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(54) **Titre : Process and plant for producing alumina from aluminum hydroxide.**

(57) **Abrégé :**

In the production of alumina from aluminum hydroxide,

a) aluminum hydroxide is purified with washing water in a hydrate filter,

b) the purified aluminum hydroxide is at least partly dried and/or precalcined in at least one preheating stage,

c) this pretreated aluminum hydroxide is calcined in a fluidized-bed reactor to obtain alumina,

d) the alumina obtained is cooled in at least one indirect cooling stage using water as coolant,

e) the steam (D) obtained from the cooling water due to the heat transfer in the indirect cooling stage is separated from the liquid fraction (A) of the exit stream from the cooling stage (E),

f) and at least one partial stream (T) of the liquid fraction (A) is guided to the hydrate filter and used there as washing water for purifying the aluminum hydroxide in the hydrate filter.

In accordance with the invention, an additional water stream (Z) is added to the partial stream (T) of the liquid fraction (A) guided to the hydrate filter and the mixing ratio of the two streams (T, Z) is adjusted such that the washing water stream (W) resulting therefrom has a constant maximum temperature value below the boiling point of water and the volume flow required by the hydrate filter as washing water.

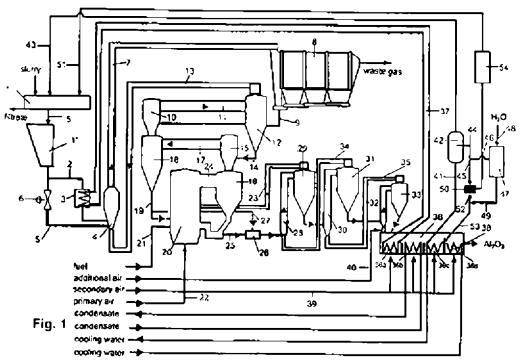


Fig. 1

Process and Plant for Producing Alumina from Aluminum Hydroxide

The present invention relates to a process and a plant for producing metal oxides from metal salts, in particular alumina from aluminum hydroxide, wherein the aluminum hydroxide (also called alumina trihydrate or 'hydrate') is first purified with washing water in a hydrate filter, the purified aluminum hydroxide then is at least partly dried and/or precalcined in at least one preheating stage, subsequently this pretreated aluminum hydroxide is calcined in a fluidized-bed reactor to obtain alumina, and the alumina obtained is cooled with water as coolant in at least one indirect cooling stage, then the steam obtained from the cooling water due to the heat transfer in the indirect cooling stage is separated from the liquid fraction of the exit stream from the cooling stage, and wherein at least one partial stream of the liquid fraction is guided to the hydrate filter and used there as washing water for purifying the aluminum hydroxide in the hydrate filter.

The production of alumina usually is effected by the so-called Bayer process. In this process, mined minerals, above all the aluminum-containing bauxite, are comminuted and mixed with sodium hydroxide solution (NaOH). Insoluble residues, above all the red mud chiefly consisting of iron oxide, are separated from the dissolved aluminum hydroxide in form of sodium aluminate ($Na[Al(OH)_4]$). From the dilute aluminate lye pure aluminum hydroxide $Al(OH)_3$ then is precipitated. This solid hydroxide is removed by filtration and washed. Subsequently, a conversion of the aluminum hydroxide to alumina (Al_2O_3) is effected by calcination.

The calcination of aluminum hydroxide involves a very high expenditure of energy. In conventional processes an energy expenditure of about 3000 kJ per kilogram of alumina produced is required. By coupling heat sources and heat sinks an attempt is made to lower the energy demand of the process and thus improve the profitability as well as the ecological balance.

A process for the energetically more efficient production of alumina from aluminum hydroxide is known for example from EP 0 861 208 B1 or from DE 10 2007 014 435 A1. Here, the moist aluminum hydroxide initially is dried in a first suspension heat exchanger and preheated to a temperature of about 160°C. After separation in a cyclone separator the solids are supplied to a second suspension heater, in which they are

further dried with the waste gas from the recirculation cyclone in a circulating fluidized bed. The predried solids then are charged to a fluidized-bed reactor with the circulating fluidized bed and calcined at temperatures of about 1000°C to obtain alumina. A partial stream of the preheated aluminum hydroxide is branched off after the first suspension preheater (EP 0 861 208 B1) or after the second suspension preheater (DE 10 2007 014 435 A1) and mixed with the hot alumina withdrawn from the recirculation cyclone of the circulating fluidized bed. The hot product mixture subsequently is cooled in a multi-stage suspension cooler in direct contact with air and then supplied to the final cooling in a fluidized bed cooler. To effectively utilize the energy recovered during cooling, this fluidized bed cooler is equipped with a plurality of chambers. The fluidization of the fluidized bed in the calcination reactor is effected by means of fluidizing gas (primary air), which in one of the chambers of the fluidized bed cooler is preheated to a temperature of about 188°C. In the suspension heat exchangers for the first cooling of the product, air additionally is heated to about 525°C in direct heat exchange with the alumina and then supplied to the fluidized-bed calcination reactor as secondary air.

From EP 0 245 751 B1 a process for performing endothermal processes on fine-grained solids is known, with which the product heat likewise should be utilized in a better way within the entire process. In the calcination of aluminum hydroxide, a partial stream of the starting material is supplied to an indirectly heated preheater and subsequently introduced into an electrostatic precipitator together with the directly supplied feedstock. The solids then are supplied from the electrostatic precipitator via two series-connected preheating systems to a circulating fluidized bed in which the solids are fluidized with fluidizing gas and calcined at temperatures of about 1000°C. The solids stream withdrawn from the circulating fluidized bed is cooled in an indirect fluidized-bed cooler forming a first cooling stage and then supplied to a second and a third cooling stage, each again in the form of fluidized-bed coolers, in order to further cool the solid product. The primary air heated up in the first fluidized-bed cooler is introduced into the fluidized-bed reactor as fluidizing air with a temperature of about 520°C, whereas the fluidizing air from the fluidized-bed cooler is fed into the fluidized-bed calcination reactor as secondary air with a temperature of 670°C. The heat-transfer medium of the second fluidized-bed cooler is supplied to the indirect preheater for the starting material as heating medium with a temperature of 200°C and then, after cooling to 160°C, recirculated to the inlet of the second fluidized-bed cooler.

Another heat sink in the process is heating up the filter water for purifying the aluminum hydroxide. Raw aluminum hydroxide, in particular the one which is obtained after pre-

cipitation from the aluminate lye, is washed before entry into the first preheating stage. In particular to remove the adhering soda, warm washing water is used for this purpose, since the solubility of the impurities is improved at elevated temperatures. However, this washing water must not reach the boiling temperature, since otherwise it would evaporate.

In AU 2 005 237 179 A1 the waste gas of the calcining reactor is utilized as heat source for heating the washing water for the aluminum hydrate filtration. According to the chemical equation

$$2\ Al(OH)_3 \rightarrow Al_2O_3 + 3\ H_2O$$

water is obtained in this reactor during the calcination. The waste gas withdrawn from the fluidized-bed reactor thus represents a mixture of the inert fluidizing gas of the reactor and the steam obtained by the reaction. The water condensed out of this mixture has a temperature of about 83°C and is recirculated to the aluminum hydrate filter as washing water. In such a process it is, however, disadvantageous that due to the comparatively low water concentration (about 50%) in the waste gas of the calcining apparatus a higher water temperature of the condensate cannot be achieved and thus the purification in the hydrate filter is not carried out under optimal conditions, namely at a water temperature slightly below the boiling point.

Another possibility for obtaining already preheated washing water for the hydrate filter is to withdraw the cooling water from an indirect cooling stage, remove the evaporated fraction and recirculate the liquid fraction to the hydrate filter. However, this process has the disadvantage that it cannot be adapted to dynamic process conditions. When the temperature or the mass flow of the material to be calcined increases, the proportion of the heat quantity to be discharged in the respective cooling stage will also increase. As a consequence, the coolant water in the cooling stage will either evaporate completely or at least to such a great extent that sufficient washing water no longer is available for the hydrate filter.

Therefore, it is the object of the invention to provide for supplying the hydrate filter with filter water as warm as possible under unsteady operating conditions.

In accordance with the invention, this object is solved with the features of claim 1. To the partial stream (W) of the liquid fraction (A) of the cooling stage outlet, which is

guided to the hydrate filter, a further water stream (R) is added, whereby the mixing ratio of the two streams is adjusted such that the washing water stream (W) resulting therefrom has a constant maximum temperature value below the boiling point and the volume flow required by the hydrate filter as washing water. At normal pressure in the hydrate filter, this maximum temperature value lies in a range between 90 and 100°C, wherein a value of 95°C is preferred and a value of 97°C is particularly preferred. When the mass flow of the alumina to be cooled increases or the temperature in the solids to be cooled increases, more steam (D) is generated. The temperature of the washing water stream (W) is controlled by adding the water stream (Z), so that the temperature falls below the constant maximum temperature value or even at high evaporation rates the volume flow does not fall below the value required for the hydrate filtration. It was found to be particularly favorable to design the indirect cooling stage as a fluidized-bed cooler with a plurality of individual chambers. To particularly effectively utilize the heat quantity contained in the still hot alumina, the heat quantity obtained in the first cooling chamber is utilized for preheating the hydrate in a hydrate drier by indirect heat transfer. The cooling water of the second fluidized-bed chamber is utilized for preheating the primary air of the process, as described in EP 0 245 751 B1, and the cooling water of the third chamber is utilized for preheating the washing water stream of the hydrate filter according to the invention.

Preferably, passing cooling water through the indirect cooling stage is operated at excess pressure, and the cooling water is expanded after passing through the indirect cooling stage. In this way, phase transitions of the coolant and, connected therewith, a reduced heat transfer in the cooling stage can be avoided. For example, if the amount of energy to be released to the cooling water fluctuates due to a transient increase of the mass flow of the alumina or due to a higher inlet temperature of the alumina, more steam is generated. Since the evaporation consumes much energy, the amount of steam in relation is not much increased and the constant amount and temperature of washing water required for a constant operation in the process is not influenced. It has turned out that a steam quantity (D) above a minimum steam quantity is advantageous for the filtration and the residual moisture content in the hydrate.

To ensure that the flow of cooling water within the respective cooling stage is constant, fresh water (F) is added to the residual stream (R) left after the separation of the partial stream of the liquid fraction, which results from the difference of the total stream (E) and the branched steam (D) and the partial stream (T). The mixed stream (M) obtained by mixing the streams (A) and (F) is at least partly recirculated into the indirect cooling

stage as cooling stream (K). To simplify the temperature control in the plant, the cooling stream (K) always can be adjusted with constant volume flow and/or with constant temperature. Due to the possibility of a flexible admixture of the fresh water stream (F), the volume flow and/or the temperature of the cooling water (K) in the cooling stage can, however, also be controlled in dependence on the quantity and/or the temperature of the alumina to be cooled.

The remaining liquid fraction (R) can, however, also first be pumped into a storage tank and be mixed there with fresh water (F), whereby a water reservoir can be established in this storage tank, whose possible temperature range lies between the fresh water temperature and the temperature of the residual stream (R).

To simplify the control principle, the water stream (Z) added to the partial stream (T) of the liquid fraction (A) still can be taken from fresh water.

It is particularly favorable when this water stream (Z) for adjusting the temperature and the volume flow of the washing water (W) is a partial stream of the mixed stream (M) pumped into the storage tank and mixed there with fresh water, as in this way a higher temperature of the water stream (Z) can be achieved without additional heating.

In energetic terms it is particularly advantageous when the hydrate filter is equipped with a steam hood, whereby the hydrate can already be subjected to a first drying during the filtration. In an advantageous aspect of the invention, this steam hood is at least partly operated with that steam (D) which is obtained from the cooling water of the indirect cooling stage, since the energy demand for further predrying stages can thus be reduced.

The invention also relates to a plant for producing alumina from aluminum hydroxide, which is suitable for carrying out the described process and includes the features of claim 8. The plant contains at least one hydrate filter in which the aluminum hydroxide is purified with washing water, at least one preheating stage in which the purified aluminum hydroxide is at least partly dried and/or precalcined, a fluidized-bed reactor in which the pretreated aluminum hydroxide is calcined to obtain alumina, and at least one indirect cooling stage with a cooling circuit with water as coolant, in which the alumina obtained is cooled. After the indirect cooling stage an apparatus for steam separation is provided, in order to separate gaseous and liquid fractions of the cooling water. A return conduit connects the cooling circuit of the indirect cooling stage with the

washing water supply conduit into the hydrate filter, wherein according to the invention a control device is provided after the steam separation, which adjusts the supply of washing water to a constant maximum temperature value below the boiling point of water and to the volume flow required by the hydrate filter as washing water, in that it controls the quantity ratios of the partial stream (W) guided to the hydrate filter and of the further water stream (Z). Furthermore, the control device is connected with the inlet of the cooling circuit via a conduit.

In accordance with a development of the invention, a storage tank is provided in the conduit opening into the inlet of the cooling circuit, which at the same time can be used as water source for adjusting the temperature and quantity of the washing water supplied to the hydrate filter.

In accordance with one aspect of the invention, the hydrate filter is equipped with a steam hood for the partial drying of the aluminum hydrate, wherein this steam hood is connected with the steam outlet of the steam separation via a conduit. As a result, the steam obtained can be used at a point in the process at which fluctuations in terms of steam quality and quantity hardly have any influence on the process control.

It is particularly advantageous when a heat exchanger is provided in the conduit proceeding from the control device and opening into the hydrate filter. During start-up of the plant, when no hot alumina is present yet in the indirect cooling stage, said heat exchanger provides for nevertheless operating the already charged hydrate filter with warm washing water. In principle, this heat exchanger can also be provided at another position, for example between the steam separation and the control device, whereby the water recirculated both to the hydrate filter and to the cooling stage is heated and thus the temperature control via the cooling stage itself proceeds in a narrow temperature range from the beginning.

Further developments, advantages and possible applications of the invention can also be taken from the following description of an embodiment and the drawing. All features described and/or illustrated form the subject-matter of the present invention per se or in any combination, independent of their inclusion in the claims or their back-reference.

In the drawing:

Fig. 1 schematically shows a plant for carrying out the process according to the invention;

Fig. 2 schematically shows a plant for carrying out the process according to the invention in accordance with a second embodiment;

Fig. 3 schematically shows a plant for carrying out the process according to the invention in accordance with a third embodiment;

Fig. 4 shows the course of the individual streams in conjunction with the cooling stage; and

Fig. 5 shows the decrease of the residual moisture in dependence on the relative steam quantity used.

According to the flow diagram of the process of the invention as shown in Fig. 1, the slurry which contains raw aluminum hydroxide ($Al(OH)_3$) is charged to a hydrate filter 1 and purified there with washing water from conduit 51. Preferably, the hydrate filter is equipped with a steam hood 1', whereby the hydrate is already partly dried during the filtration. The filtrate is discharged.

After the purification, the aluminum hydroxide is introduced via a conduit 5 into a bunker 1', by means of which fluctuations in the educt addition can be compensated. From there, the hydrate is introduced via conduit 2 into a hydrate drier 3, in which the hydrate is heated to a temperature of about 100 to 110°C by indirect heat exchange with a liquid heat-transfer medium, in particular water, and is dried almost completely proceeding from a moisture of e.g. 6%. The dried hydrate subsequently is supplied to a suspension heat exchanger 4 of a first preheating stage and preheated to a temperature of 100 to 200°C.

Via a bypass conduit 5', past the hydrate drier 3, a partial stream of the hydrate can directly be supplied to the suspension heat exchanger 4. The size of the partial stream is adjusted via a control valve 6 which can be arranged in the conduit 2 or the bypass conduit 5. The control of the bypass stream is effected in dependence on the waste gas temperature, in order to keep the energy loss as low as possible. If a greater amount of the hydrate is guided over the hydrate drier 3, the waste gas temperature of the suspension heat exchanger 4 increases, since more moisture (water) is removed in the

hydrate drier 3 and evaporated not only in the succeeding suspension heat exchanger 4. When supplying a small hydrate quantity to the hydrate drier 3, a greater amount of moist hydrate is supplied to the suspension heat exchanger 4 and the waste gas temperature decreases correspondingly. The solids introduced into the suspension heat exchanger 4 are seized by a waste gas stream coming from a second preheating stage, heated by the same and via a conduit 7 pneumatically introduced into the inlet region of an electrostatic gas cleaning (ESP) 8, which constitutes a preseparator. In the electrostatic precipitator 8, the gas is cleaned and with a temperature of 110 to 170°C, preferably 120 to 140°C, discharged into a non-illustrated chimney.

The solids emerging from the electrostatic gas cleaning 8 are delivered via a conduit 9 into a second suspension heat exchanger 10 of the second preheating stage, in which the solids are seized by the gas stream emerging from a third preheating stage, heated to a temperature of 150 to 300°C and supplied to a separating cyclone 12 via a conduit 11. The waste gas stream of the separating cyclone 12 is supplied to the suspension heat exchanger 4 via a conduit 13, in order to heat the hydrate and deliver the same to the electrostatic precipitator.

Via a conduit 14, the solids from the separating cyclone 12 are introduced into a third suspension heat exchanger 15 (third preheating stage), seized by a gas stream emerging from a recirculation cyclone of a circulating fluidized bed and further dewatered and at least partly dehydrated (precalcined) to obtain monohydrated alumina (chemical formulae $Al_2O_3.H_2O$, or AlOOH), hereafter called monohydrate, at temperatures of 200 to 450°C, in particular 250 to 370°C.

Via a conduit 17, the gas-solids stream is supplied to a separating cyclone 18 in which in turn a separation of the gas-solids stream is effected, wherein the solids are discharged downwards through a conduit 19 and the waste gas is introduced into the second suspension heat exchanger 10 of the second preheating stage.

In the second and in particular the third preheating stage a precalcination of the aluminum hydroxide thus is effected. Precalcination in the sense of the present invention is understood to be the partial dehydration or splitting off of compounds, such as e.g. HCl and NOx. Calcination, on the other hand, refers to the complete dehydration or splitting off of compounds such as e.g. SO_2.

After the separating cyclone 18 following the third suspension heat exchanger 14, the solids are divided by means of an apparatus described for example in DE 10 2007 014 435 A1. Via a conduit 19, a main stream containing about 80 to 90 wt-% of the solids stream is supplied to a fluidized-bed reactor 20 in which the solids are calcined and dehydrated to alumina (Al_2O_3) at temperatures of 850 to 1100°C, in particular about 950°C.

The supply of the fuel required for the calcination is effected via a fuel conduit 21 which is arranged at a small height above the grate of the fluidized-bed reactor 20. The oxygen-containing gas streams required for combustion are supplied via a supply conduit 22 as fluidizing gas (primary air) and via a supply conduit 23 as secondary air. As a result of the gas supply a relatively high suspension density is obtained in the lower reactor region between the grate and the secondary gas supply 23, and above the secondary gas supply 23 a comparatively low suspension density is obtained. After the usual compression, the primary air is fed into the fluidized-bed reactor 23 at a temperature of about 80°C without further heating. The temperature of the secondary air is about 550°C.

Via a connecting conduit 24, the gas-solids suspension enters into the recirculation cyclone 16 of the circulating fluidized bed, in which a further separation of solids and gas is effected. The solids emerging from the recirculation cyclone 16 via the conduit 25 with a temperature of about 950°C are introduced into a mixing tank 26. Via a bypass conduit 27, the partial stream separated below the separating cyclone 27 and chiefly consisting of monohydrate also is introduced into the mixing tank 26 with a temperature of about 320 to 370°C. In the mixing tank 26 a mixing temperature of about 700°C is adjusted corresponding to the mixing ratio between the hot alumina stream supplied via the conduit 25 and the monohydrate stream supplied via the bypass conduit 27. The two product streams are intermixed in the mixing tank 26 which includes a fluidized bed, in order to also completely calcine the monohydrate supplied via the bypass conduit 27 to obtain alumina. A very long retention time of up to 30 minutes, preferably of up to 60 minutes, leads to an excellent calcination in the mixing tank. However, a retention time of less than 2 minutes, in particular 1 minute or even less than 30 seconds can also be sufficient.

The product obtained is supplied from the mixing tank 26 to a first suspension cooler formed of rising conduit 28 and cyclone separator 29. Via the conduit 23, the waste gas of the cyclone separator 29 flows into the fluidized-bed reactor 20 as secondary air, the

solids are delivered into the second suspension cooler formed of rising conduit 30 and cyclone separator 31, and finally into the third suspension cooler formed of rising conduit 32 and cyclone separator 33. The gas flow through the individual suspension coolers is effected in counterflow to the solids via the conduits 34 and 35.

After leaving the last suspension cooler, the alumina produced undergoes a final cooling in the fluidized bed cooler 36 equipped with three to four cooling chambers. The alumina enters into its first chamber 36a with a temperature of about 300°C and heats up a liquid heat-transfer medium, in particular water, to a temperature of 140 to 195°C, preferably 150 to 190°C, and in particular 160 to 180°C. Via a circulation conduit 37, the heated heat transfer medium is supplied to the hydrate drier 3, in order to there dry the metal salt (hydrate) by indirect heat exchange.

After passing through the hydrate drier 3, the heat-transfer medium is recirculated via the circulation conduit 37 to the first stage 36a of the fluidized bed cooler with a temperature of 100 to 190°C, preferably 120 to 180°C and in particular 140 to 170°C. The pressure in the heat transport circuit preferably is adjusted such that a condensation of the heat-transfer medium in the hydrate drier 3 is avoided, and lies at about 1 to 50 bar, in particular between 2 and 40 bar. In the downstream chamber 36b the alumina is cooled further by a countercurrently guided heat-transfer medium, preferably water. The heat-transfer medium can be used for preheating the primary air, which is blown into the fluidized-bed reactor 20 via conduit 22.

In the third heating chamber 36c the heat transfer medium has a temperature between 100 and 140°C, preferably 110 to 135°C, and particularly preferably about 120°C. Via conduit 41 it is supplied to a steam separation 42 in which the steam is separated from the liquid fraction. Via conduit 43, this steam can be supplied to the hydrate filter 1 or to its steam hood 1' and here already subject the hydrate to a first predrying.

Via conduit 44, the liquid fraction is withdrawn from the steam separation 42. The control device 50 withdraws a part of this liquid fraction via conduit 45 and mixes the same with an additional water stream, which is fed into the control device 50 via the conduit 52. The newly formed stream is mixed such that it is adjusted to a certain temperature value, preferably 95°C and more preferably 97°C, with fluctuations of +/- 2°C, preferably +/- 1°C, and particularly preferably +/- 0.5°C. Furthermore, the washing water stream guided to the hydrate filter 1 via conduit 51 has a certain volume flow. In conduit 51 a heat exchanger 54 is provided, which heats the washing water to the

required temperature value when the cooling stage 36c cannot provide enough energy, as is the case for example in start-up processes.

The fraction of the liquid stream discharged via conduit 45 is supplied through a conduit 46 to a storage and mixing tank 47, to which in addition fresh water is supplied via a conduit 48. By means of conduit 49, a mixture of the liquid fraction of the cooling stage and fresh water can be withdrawn from the storage tank 47 and then partly be introduced via conduit 52 into the control device 50 for adjusting the required maximum temperature value and the volume flow of the washing water for the hydrate filter 1. Via conduit 53, the remaining rest is again fed into the cooling circuit of the cooling stage 36c as cooling medium, wherein it was found to be particularly favorable when this volume flow is kept constant and in an advantageous aspect also has a constant temperature. As control variable, the temperature of the washing water entering into the hydrate filter 1 is used.

The pressure in the cooling circuit of the cooling chamber 36c either can be kept constant at 5 bar or be adjusted in dependence on the flow rate and/or the cooling water temperature after passing through the chamber 36c.

The chambers 36a to 36d are fluidized by means of secondary air, which is supplied via a conduit 39 with a temperature of 80 to 100°C. The secondary air subsequently is withdrawn from the fluidized bed cooler 36 and used as conveying air for the third suspension cooler. The secondary air passes through the suspension cooler in counterflow to the solids stream withdrawn from the fluidized-bed reactor 20, wherein it is heated up before it is fed into the fluidized-bed reactor 20 via the conduit 23. Via a conduit 40, additional air can be guided into the cooling stages 36. Instead of air, pure oxygen or air enriched with oxygen with an oxygen content of 21 to 100 vol-% can also be supplied via the conduit 39 and/or 40.

Fig. 2 shows a simplified representation of a calcining plant with which aluminum, but also other metal hydrates, can be calcined. Analogous to Fig. 1, the hydrate slurry is charged to a filter 1 and washed with water from the conduit 51. Here as well, the filter preferably is equipped with a steam hood into which steam is introduced via conduit 51, whereby the material removed by filtration is already partly dried. The filtrate is discharged and the hydrate obtained is brought into a bunker 1' via conduit 5. From there, it can uniformly be used for charging the plant via conduit 5'.

This plant includes a suspension heat exchanger 4, from which the material is introduced into a filter device 8 via conduit 7. Via conduit 9, it is delivered from there into a further suspension heat exchanger 15 which is connected with a separating cyclone 18 by conduit 17.

Via conduit 19, the preheated and dried material then is delivered into the calcining reactor 20. This reactor is connected with the recirculation cyclone 16 by conduit 24. It is also favorable to design the reactor as fluidized-bed reactor and to introduce heated fluidizing gas into the reactor via the conduit 22. The conditions in the pretreatment and calcination substantially correspond to those described in Fig. 1 in connection with the calcination of aluminum.

The solids emerging from the recirculation cyclone 16 via the conduit 25 and the solids separated via a bypass conduit 27 below the separating cyclone 18 are introduced into a mixing tank 26. In this mixing tank 26 a mixing temperature is adjusted corresponding to the mixing ratio between the hot oxide stream supplied via the conduit 25 and the hydrate stream supplied via the bypass conduit 27, and the hydrate likewise is calcined. To ensure good intermixing, it turned out to be favorable when the solids are present in the mixing tank 26 as a circulating fluidized bed.

Through conduit 35, the solids then are introduced into a cyclone separator 33 which is connected with a multistage fluidized bed cooler 36. The chambers of the cooler 36 can be used for preheating various process streams. The circuitry shown here corresponds to the one known from Fig. 1.

Via conduit 41, water heated in one of the chambers is supplied to a steam separation 42 in which the steam is separated from the liquid fraction. Via conduit 43, this steam can be supplied to the hydrate filter 1.

Via conduit 44, the liquid fraction is withdrawn from the steam separation 42 and introduced into a control device 50. The same withdraws a part of this liquid fraction via conduit 45 and mixes the same with an additional water stream, which is delivered into the control device 50 via the conduit 52. The newly formed stream thus can be adjusted to a certain temperature value, preferably 95°C and more preferably 97°C, with fluctuations of +/- 2°C, preferably +/- 1°C, and particularly preferably +/- 0.5°C.

Via conduit 51, the washing water stream is guided to the hydrate filter 1, wherein in conduit 51 a heat exchanger 54 is provided, which can heat the washing water to the required temperature value, when the same does not yet have the required temperature.

The fraction of the liquid stream not discharged via conduit 45 is supplied through a conduit 46 to a storage and mixing tank 47. Into this mixing tank fresh water additionally is delivered via a conduit 48. Through conduit 49 water can be removed from the storage tank 47 and then partly be supplied to the control device 50 via conduit 52 for adjusting the required maximum temperature value and the volume flow of the washing water for the hydrate filter 1. Via conduit 53, the remaining rest is again fed into the cooling circuit of the cooling stage 36c as cooling medium. Control variable is the temperature of the washing water entering into the hydrate filter 1 via conduit 51.

Fig. 3 corresponds to the representation of Fig. 2 with the exception that after the calcining reactor 20 and the mixing tank 26 not one, but two suspension heat exchangers 29, 33 are provided, which are connected with each other via conduit 35.

Fig. 4 shows a schematic representation of the individual streams inside the unit consisting of cooling stage 36c, hydrate filter 1 and the associated cooling circuit system. In the cooling stage 36c, warm alumina preferably is introduced in a fluidized-bed chamber. If the cooling stage is designed as fluidized-bed cooling stage, fluidizing gas is supplied to the same, as shown in Fig. 4. Above the fluidized bed, additional gas can flow. The stream E withdrawn from the cooling stage 36c contains the total stream of the coolant heated in the cooling stage. In the steam separation 42, the gaseous fraction is branched off from this stream E as steam stream D and the liquid fraction is withdrawn as stream A. It is favorable that the stream E is under excess pressure and is expanded to normal pressure in the steam separation 42 and an upstream unit, respectively. The liquid fraction A withdrawn from the steam separation 42 is divided into a partial stream T and a residual stream R. The fraction T represents that fraction which ultimately is recirculated into the hydrate filter 1 as washing water.

To avoid that the washing water of the hydrate filter 1 boils during the filtration and thus no longer is available for the cleaning process, an additional stream Z is admixed to the partial stream T, wherein the admixed fraction is so large that the temperature of the total stream of the washing water W obtained by mixing the streams T and Z has a fixed temperature value of about 95°C, preferably 97°C, but in any case below the

boiling point of water. In addition, the volume flow of the washing water is kept constant.

The fraction of the liquid stream A used as washing water is supplied to the storage tank 47 as residual stream R. It is mixed there with fresh water from the stream F. The mixture withdrawn from the storage tank 47, namely the mixed stream M, is partly used as stream Z.

The difference between the streams M and Z is fed back into the indirect cooling 36c as cooling stream K. The volume flow of this cooling stream K is kept constant.

In a usual plant, about 3 t h^{-1} of steam will be obtained in the third cooling chamber 36c at full load operation. For safety reasons, the plant sections connected with the third cooling chamber 36c must be designed such that all waters of the cooling circuit would be able to evaporate. This quantity results from the multiplication of the water quantity guided as cooling water with the temperature difference occurring via the cooling stage and the thermal capacity of water at the mean temperature in the cooling chamber 36c. With a water quantity of 72 t h^{-1}, a temperature difference of 48°C and a mean thermal capacity of 4.2 kJ kg^{-1} K^{-1}, an amount of energy of 14.5 GJ h^{-1} is calculated, which corresponds to a steam quantity of 7960 Nm^3 h^{-1}. Therefore, all valves must be designed for a load of about 8000 Nm^3 h^{-1} of steam.

Fig. 5 shows the decrease of the residual moisture in the hydrate in dependence on the steam quantity used, wherein this steam quantity is indicated relative to the solids quantity used. By using higher steam quantities, the residual moisture in the hydrate thus can be lowered, which leads to the stabilization of the process, as the input of large amounts of water into the process can thus be prevented. The advantageous reduction of the moisture of the hydrate thus leads to a decrease of the energy demand in the calcining process.

Example

The values of Table 1 refer to a circuitry as it is shown in Fig. 4. In columns 2 to 9 the respective mass flows per hour are depicted, whereas in columns 10 to 16 the temperatures of the respective streams are indicated. The Table illustrates the size of the individual streams and their respective temperature at different conditions, in particular at different volume flows of the washing water to the hydrate filter. If less water is

required in the hydrate filter 1, larger fractions are collected in the storage tank 47 at the same total volume.

Table 1.1: Mass flows and temperature values in a circuitry according to the process of the invention.

	M [kg h^{-1}]	Z [kg h^{-1}]	K [kg h^{-1}]	E [kg h^{-1}]	A [kg h^{-1}]	W [kg h^{-1}]	F [kg h^{-1}]	D [kg h^{-1}]	T(M) [°C]	T(E) [°C]	T(W) [°C]	T(D) [°C]	T(S)* [°C]	T(A)* [°C]
1	8200	9169	72831	72831	72355	81524	82000	476	52	106	97	103	161	68
2	8200	9135	72865	72865	71919	73862	74808	946	56	109	97	103	161	67
3	8200	9080	72920	72920	71508	66287	67698	1411	61	113	97	103	161	67
4	8200	9017	72983	72983	71110	58794	60667	1873	65	116	97	103	161	67
5	8200	8815	73185	73185	70910	51361	53636	2275	70	119	97	103	161	67
6	8200	8649	73351	73351	70639	43969	46680	2712	74	122	97	103	161	67
7	8200	8416	73584	73584	70441	36592	39735	3143	78	125	97	103	161	68
8	8200	8240	73760	73760	70141	29283	32901	3618	82	129	97	103	161	68
9	8200	7902	74098	74098	70009	21904	25993	4089	87	132	97	103	161	68
10	8200	6779	75221	75221	70713	12851	18358	4508	91	134	97	103	161	68

*T(S): Temperature at the boiling point of the steam

*T(A): Exit temperature of the aluminum

List of Reference Numerals:

1	hydrate filter
1'	bunker
2	conduit
3	hydrate drier
4	suspension heat exchanger
5, 5	conduit
6	control valve
7	conduit
8	electrostatic precipitator
9	conduit
10	suspension heat exchanger
11	conduit
12	separating cyclone
13	conduit
14	conduit
15	suspension heat exchanger
16	recirculation cyclone
17	conduit
18	separating cyclone
19	conduit
20	fluidized-bed reactor
21	fuel conduit
22	supply conduit
23	supply conduit
24	connecting conduit
25	conduit
26	mixing tank
27	bypass conduit
28	rising conduit
29	cyclone separator
30	rising conduit
31	cyclone separator
32	rising conduit
33	cyclone separator
34	conduit

35	conduit
36	fluidized-bed cooler (several chambers)
36a-d	chambers of the fluidized-bed cooler 36
37	circulation conduit
38	conduit
39	conduit
40	conduit
41	conduit
42	steam separation
43	conduit
44	conduit
45	conduit
46	conduit
47	storage tank
48	conduit
49	conduit
50	control device
51	return conduit
52	conduit
53	conduit
54	heat exchanger

A	liquid fraction
D	steam stream
E	coolant stream
F	fresh water stream
M	mixed stream
R	residual stream
T	partial stream
W	washing water stream
Z	additional stream

Claims

1. A process for producing alumina from aluminum hydroxide, wherein

a) aluminum hydroxide is purified with washing water in a hydrate filter,

b) the purified aluminum hydroxide is at least partly dried and/or precalcined in at least one preheating stage,

c) this pretreated aluminum hydroxide is calcined in a fluidized-bed reactor to obtain alumina,

d) the alumina obtained is cooled in at least one indirect cooling stage using water as coolant,

e) the steam (D) obtained from the cooling water due to the heat transfer in the indirect cooling stage is separated from the liquid fraction (A) of the exit stream from the cooling stage (E),

f) and at least one partial stream (T) of the liquid fraction (A) is guided to the hydrate filter and used there as washing water for purifying the aluminum hydroxide in the hydrate filter,

characterized in that to the partial stream (T) of the liquid fraction (A) guided to the hydrate filter an additional water stream (Z) is added, and that the mixing ratio of the two streams (T, Z) is adjusted such that the washing water stream (W) resulting therefrom has a constant maximum temperature value below the boiling point of water and the volume flow required by the hydrate filter as washing water.

2. The process according to claim 1, **characterized in** that the passage of cooling water through the indirect cooling stage is operated at excess pressure and the cooling water is expanded after passing through the indirect cooling stage.

3. The process according to claim 1 or 2, **characterized in** that fresh water (F) is added to the residual stream (R) remaining after the separation of the partial stream (T) of the liquid fraction (A) and the resulting mixed stream (M) is at least partly recirculated into the cooling stage.

4. The process according to claim 3, **characterized in** that the residual stream (R) is pumped into a storage tank and mixed there with the fresh water (F).

5. The process according to any of the preceding claims, **characterized in** that the additional water stream (Z) consists of fresh water.

6. The process according to claim 3 or 4, **characterized in** that the water stream (Z) for adjusting the temperature and the volume flow of the washing water (W) is a partial stream of the mixed stream (M) mixed with fresh water.

7. The process according to any of the preceding claims, **characterized in** that the hydrate filter is equipped with a steam hood which is at least partly operated with the steam (D) obtained from the cooling water of the indirect cooling stage.

8. A plant for producing alumina from aluminum hydroxide with a process according to any of the preceding claims, comprising

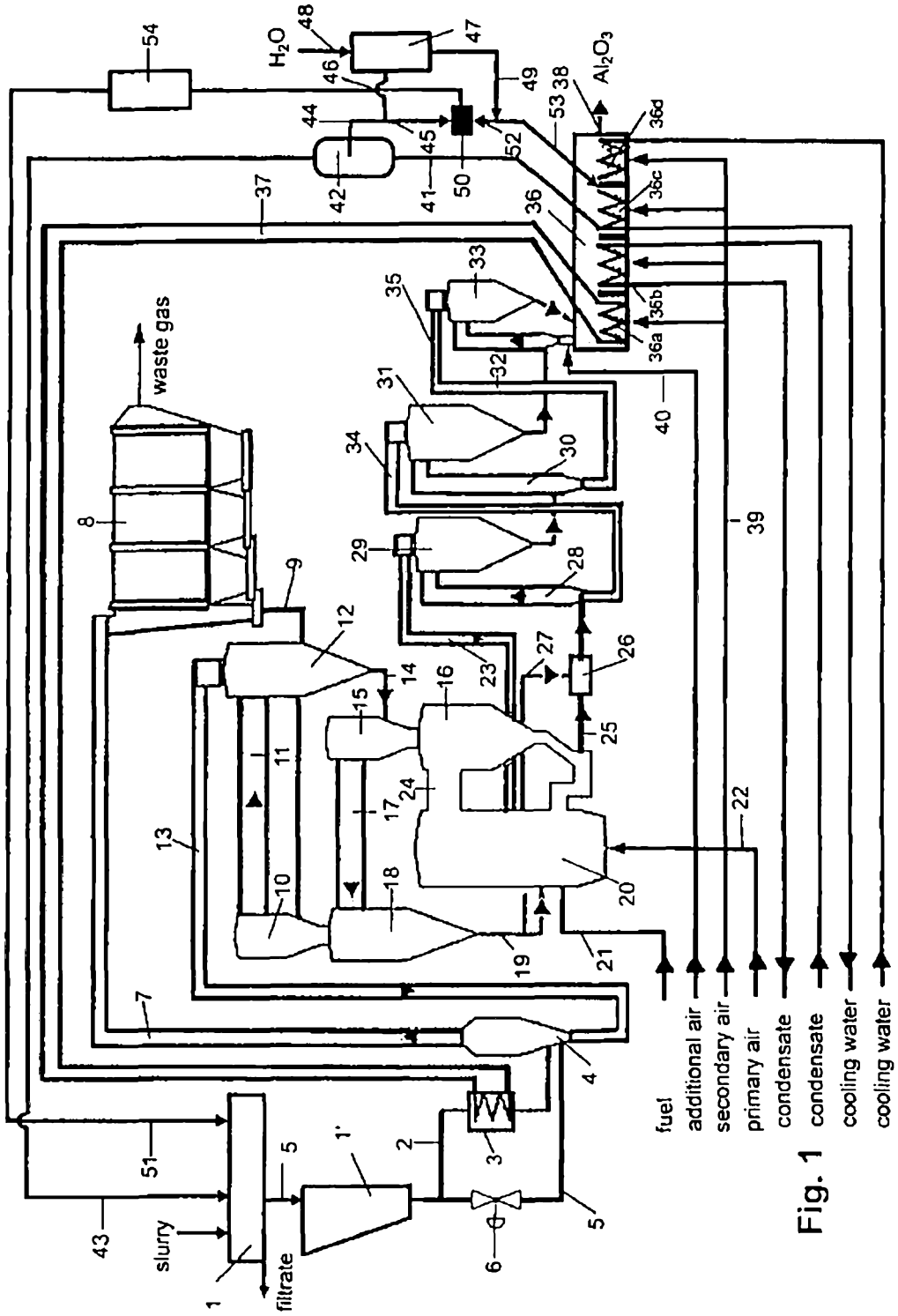
a) a hydrate filter (1) in which the aluminum hydroxide is purified with washing water,
b) at least one preheating stage (10, 12) in which the purified aluminum hydroxide is at least partly dried and/or precalcined,
c) a fluidized-bed reactor (20) in which the pretreated aluminum hydroxide is calcined to obtain alumina,
d) at least one indirect cooling stage (36) with water as coolant, in which the alumina obtained is cooled,
e) an apparatus provided after the indirect cooling stage (36) for the steam separation (42) for splitting up the gaseous and liquid fractions of the cooling water, and
f) a conduit (44, 45, 51) arranged after the steam separation (42) and connected with the hydrate filter (1),

characterized in that in the conduit (44, 45, 51) a control device (50) is provided for adjusting the washing water supply to a constant maximum temperature value below the boiling point of water and the volume flow required by the hydrate filter (1) as washing water by adjusting the quantity ratios of the partial stream (W) guided to the hydrate filter and of the additional water stream (Z) and that the control device (50) is connected with the cooling circuit of the indirect cooling stage (36) via a conduit (53).

9. The plant according to claim 8, **characterized in** that in the conduit (53) a storage tank (47) is arranged as water source for the further water stream (Z).

10. The plant according to claim 8 or 9, **characterized in** that the hydrate filter (1) is equipped with a steam hood (1') for the partial drying of the aluminum hydrate and that this steam hood (1') is connected with the steam outlet of the steam separation (42) via a conduit (43).

11. The plant according to any of claims 8 to 10, **characterized in** that in the conduit (51) a heat exchanger (54) is provided.


H_2O
Al_2O_3
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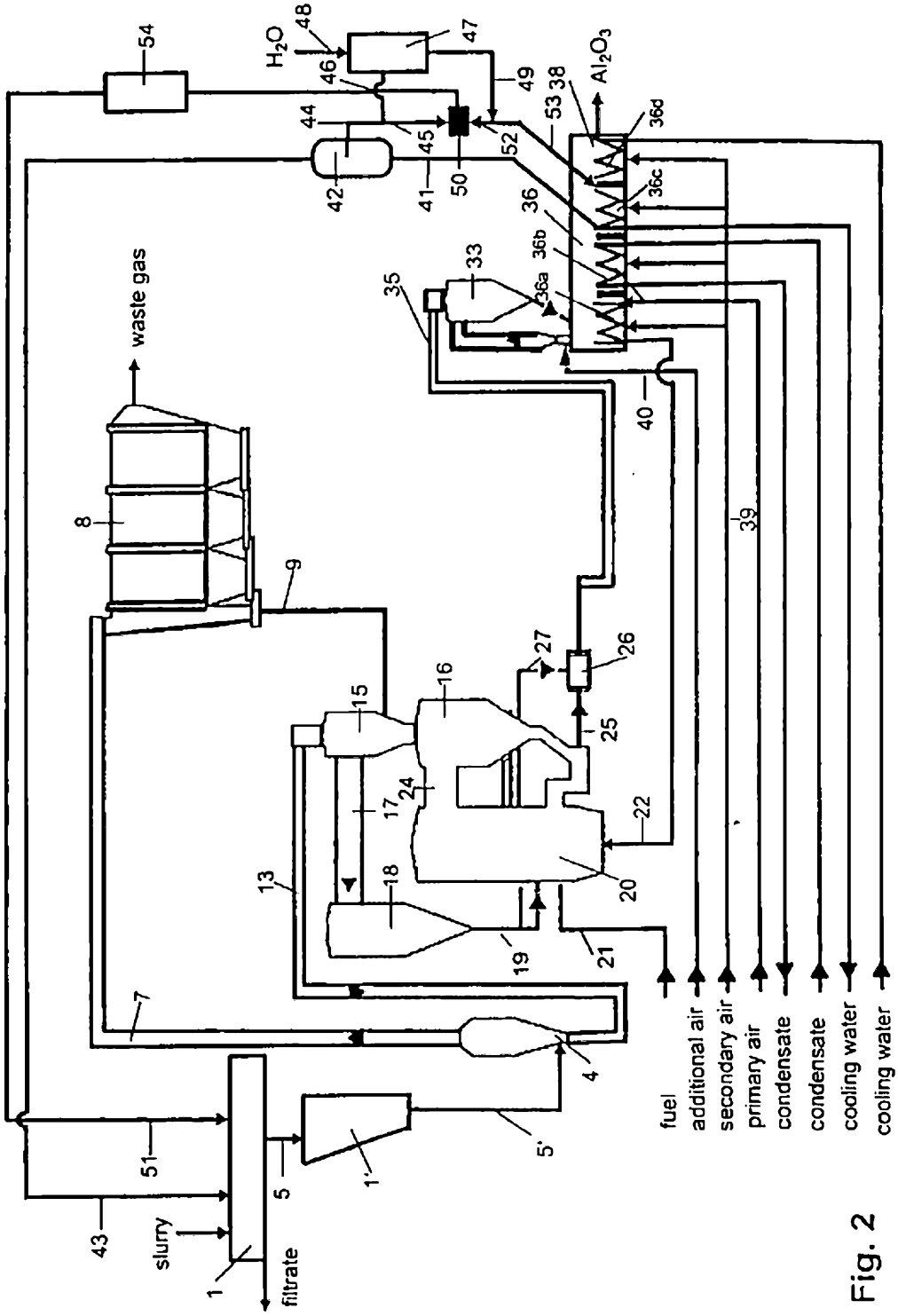
slurry
filtrate
fuel
additional air
secondary air
primary air
condensate
condensate
cooling water
cooling water

Fig. 1


H_2O
Al_2O_3
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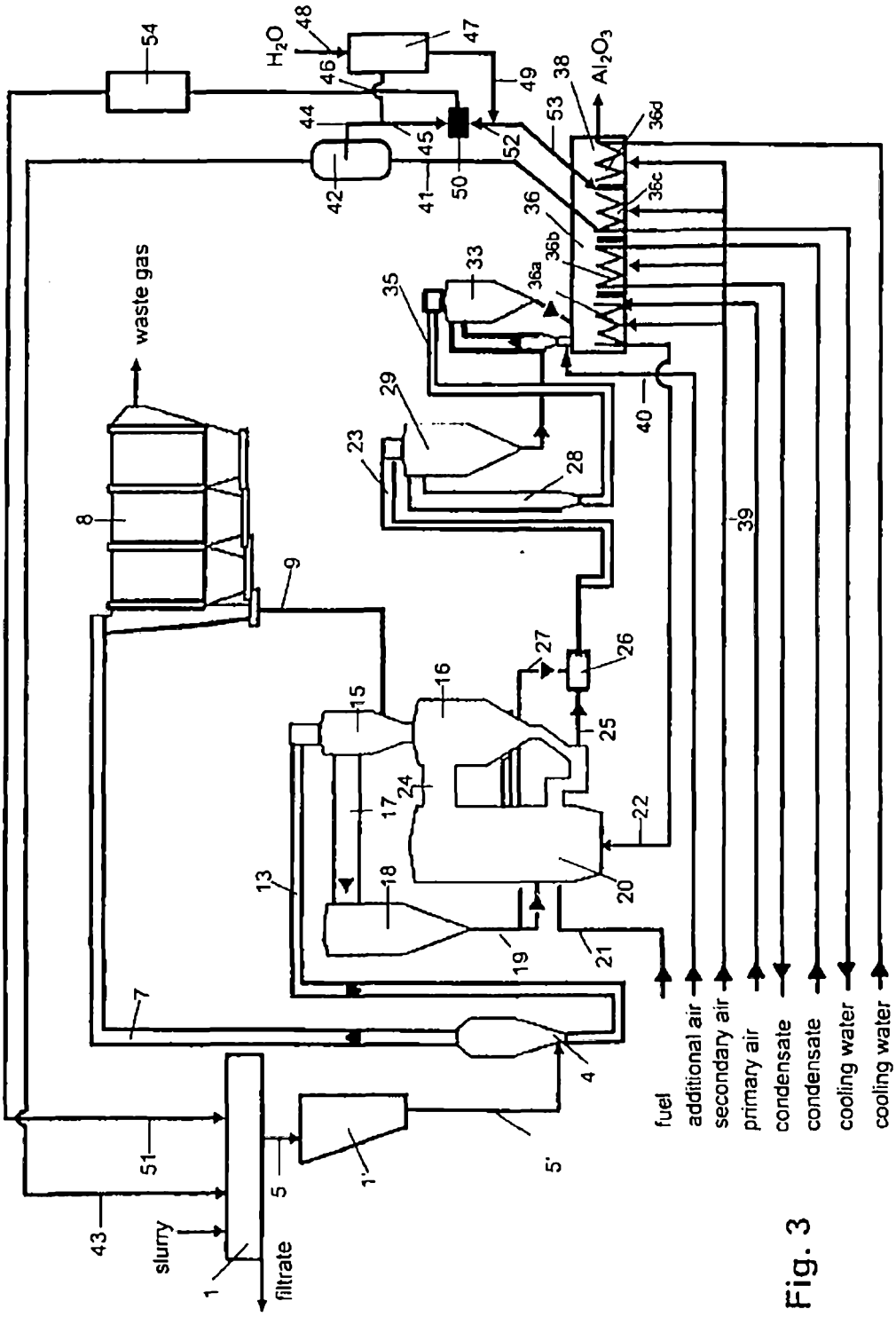
slurry
filtrate
fuel
additional air
secondary air
primary air
condensate
condensate
cooling water
cooling water

Fig. 2


H_2O
Al_2O_3
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filtrate
fuel
additional air
secondary air
primary air
condensate
condensate
cooling water
cooling water

Fig. 3

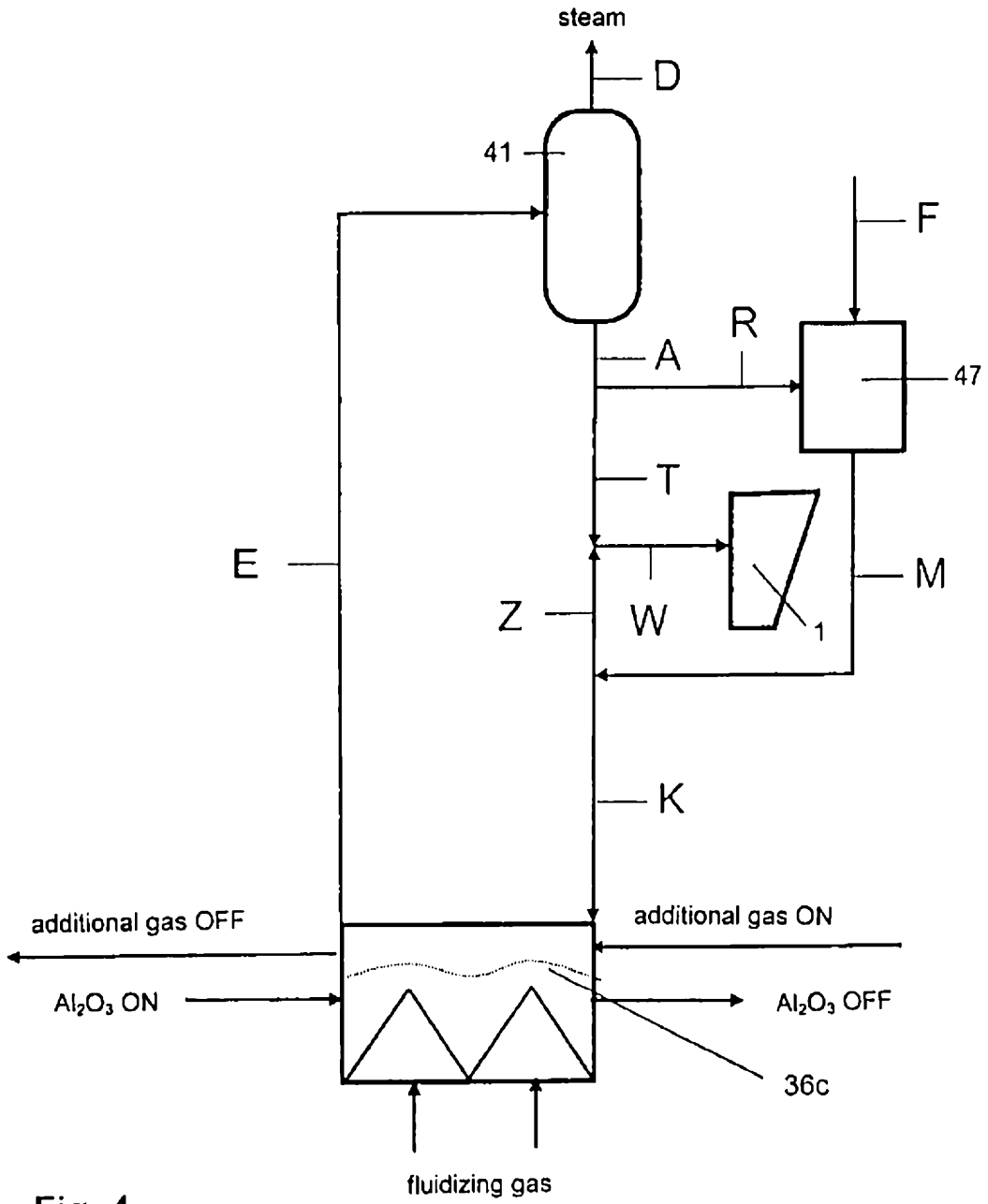
steam
D
41
F
R
A
47
T
E
M
Z
W
1
K
additional gas OFF
additional gas ON
Al2O3 ON
Al2O3 OFF
36c
fluidizing gas

Fig. 4

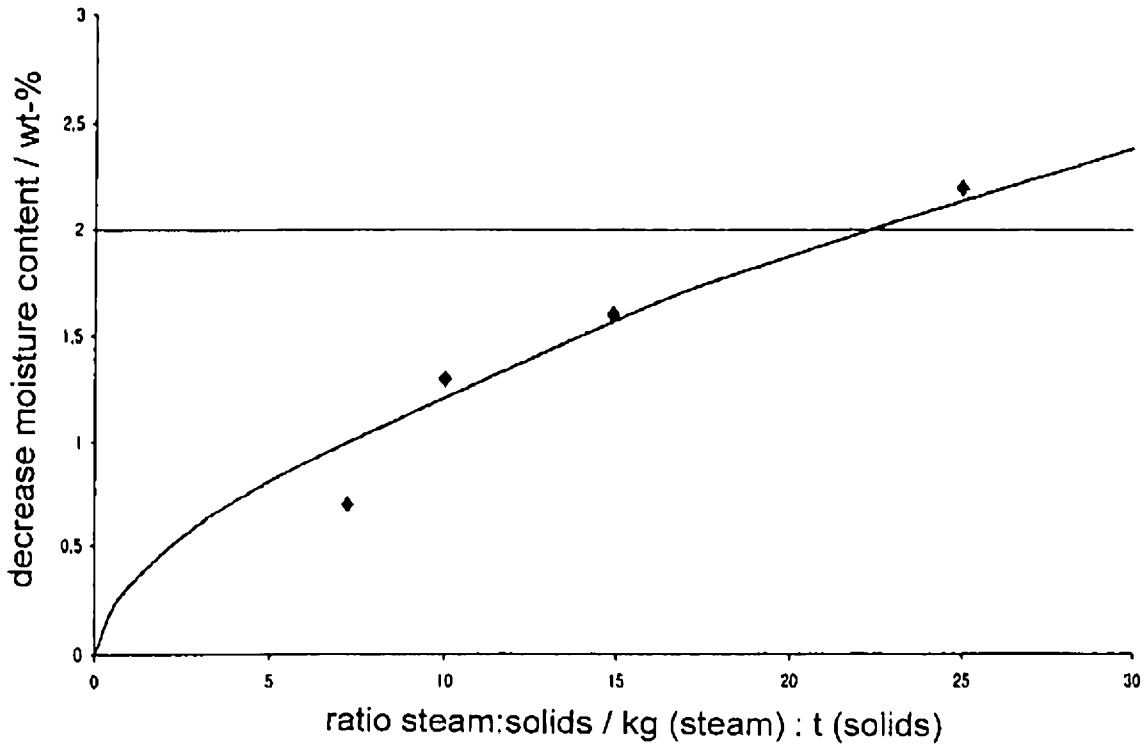

Fig. 5