du sulphate de nickel dans une cuve électrolytique (1), qui comprend un certain nombre d'anodes (2) et un certain nombre de cathodes (3) disposées de façon alternée, chaque anode (2) étant disposée à l'intérieur d'une enveloppe d'anode (4), l'enveloppe d'anode consistant en un matériau, qui s'imprègne par l'électrolyte d'une façon contrôlée, et définissant, à l'intérieur, un espace anodique (5) et, à l'extérieur, un espace cathodique libre, dans lequel sont situées les cathodes (3), une précipitation de nickel ayant lieu sur la surface de la cathode et sur les anodes sont produits de l'acide et de l'oxygène, et les ions d'hydrogène générés sur l'anode sont empêchés, au moyen d'une différence de pression, de passer à travers la membrane tissée, de sorte que l'électrolyte s'écoule constamment depuis l'espace cathodique vers l'espace anodique à l'intérieur de l'enveloppe d'anode, et le catholyte est amené dans l'espace cathodique de la cuve électrolytique, dont il est enlevé par débordement et re-circulé dans l'espace cathodique, et l'anolyte est enlevé séparément de chaque enveloppe d'anode par débordement ou par aspiration, procédé, dans lequel une membrane tissée est sélectionnée, comme matériau de l'enveloppe d'anode, parmi un groupe de membranes tissées ayant des perméabilités différentes, procédé **caractérisé en ce que** les dépendances de la viscosité du catholyte et de la différence de pression de la perméabilité de la membrane tissée sont déterminées et, sur la base de ces dépendances déterminées, la vitesse, à laquelle l'anolyte est enlevé de l'enveloppe d'anode, est ajustée par la densité du courant utilisée, la différence de pression et la viscosité du catholyte, de façon à obtenir une teneur en acide de l'anolyte d'au moins 122 g/l, et **caractérisé en ce que** la concentration de sulphate de nickel dans le catholyte (8) et/ou la viscosité du catholyte sont mesurées et la vitesse de circulation du catholyte est augmentée, si la concentration de sulphate de nickel dans le catholyte et/ou la viscosité excèdent une valeur limite prédéfinie et la vitesse de circulation du catholyte est réduite, si la concentration de sulphate de nickel dans le catholyte et/ou la viscosité du catholyte sont inférieures à une valeur limite prédéfinie.
2. Procédé suivant la revendication 1, **caractérisé en ce que** la différence de pression est ajustée en modifiant la différence en hauteur entre les niveaux de l'anolyte et du catholyte.
3. Procédé suivant une quelconque des revendications 1 ou 2, **caractérisé en ce que** l'anolyte (7) est enlevé de chaque enveloppe d'anode (4) par débordement de sorte que pour produire une pression hydrostatique, le niveau de l'anolyte est maintenu plus bas que le niveau du catholyte.
4. Procédé suivant la revendication 3, **caractérisé en ce que** l'anolyte (7) est enlevé de chaque enveloppe d'anode (4) au moyen d'un tuyau de trop-plein (9), dont la tête (10) définit le niveau de l'anolyte dans l'enveloppe d'anode.
5. Procédé suivant la revendication 4, **caractérisé en ce que** l'anolyte (7) est acheminé depuis les tuyaux de trop-plein (9) à un collecteur (11).
6. Procédé suivant une quelconque des revendications 1 à 5, **caractérisé en ce que** l'anolyte (7) est enlevé de chaque enveloppe d'anode (4) au moyen d'un premier tuyau aspirant (12).
7. Procédé suivant une quelconque des revendications 1 à 6, **caractérisé en ce que** l'oxygène et/ou les brouillards d'acide sont aspirés de l'enveloppe d'anode (4).
8. Procédé suivant la revendication 7, **caractérisé en ce que** l'oxygène et/ou les brouillards d'acide sont aspirés de l'enveloppe d'anode (4) à travers le premier tuyau aspirant (12), un second tuyau aspirant (13) et/ou le tuyau de trop-plein (9).

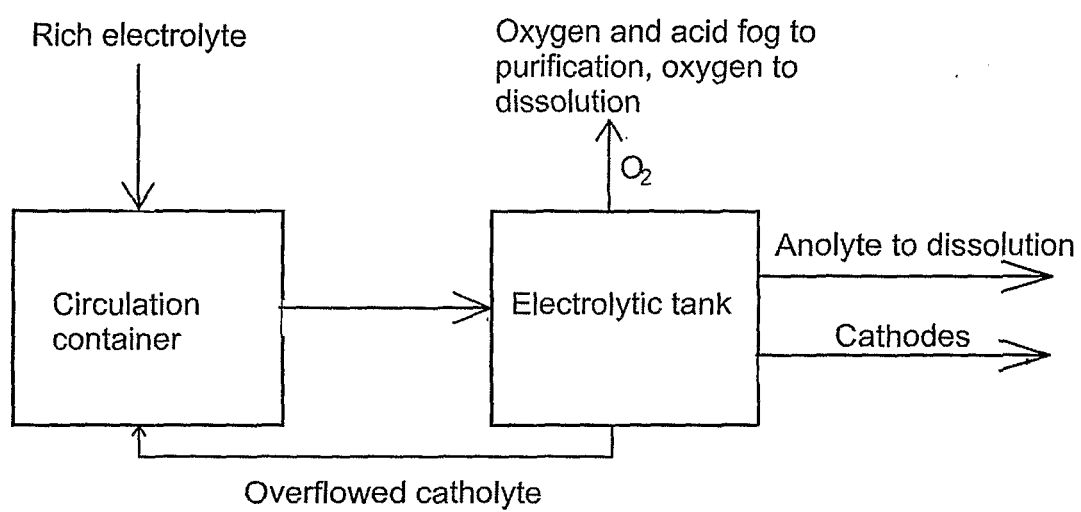


Fig. 1

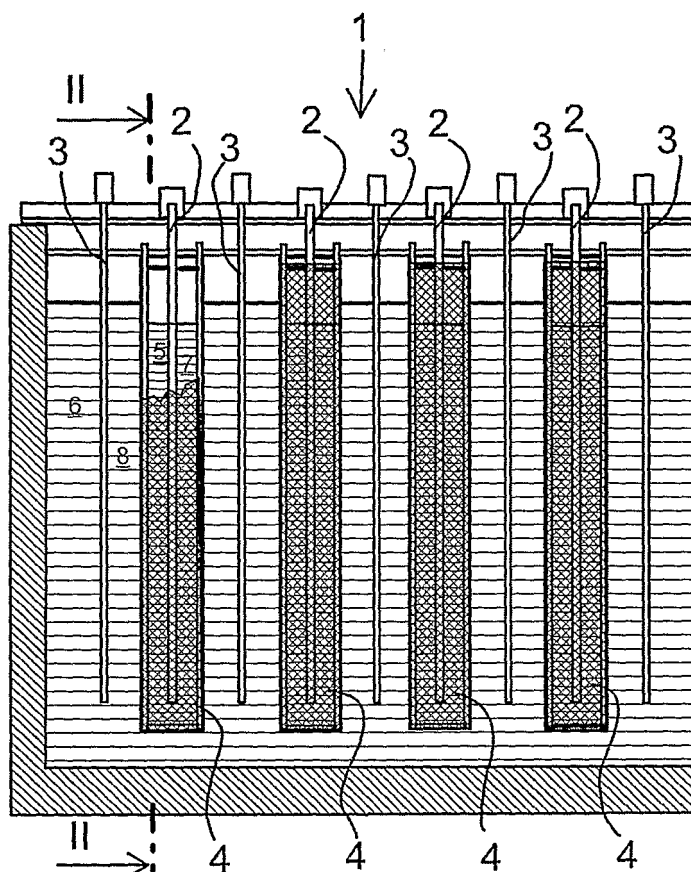


Fig. 2

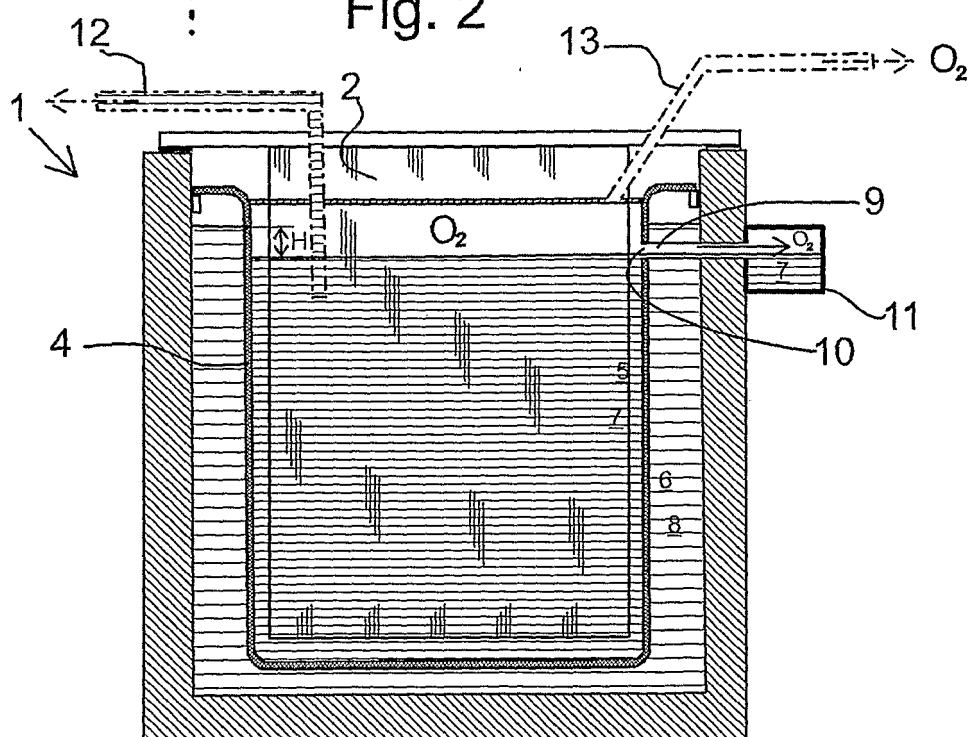


Fig. 3

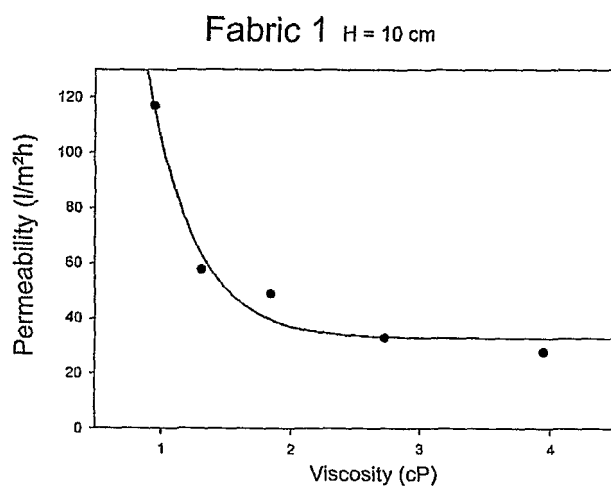


Fig. 4

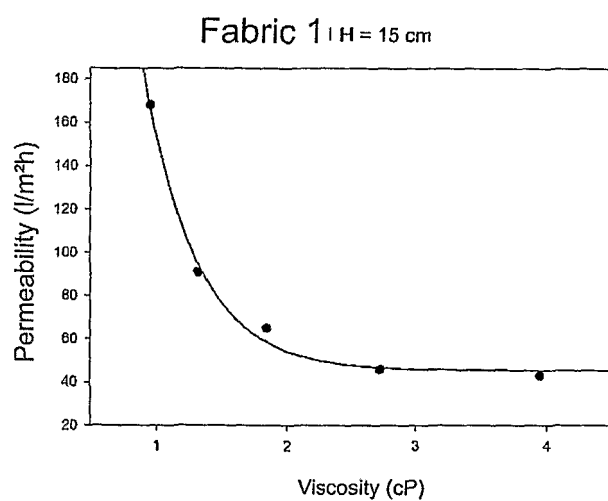


Fig. 5

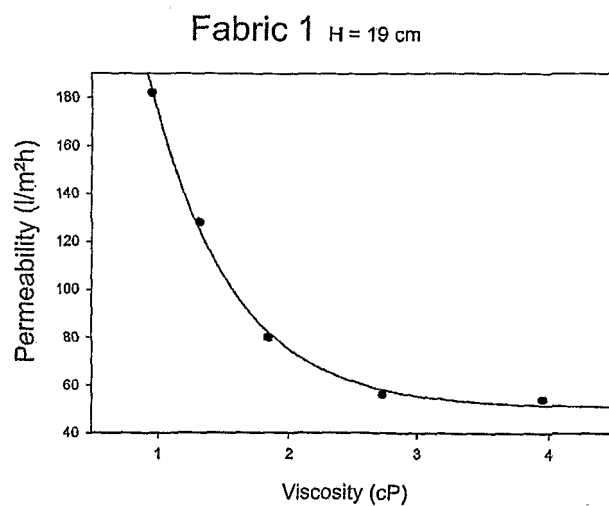


Fig. 6

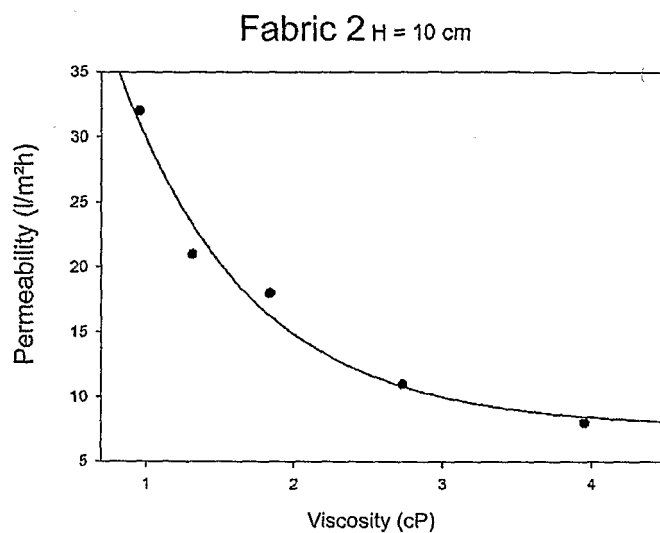


Fig. 7

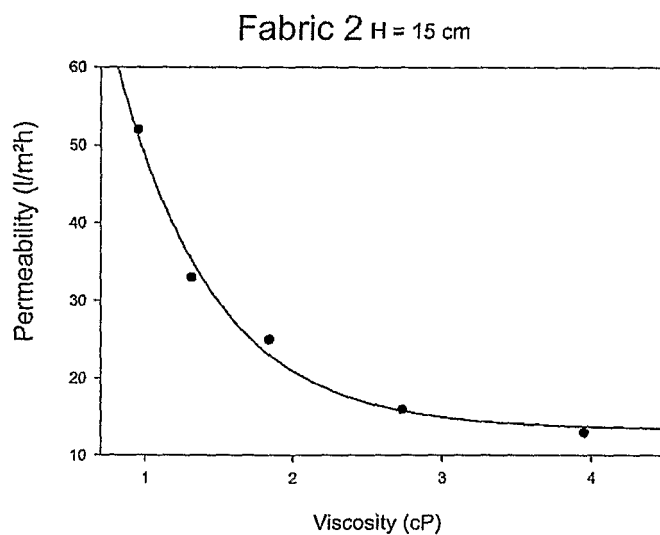


Fig. 8

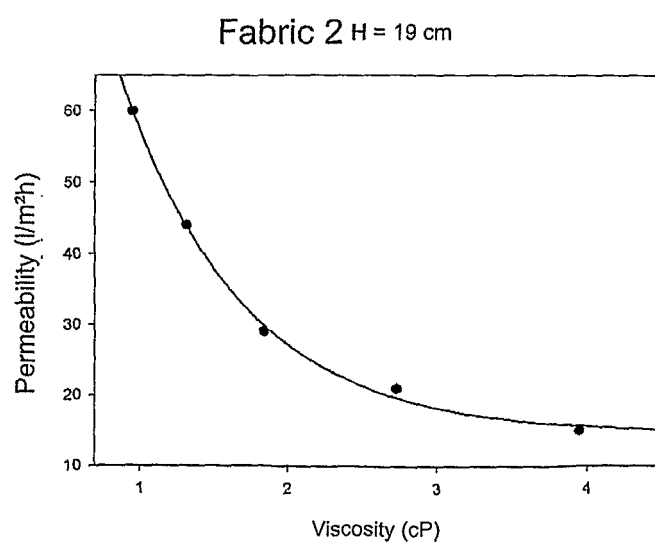


Fig. 9

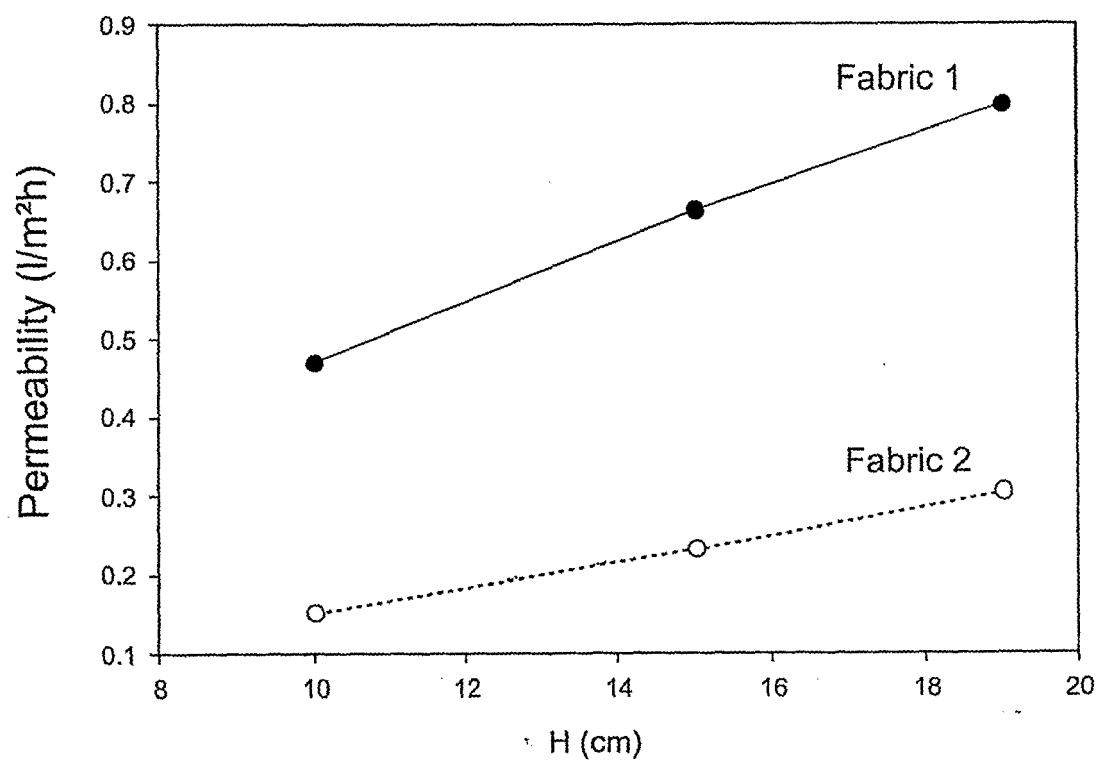


Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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