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(54) **PROCESS AND PLANT FOR PRODUCING SULFURIC ACID FROM GASES RICH IN SULFUR DIOXIDE**

VERFAHREN UND ANLAGE ZUR HERSTELLUNG VON SCHWEFELSÄURE AUS SCHWEFELDIOXIDREICHEN GASEN

PROCESSUS ET INSTALLATIONS POUR PRODUIRE DE L'ACIDE SULFURIQUE A PARTIR DE GAZ RICHE EN DIOXYDE DE SOUFRE

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Description

Technical Field

[0001] The present invention relates to a process for producing sulfuric acid, oleum or liquid sulfur trioxide, in which a starting gas containing sulfur dioxide at least partly reacts with molecular oxygen in at least one contact with at least one contact stage to form sulfur trioxide, and in which the sulfur-trioxide-containing gas produced is introduced into an absorber and converted to sulfuric acid, and to a corresponding plant.

[0002] Conventionally, the production of sulfuric acid is effected by the so-called double absorption process which is described in Ullmann's Encyclopedia of Industrial Chemistry, 5th edition, Vol. A25, pages 635 to 700. For catalyzing the oxidation of sulfur dioxide to sulfur trioxide, catalysts containing vanadium pentoxide as active component are typically used with an operating range of 380 to 640°C. While an irreversible damage of the catalyst occurs at temperatures above 640°C, the same is inactive at temperatures below 380°C. To avoid a damage of the catalyst, starting gases with a sulfur dioxide content of maximally 13 vol-% are usually charged thereto, as excessive temperatures are obtained in the catalyst bed due to the exothermicity of the oxidation reaction, when gases of a higher concentration are used. The result is that before being charged to the catalyst, gases of a higher concentration must first be diluted with air and/or tonnage oxygen, and correspondingly large gas volumes must be passed through the catalyst. In particular when utilizing pyrometallurgical waste gases as sulfur-dioxide-containing starting gases, which are produced for instance when calcining and melting sulfidic copper and nickel concentrates and typically have a sulfur dioxide content of 20 to 60 vol-%, a great dilution factor thus is necessary. This leads to, disproportionately high investment and operating costs of the sulfuric acid plant.

[0003] Beside the temperature, the yield of sulfur trioxide is decisively influenced by the volumetric ratio of sulfur dioxide to oxygen in the starting gas. The partial reactions taking place during the oxidation of sulfur dioxide to sulfur trioxide by means of conventional vanadium pentoxide catalysts can be described in a simplified way by the following formulae:

$$SO_2 + V_2O_5 \Leftrightarrow SO_3 + V_2O_4$$

$$V_2O_4 + ½\ O_2 \Leftrightarrow V_2O_5,$$

which corresponds to a total reaction of

$$SO_2 + ½\ O_2 \Leftrightarrow SO_3.$$

[0004] According to the principle of Le Châtelier, a higher yield of sulfur trioxide thus can be expected with increasing partial pressure of sulfur dioxide in the starting gas. In practice, a hyperstoichiometric amount of oxygen therefore is used for the oxidation of sulfur dioxide to sulfur trioxide, based on the amount of SO_2, namely an amount of O_2 corresponding to a volumetric ratio O_2/SO_2 greater than 0.75, preferably corresponding to a ratio of 1 to 1.2, which corresponds to a volumetric ratio SO_2/O_2 of 1:1 to 1:0.83. Therefore, the sulfur-dioxide-containing starting gases, which in general were obtained by combustion of sulfur, must be further diluted with air or tonnage oxygen, apart from the necessity to adjust the sulfur dioxide content to a value below 13 vol-%, also for adjusting a favourable volumetric ratio of O_2 to SO_2, which contributes to the correspondingly large gas volumes to be passed through the catalyst and to the correspondingly high investment and operating costs of conventional sulfuric acid plants.

[0005] To overcome these disadvantages, processes for producing sulfuric acid have already been proposed, in which starting gases with a sulfur dioxide content of more than 13 vol-% can be supplied to the catalyst.

[0006] Some of these processes provide an alternative catalyst, which can also be operated at temperatures higher than 640°C (WO 99/36175 A1).

[0007] DE-OS 20 26 818 discloses a process for the catalytic oxidation of sulfur dioxide to sulfur trioxide in a plurality of contact stages with an intermediate absorption of the sulfur trioxide formed, in which before being introduced into the first contact stage, the starting gases are diluted with dilution air and with sulfur trioxide expulsed from oleum to obtain a sulfur dioxide concentration of 10 to 20 wt-%. What is disadvantageous in this process, however, is the amount of apparatus involved and the technical expenditure necessary for the continuous expulsion of sulfur trioxide from oleum and the comparatively low utilization of the sulfur dioxide in the first contact stage, as only sulfur trioxide is recirculated, but not the reactants sulfur dioxide and oxygen.

[0008] To be able to process starting gases with a sulfur dioxide content of 13 to 66 vol-% to sulfuric acid at low cost by using conventional catalysts, DE 102 49 782 A1 proposes a process for producing sulfuric acid, in which from a contact stage upstream of the last main contact stage a partial stream of the gas containing sulfur dioxide and sulfur trioxide is withdrawn, this partial stream is mixed with the starting gas to obtain a contact gas with a sulfur dioxide content

of more than 13 vol-% and is recirculated to the first contact stage. As a result of the dilution of the starting gas, comparatively large gas volumes are, however, passed through the catalyst in this process as well.

[0009] From US 2,180,727 there is finally known a process for the catalytic conversion of sulfur dioxide to sulfur trioxide with three contact stages, in which a contact gas with a maximum sulfur dioxide concentration of 16 vol-%, a ratio of sulfur dioxide to oxygen of maximally 2.67:1, and a temperature of 412 to 415°C is supplied to the first contact stage, and after the catalytic conversion the sulfur-trioxide-containing process gas withdrawn from the first contact stage is mixed with a corresponding volume of air for cooling and adjusting a hyperstoichiometric oxygen content, before the resulting gas mixture is supplied to the second contact stage and further oxidized therein. The gas leaving the second contact stage is cooled again and, to adjust a hyperstoichiometric ratio of sulfur dioxide to oxygen, mixed with oxygen and supplied to a third contact stage, before the gas leaving the third contact stage finally is supplied to an absorption stage for forming sulfuric acid. However, this process is also limited as regards the maximum concentration of sulfur dioxide in the starting gas supplied to the first contact stage, so that large gas volumes must be passed through the individual contact stages. In addition, the vanadium catalyst used will deteriorate under the chosen process conditions and will become inactive after a certain period.

[0010] Document EP 0 218 411 A1 discloses the preparation of sulfur trioxide from sulfur dioxide by catalytic conversion. The gas mixture led to first catalyst stage comprises more than 25 vol-% SO_2, wherein the maximum molar ratio of sulfur dioxide to oxygen is 4:1. This small ratio of sulfur dioxide to oxygen is generated by adding pure oxygen or oxygen-enriched gas to the gas mixture upstream of its entry into the catalytic converter.

[0011] Document US 3,907,971 discloses a plant for the production of sulfuric acid wherein a part of the SO_3 lean cycle gas containing a rest of sulfur trioxide is recycled from the absorption tower to the contact vessel. The SO_3 rich gas leaving the contact stages is led to the subsequent contact stages.

[0012] Document WO2004/027719 A1 published after the priority date of the present patent application shows a recirculation of the SO_3 containing gas from the main contact to the pre-contact.

Description of the Invention

[0013] Therefore, it is the object of the present invention to provide for the inexpensive production of sulfuric acid on the basis of concentrated starting gases, in particular to provide a process for producing sulfuric acid, in which only small gas volumes must be supplied to the first contact stage, based on the amount of sulfur dioxide used.

[0014] In accordance with the invention, this object is solved by a process and a plant comprising the features of claims 1 and 17, respectively.

[0015] Preferred embodiments of the invention are evident from the dependent claims.

[0016] In accordance with the present invention it could surprisingly be found that the catalytic oxidation of sulfur dioxide to sulfur trioxide with a understoichiometric oxygen content, namely a volumetric ratio SO_2/O_2 of more than 8:1 or even more than 10:1, can be operated continuously when the starting gas has an SO_2 content of 80 to 99.99 vol-%. The use of normal catalysts containing vanadium pentoxide is possible, a satisfactory yield also being achievable on an industrial scale without damage to the catalyst. Due to the comparatively high SO_2 content on the one hand and the comparatively low oxygen content on the other hand, considerably smaller volumes of starting gas, based on the amount of SO_2, are supplied to the first contact stage in the process of the invention as compared to the prior art. The investment costs for the plant required for performing the process thereby are reduced considerably. In particular, this amount of 50 to 150 liters/daily ton of starting gas compared with the conventionally required amount of 160 to 250 liters/daily ton of starting gas requires a substantially lower specific quantity of catalyst. The displacement of the equilibrium of the oxidation reaction as a result of the high SO_2 content on the part of the products is compensated by the understoichiometric oxygen content, based on the amount of SO_2, which displaces the thermodynamic equilibrium of the oxidation reaction on the part of the educts. By correspondingly adjusting the SO_2 content on the one hand and the volumetric ratio SO_2/O_2 on the other hand, the temperature in the contact stage thus can be adjusted to a value below the temperature that leads to an irreversible damage of the catalyst, in the case of the use of vanadium pentoxide to a temperature of maximally 640°C, and an overheating of the catalyst thus can be avoided.

[0017] The contact gas supplied to the first contact stage has a sulfur dioxide content of 80 to 99.99 vol-%, in particular preferably more than 90 vol-%. In this way, the amounts of contact gas to be supplied to the first contact stage, based on the amount of SO_2, are particularly low.

[0018] To avoid an irreversible damage of the catalyst as a result of overheating, the volumetric ratio of SO_2 to oxygen of the contact gas supplied to the first contact stage, in dependence on the amount of SO_2, is more than 8:1, and highly preferably more than 10:1.

[0019] In principle, all concentrated gas mixtures containing sulfur dioxide and oxygen, which were produced in any way known to those skilled in the art, for instance corresponding gases produced in pyrometallurgical plants, can be used as starting gases in the process of the invention. In particular gas mixtures obtained by combustion of elementary sulfur with tonnage oxygen, which preferably has an oxygen content of at least 95 to 98 vol-%, preferably those with a

sulfur dioxide content of 80 to 99.99 vol-%, an oxygen content of 0.01 to 10 vol-%, and a content of molecular nitrogen or other inert gases of 0 to maximally 10 vol-%, and particularly preferably those with a sulfur dioxide content of 90 to 95 vol-%, an oxygen content of 3 to 7 vol-%, and with a content of molecular nitrogen or other inert gases of 0 to maximally 5 vol-%, or gas mixtures of the same composition, which were produced by other processes, turned out to be useful as starting gases. The same can be supplied to the first contact stage undiluted or upon dilution with air or preferably tonnage oxygen for adjusting a suitable volumetric ratio SO_2/O_2 and a suitable SO_2 content. A particular advantage of this embodiment consists in that due to the absence or the low content of molecular nitrogen in the contact gas, the sulfuric acid obtained with the process of the invention contains no nitrogen oxide (NO_x) impurities or at least, compared with the processes known in accordance with the prior art, in which air with an N_2 content of about 79 vol-% is used as combustion gas, contains nitrogen oxide (NO_x) impurities reduced by one order of magnitude. Accordingly, in dependence on the purity of the tonnage oxygen used for the combustion of sulfur and/or of the tonnage oxygen possibly used for diluting the sulfur-dioxide-containing starting gas, no or at best very small amounts of waste gas are produced, so that the specific emissions, based on the amount of sulfuric acid formed, are substantially lower as compared to the conventional processes. Furthermore, no drying tower for drying the ambient air is required for performing the process of the invention, if no dilution gas or tonnage oxygen is used as dilution gas instead of air.

[0020] In principle, any catalyst known to those skilled in the art as useful for oxidizing sulfur dioxide to sulfur trioxide can be used in the process of the invention. Good results are obtained in particular with conventional catalysts containing vanadium pentoxide. What has also been used quite successfully are iron-containing catalysts, in particular granular catalysts comprising a porous supporting material, preferably with a BET surface area of 100 to 2000 m^2/g and an SiO_2 content of at least 90 wt-% and an active component containing 10 to 80 wt-% iron, the weight ratio of supporting material to active component particularly preferably lying in the range from 1 to 100.

[0021] In the case of catalysts containing vanadium pentoxide, for instance, an inlet temperature of the contact gas into the first contact stage of about 450°C, in particular of about 470°C and most preferably about 500°C turned out to be particularly useful. When using granular catalysts comprising a porous supporting material of SiO_2 with an active component containing 10 to 80 wt-% iron, the inlet temperature in this catalyst preferably is about 500°C, particularly preferably about 520°C and quite particularly preferably about 540°C.

[0022] Preferably, the contact gas is supplied to the first contact stage with a pressure of 1 to 30 bar, and particularly preferably with a pressure of 3 to 12 bar. In this way, the amount of gas actually supplied to the first contact stage is further reduced on the one hand, and on the other hand the thermodynamic equilibrium of the oxidation reaction is displaced on the part of SO_3 because of the elevated pressure. Since the yield of SO_3 in particular depends on four parameters, namely the temperature, the pressure, the amount of SO_2 and the ratio SO_2/O_2 in the first contact stage, satisfactory yields of sulfur trioxide can be obtained even with a particularly high ratio SO_2/O_2 due to the elevated pressure. In this embodiment, it has also turned out to be expedient to produce the starting gas already under the chosen pressure, in that for instance during the combustion of elementary sulfur both the liquid sulfur and the tonnage oxygen used for combustion and/or the used combustion air are supplied to the combustion chamber with the indicated pressure and the combustion chamber is operated at this pressure. The advantage is that the sulfuric acid plant requires no gas blower for conveying the process gases through the contact and absorption stages.

[0023] To avoid an irreversible damage of the catalyst during operation of the first contact stage, the sulfur dioxide content, the volumetric ratio SO_2/O_2, the inlet pressure and the inlet temperature of the contact gas supplied to the first and all succeeding contact stages are chosen such that in the contact stage a temperature is obtained, which lies below the temperature that leads to a damage of the catalyst, but above the operating temperature of the catalyst. In the case of a catalyst containing vanadium pentoxide, the upper limit of the temperature to be adjusted is about 640°C, and the lower limit is about 380°C.

[0024] In accordance with a first embodiment of the present invention, further contact stages, preferably 2 to 4 further contact stages, are provided downstream of the first contact stage, the individual contact stages being combined to one or more, preferably one or two contacts. Downstream of each contact, an absorber can be provided, in which sulfur trioxide is at least partly, preferably completely removed from the process gas and converted to sulfuric acid, liquid SO_3 or oleum in a manner known to those skilled in the art. The sulfur-trioxide-containing process gas leaving the first to penultimate contact stages is mixed with oxygen for adjusting a suitable ratio SO_2/O_2 and cooled to an inlet temperature suitable for the next contact stage, before it is supplied to the respectively succeeding contact stage for further oxidation. The adjustment of the necessary inlet temperature into the respectively succeeding contact stage can be achieved by adding correspondingly tempered oxygen-containing gas, for instance liquefied O_2, and/or by means of a heat exchanger. It is mostly necessary to also operate the second and/or the succeeding contact stages with a contact gas with a understoichiometric oxygen content, based on the SO_2 content. The process gas leaving the last contact stage is supplied to an absorber, in which sulfur trioxide is removed from the process gas by forming sulfuric acid, liquid SO_3 or oleum, and the resulting waste gas can, if necessary, be removed via a chimney, for instance after a chemical posttreatment in a gas washing plant operated e.g. with hydrogen peroxide, or be supplied to a further treatment in the sulfuric acid plant.

[0025] In accordance with a second embodiment of the present invention it is likewise provided that downstream of

the first contact stage further contact stages, preferably 2 to 4 contact stages, are disposed, which are preferably combined to one or two contacts, but that a partial stream of the contact gas leaving the first contact stage and/or one or more of the succeeding contact stages is withdrawn and this partial stream or these partial streams is/are mixed with the starting gas before the same enters the first contact stage. In this way, the sulfur dioxide content and the ratio SO_2/O_2 of the starting gas can be adjusted to a suitable value for the first contact stage. On the other hand, this results in a better utilization of energy, as the recirculation of the thermal energy of the recirculated, partly converted and hot process gas is utilized for preheating the starting gases. As a result, this procedure requires correspondingly smaller heat exchangers. In accordance with the invention, however, only such amounts of process gas are recirculated, which provide a contact gas supplied to the first contact stage with a sulfur dioxide content of more than 16 vol-% and with a volumetric ratio of sulfur dioxide to oxygen of more than 2.67:1.

[0026] As an alternative, it is also possible to withdraw and recirculate the partial stream or the partial streams not directly at the outlet of the respective contact stages, but only after the intermediate or final absorption stages, so that less sulfur trioxide, which displaces the thermodynamic equilibrium of the oxidation reaction on the part of the educts, is introduced into the contact gas to be supplied to the first contact stage.

[0027] Furthermore, instead of being recirculated to the gas to be supplied to the first contact stage, the partial stream withdrawn from a contact stage and/or from the first intermediate absorber can also be supplied to the gas (air or preferably tonnage oxygen) used for the combustion of sulfur for producing the sulfur-dioxide-containing starting gas and/or directly to the sulfur burner. As those skilled in the art will recognize, it is of course also possible to combine the aforementioned alternatives in any way, for instance to supply one part of the partial stream to the gas to be supplied to the first contact stage and the other part of the partial stream to the gas used for the combustion of the elementary sulfur.

[0028] Finally, in accordance with a third embodiment of the present invention, the process can be operated with only one contact, which preferably consists of 1 to 3 contact stages, wherein preferably at least part of the process gas leaving the contact and/or the absorber downstream of the contact is withdrawn and recirculated to the starting gas to be supplied to the first contact stage and/or to the combustion gas to be supplied to the combustion of sulfur and/or directly into the sulfur burner.

[0029] Preferably, the partial stream or partial streams in accordance with the second and third embodiments of the invention, which was/were mixed with the starting gas before entrance thereof into the first contact stage, is/are dimensioned such that the contact gas supplied to the first contact stage consists of 90 to 95 vol-% sulfur dioxide, 3 to 7 vol-% oxygen, 0.01 to 5 vol-% sulfur trioxide and 0 to maximally 5 vol-% nitrogen or another inert gas.

[0030] Furthermore, the present invention relates to a plant for producing sulfuric acid, liquid SO_3 or oleum from gases rich in sulfur dioxide, which can be used in particular for performing the process of the invention.

[0031] In accordance with the invention, the plant includes at least one contact with a least one contact stage for reacting a starting gas containing SO_2 with oxygen to obtain SO_3, and at least one absorber, wherein the inlet region of the first contact stage is connected with the outlet region of one or more contact stages and with the outlet region of one or more absorbers via one or more recirculation conduit(s).

[0032] Preferably, the at least one recirculation conduit leads from the outlet region of the first contact to the inlet region of the first contact stage.

[0033] In accordance with a development of the invention it is proposed that the plant includes 3 to 5 contact stages, which particularly preferably are combined in one or two contacts. In principle, the individual contact stages can include any catalyst material known to those skilled in the art for this purpose. Preferably, however, conventional catalysts are provided, for instance those on the basis of vanadium pentoxide with or without addition of caesium, or on the basis of other metal oxides such as iron oxide.

[0034] In accordance with a particular embodiment of the present invention, the plant additionally includes a sulfur burner with a combustion chamber for the combustion of elementary sulfur with tonnage oxygen or air, the sulfur burner and/or the inlet region of the combustion chamber being connected with the outlet region of one or more contact stages and/or with the outlet region of one or more absorbers.

[0035] The invention will subsequently be explained in detail with reference to embodiments and the drawing. All features described and/or illustrated in the Figures form the subject-matter of the invention, independent of their inclusion in the claims or their back-reference.

Brief Description of the Drawings

[0036]

Fig. 1 shows a process diagram of a process and a plant in accordance with the prior art;

Fig. 2 shows a process diagram of a process and a plant in accordance with the prior art;

Fig. 3 shows a process diagram of a process and a plant in accordance with a first embodiment of the present invention;

Fig. 4 shows a process diagram of a process and a plant in accordance with a second embodiment of the present invention;

Fig. 5 shows a process diagram of a process and a plant in accordance with a third embodiment of the present invention.

Detailed Description of the Preferred Embodiments

[0037] The conventional plant as shown in Fig. 1 for producing sulfuric acid in accordance with the prior art, as it is described for Instance in Ullmann's Encyclopedia of Industrial Chemistry, comprises a sulfur burner 1, two contacts 2, 3, an intermediate absorber 4 and a final absorber 5. While the first contact 2 (primary contact) includes three contact stages (catalyst layers) 6_1 to 6_3, which each have a catalyst on the basis of vanadium pentoxide, the second contact 3 (secondary contact) Includes two contact stages 6_4, 6_5. Between the individual contact stages 6_1 to 6_5, there is each disposed an intermediate cooler (not shown), in which the process gas leaving the preceding contact stage 6_1 to 6_4 is cooled down to a temperature suitable for entrance into the respectively next contact stage 6_2 to 6_5.

[0038] In the sulfur burner 1, starting gas with less than 13 vol-%, usually with 10 to 12 vol-% sulfur dioxide and with a volumetric ratio SO_2/O_2 of about 1:1 to 1:0.83 is produced by combustion of elementary sulfur with air. For this purpose, elementary sulfur, generally in liquid form with a temperature of 140 to 150°C, is continuously supplied to the sulfur burner 1 via supply conduit 7, and air which has possibly been dried in advance in a drying tower (not shown) is supplied via supply conduit 8, wherein the hyperstoichiometric oxygen content in the resulting starting gas is controlled by the amount of air introduced into the sulfur burner and/or adjusted by the subsequent addition of dilution air. Via conduit 9, the starting gas is passed through a heat exchanger (not shown), in which the same is preheated to the inlet temperature of the first contact stage 6_1 and is subsequently supplied to the first contact stage 6_1, before the gas mixture is sequentially passed through the three contact stages 6_1 to 6_3 of the first contact 2 for oxidation. Gas leaving the first contact 2 is supplied to the intermediate absorber 4 via conduit 10 and brought in contact with aqueous sulfuric acid, a large part of the sulfur trioxide formed in the first contact being absorbed by forming sulfuric acid. Subsequently, the remaining gas is supplied to the second contact 3 via conduit 11 and sequentially passed through its two contact stages 6_4 and 6_5. Gas leaving the second contact 3 is supplied via conduit 12 to the final absorber 5, in which the sulfur trioxide formed is converted to sulfuric acid. While the waste gas is discharged from the plant via the chimney 13, the sulfuric acid produced in the intermediate absorber 4 and in the final absorber 5 is combined and discharged from the plant as a single mass flow via the product discharge conduit 14.

[0039] As can be taken from Fig. 2, the plant comprises the components of the conventional apparatus described above, which for the sake of simplicity are provided with the same reference numerals, and in addition includes a plurality of supply conduits 8, 15, 16 for tonnage oxygen, which lead into the sulfur burner 1, the gas supply conduit 9 and the gas conduits provided between the contact stages 6_1 and 6_2 as well as 6_2 and 6_3, respectively.

[0040] In the process of the invention, in contrast to the prior art, a contact gas with a sulfur dioxide content of ≥ 80 vol-% and with a volumetric ratio of sulfur dioxide to oxygen of more than 8:1 is supplied to the first contact stage. In the process performed as shown in Fig. 2, this contact gas is produced in that elementary sulfur is continuously introduced into the sulfur burner 1 via supply conduit 7, and tonnage oxygen as combustion gas is introduced via the supply conduits 16 and 8. By adjusting the amount of tonnage oxygen supplied to the sulfur burner 1 per unit of time, based on the amount of elementary sulfur, the sulfur dioxide content of the resulting gas can be adjusted to the desired value, which is more than 80 vol-% and particularly preferably more than 90 vol-%.

[0041] The highly concentrated gas produced is withdrawn from the sulfur burner 1 via conduit 9, and its oxygen content, based on the sulfur dioxide content, is possibly adjusted to a desired value by means of tonnage oxygen supplied via conduit 15, preferably to a volumetric ratio of sulfur dioxide to oxygen of more than 8:1 and highly preferably more than 10:1. Subsequently, the gas mixture thus produced is passed through a heat exchanger (not shown), in which it is heated to the suitable inlet temperature of the first contact stage 6_1, in the case of a catalyst comprising vanadium pentoxide preferably to about 450°C and particularly preferably to about 470°C, and supplied to the first contact stage 6_1. To avoid a damage of the catalyst in the case of a continuous operation of the plant, the sulfur dioxide content, the volumetric ratio SO_2/O_2, the inlet pressure and the inlet temperature of the contact gas supplied to the first contact stage 6_1 and to the succeeding contact stages 6_2 to 6_5 are chosen such that in the respective contact stage a temperature is obtained, which lies below the temperature that leads to a damage of the catalyst, but above the operating temperature of the catalyst.

[0042] Upon cooling, process gas withdrawn from the first contact stage 6_1 is mixed with tonnage oxygen supplied via conduit 16 for adjusting a volumetric ratio SO_2/O_2 suitable for the second contact stage 6_2, which in dependence on the SO_2 content of the process gas can correspond to a understoichiometric or hyperstoichiometric oxygen content, and

is possibly supplied to an intermediate cooler, the optimum volumetric ratio depending in particular on the SO_2 content of the process gas and on the inlet pressure and the inlet temperature of the second contact stage 6_2.

[0043] Due to the comparatively high SO_2 content on the one hand and the comparatively low oxygen content, based on the SO_2 content, on the other hand, considerably smaller volumes of starting gas, based on the amount of SO_2, are supplied to the first contact stage in this process as compared to the known processes of the prior art, which on the whole results in considerably lower investment costs as compared to the conventional processes. In particular, a significantly lower specific quantity of catalyst is required as a result thereof.

[0044] In contrast to the apparatus shown in Fig. 2, the plant illustrated in Fig. 3 includes a plurality of recirculation conduits 15, 17, 18, of which two recirculation conduits 17 each lead from the outlet of the third contact stage 6_3 and the outlet of the fifth contact stage 6_5 to the gas conduit 9 leading to the first contact stage 6_1, and of which two recirculation conduits 18 each lead from the outlet of the intermediate absorber 4 and the outlet of the final absorber 5 to the sulfur burner 1, and via each of which a partial stream of the process gas is recirculated. In addition, via the recirculation conduit 15 leading from the outlet of the sulfur burner 1 to the gas conduit 18, a partial stream of the SO_2-containing starting gas is recirculated to the sulfur burner **1**.

[0045] By means of the recirculation of the process gases, a better utilization of energy is achieved as compared to the conventional processes, as hereby the thermal energy of the recirculated, partly converted and hot process gases is utilized for preheating the starting gases and/or the sulfur burner 1, so that merely a correspondingly smaller amount of thermal energy must be supplied externally. Apart from this, the recirculation of partial process gas streams withdrawn from the outlet of the two contacts 2, 3, which apart from SO_2 and O_2 also contain SO_3, effects a greater variability in terms of process control. This is connected with the fact that SO_3 displaces the thermodynamic equilibrium of the oxidation reaction on the part of the products, so that in this embodiment a total of five parameters, namely the inlet temperature, the inlet pressure, and the SO_2, O_2 and SO_3 contents, are available for controlling the temperature in the first contact stage 6_1. Finally, the recirculation of the process gases also contributes to a greater yield. In accordance with the invention, however, only such amounts of process gas are recirculated, which provide a contact gas supplied to the first contact stage with a sulfur dioxide content of $\geq$ 80 vol-% and with a volumetric ratio of sulfur dioxide to oxygen of more than 6:1.

[0046] In contrast to the apparatus shown in Fig. 3, the plant illustrated in Fig. 4 includes only one contact 2, which consists of the three contact stages 6_1 to 6_3, as well as an absorber 5. In addition, this embodiment Includes only one recirculation conduit 18 extending from the outlet of the absorber 5, which via the partial conduit 18' leads to the inlet conduit 9 for the first contact stage 6_1 and via the partial conduit 18" to the sulfur burner 1. Due to the only one contact 2, the plant is correspondingly compact and inexpensive. A yield of nevertheless approximately 100%, even with the use of highly concentrated starting gases, based on the amount of SO_2, for instance those with an SO_2 content of more than 90 vol-%, can be achieved by a correspondingly high degree of recirculation.

[0047] The process diagram shown in Fig. 5 differs from the one shown in Fig. 4 in that beside a recirculating conduit 18 leading from the outlet of the absorber 5 into the sulfur burner 1 there are provided three recirculation conduits 17 extending from the outlet of the individual contact stages 6_1 to 6_3, which converge to one collecting conduit and lead to the inlet conduit 9. By providing a recirculation conduit 17 after each contact stage 6_1 to 6_3, an even greater variability of the process is achieved in terms of process control.

List of reference numerals:

[0048]

1	sulfur burner
2	first contact (primary contact)
3	second contact (secondary contact)
4	intermediate absorber
5	final absorber
6	contact stage
7	sulfur supply conduit
8	supply conduit for combustion gas
9	supply conduit to the first contact
10	gas conduit to the intermediate absorber
11	supply conduit to the second contact
12	conduit to the final absorber
13	chimney
14	product discharge conduit
15	bypass conduit

16 supply conduit for tonnage oxygen
17 recirculation conduit
18 recirculation conduit

Claims

1. A process for producing sulfuric acid, oleum or liquid sulfur trioxide, in which a starting gas containing sulfur dioxide at least partly reacts with molecular oxygen in at least one contact (2, 3) with at least one contact stage (6_1) to form sulfur trioxide, and in which the sulfur-trioxide-containing gas produced is introduced into an absorber (4, 5) and converted there to sulfuric acid, **characterized in that** a contact gas with a sulfur dioxide content of 80 to 99.99 vol-% and having an oxygen content of 0.01 to 10 vol-% and with a volumetric ratio of sulfur dioxide to oxygen of more than 8:1 is supplied to the first contact stage (6_1).

2. The process as claimed in claim 1, **characterized in that** the contact gas supplied to the first contact stage (6_1) has a sulfur dioxide content of more than 90 vol-%.

3. The process as claimed in claim 1 or 2, **characterized in that** the volumetric ratio of sulfur dioxide to oxygen of the contact gas supplied to the first contact stage (6_1) is more than 10:1.

4. The process as claimed in any of the preceding claims, **characterized in that** the contact gas supplied to the first contact stage (6_1) consists of 90 to 95 vol-% sulfur dioxide, 3 to 7 vol-% oxygen, and 0 to maximally 5 vol-% nitrogen or another inert gas.

5. The process as claimed in claim 4, **characterized in that** the contact gas is produced by combustion of elementary sulfur with tonnage oxygen.

6. The process as claimed in any of the preceding claims, **characterized in that** the first contact stage (6_1) includes a catalyst comprising vanadium pentoxide.

7. The process as claimed in claim 6, **characterized in that** the contact gas is supplied to the first contact stage (6_1), which includes a catalyst comprising vanadium pentoxide, with a temperature of at least 450°C, and particularly preferably of at least 470°C.

8. The process as claimed in any of the preceding claims, **characterized in that** the contact gas is supplied to the first contact stage (6_1) with a pressure of 1 to 30 bar, and particularly preferably of 3 to 12 bar.

9. The process as claimed in any of the preceding claims, **characterized in that** the sulfur dioxide content, the volumetric ratio SO_2/O_2, the inlet pressure and the inlet temperature of the contact gas supplied to the first contact stage (6_1) are chosen such that in the contact stage (6_1) a temperature is obtained, which is below the temperature that will lead to a damage of the catalyst, but above the operating temperature of the catalyst.

10. The process as claimed in any of the preceding claims, **characterized in that** downstream of the first contact stage (6_1), 2 to 4 further contact stages (6_2, 6_3, 6_4, 6_5) are provided, which preferably are combined to one or two contacts (2, 3).

11. The process as claimed in claim 10, **characterized in that** the process gas leaving the first to penultimate contact stages (6_1, 6_2, 6_3, 6_4) is mixed with oxygen, possibly upon passage through an intermediate absorber (4), is adjusted to an inlet temperature suitable for the next contact stage (6_2, 6_3, 6_4, 6_5), and is supplied to the respectively next contact stage (6_2, 6_3, 6_4, 6_5).

12. The process as claimed in claim 10 or 11, **characterized in that** the process gas leaving the last contact stage (6_5) is supplied to an absorber (5).

13. The process as claimed in any of claims 10 to 12, **characterized in that** from the process gas leaving the first contact stage (6_1) and/or from one or more of the process gases leaving the second to last contact stages (6_2, 6_3, 6_4, 6_5) at least one partial stream is withdrawn, and this partial stream is mixed with the starting gas before the same enters the first contact stage (6_1) and/or with the combustion gas used for the combustion of elementary sulfur for

producing the sulfur-dioxide-containing starting gas and/or is supplied directly to the sulfur burner (1).

14. The process as claimed in any of claims 10 to 12, **characterized in that** from the process gas leaving the intermediate absorber (4) and/or the final absorber (5) at least one partial stream is withdrawn, and this partial stream is mixed with the starting gas before the same enters the first contact stage (6_1) and/or with the combustion gas used for the combustion of elementary sulfur for producing the sulfur-dioxide-containing starting gas and/or is supplied directly to the sulfur burner (1).

15. The process as claimed in any of claims 1 to 9, **characterized in that** only one contact (2) with downstream absorber (5) is provided, from the process gas leaving a contact stage (6_1, 6_2, 6_3) a partial stream is withdrawn before and/or after the absorption stage (5), and this partial stream is mixed with the starting gas before the same enters the first contact stage (6_1) and/or with the combustion gas used for the combustion of elementary sulfur for producing the sulfur-dioxide-containing starting gas and/or is supplied directly to the sulfur burner (1).

16. The process as claimed in any of claims 10 to 15, **characterized in that** the contact gas supplied to the first contact stage (6_1) consists of 90 to 95 vol-% sulfur dioxide, 3 to 7 vol-% oxygen, 0.01 to 5 vol-% sulfur trioxide, and 0 to maximally 5 vol-% nitrogen or another inert gas.

17. A plant for producing sulfuric acid, oleum or liquid sulfur trioxide, in particular for performing a process as claimed in any of claims 1 to 16, with at least one contact (2, 3) comprising at least one contact stage (6_1) for reacting a starting gas containing sulfur dioxide with oxygen to obtain sulfur trioxide, and at least one absorber (5), **characterized in that** the inlet region of the first contact stage (6_1) is connected with the outlet region of one or more contact stages (6_1, 6_2, 6_3, 6_4, 6_5) and/or with the outlet region of one or more absorbers (4, 5) via one or more recirculation conduits (17, 18) and that a sulfur burner (1) with a combustion chamber for the combustion of elementary sulfur with tonnage oxygen or air is connected with the outlet region of one or more contact stages (6_1, 6_2, 6_3, 6_4, 65) and/or with the outlet region of one or more absorbers (4, 5).

18. The plant as claimed in claim 17, **characterized in that** the at least one recirculation conduit (17, 18) leads from the outlet region of the first contact (2) to the inlet region of the first contact stage (6_1).

19. The plant as claimed in claim 17 or 18, **characterized in that** the same includes 3 to 5 contact stages (6_1, 6_2, 6_3, 6_4, 6_5), preferably combined in one or two contacts (2, 3).

Patentansprüche

1. Verfahren zur Herstellung von Schwefelsäure, Oleum oder flüssigem Schwefeltrioxid, bei dem ein Schwefeldioxid enthaltendes Ausgangsgas mit molekularem Sauerstoff in wenigstens einem Kontakt (2, 3) mit wenigstens einer Kontaktstufe (6_1) zumindest teilweise zu Schwefeltrioxid reagiert und bei dem das erzeugte schwefeltrioxidhaltige Gas in einen Absorber (4, 5) geführt und dort zu Schwefelsäure umgesetzt wird, **dadurch gekennzeichnet, dass** der ersten Kontaktstufe (6_1) ein Kontaktgas mit einem Schwefeldioxidgehalt von 80 bis 99,99 Vol.-% und mit einem Sauerstoffgehalt von 0,01 bis 10 Vol.-% und mit einem volumetrischen Verhältnis von Schwefeldioxid zu Sauerstoff von mehr als 8:1 zugeführt wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das der ersten Kontaktstufe (6_1) zugeführte Kontaktgas einen Schwefeldioxidgehalt von mehr als 90 Vol.-% aufweist.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das volumetrische Verhältnis von Schwefeldioxid zu Sauerstoff des der ersten Kontaktstufe (6_1) zugeführten Kontaktgases mehr als 10:1 beträgt.

4. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das der ersten Kontaktstufe (6_1) zugeführte Kontaktgas aus 90 bis 95 Vol.-% Schwefeldioxid, 3 bis 7 Vol.-% Sauerstoff und 0 bis maximal 5 Vol.-% Stickstoff oder einem anderen Inertgas besteht.

5. Verfahren nach Anspruch 4, **dadurch gekennzeichnet, dass** das Kontaktgas durch Verbrennung von elementarem Schwefel mit technischem Sauerstoff hergestellt wird.

6. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die erste Kontaktstufe

(6_1) einen Katalysator umfassend Vanadiumpentoxid enthält.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** das Kontaktgas der ersten, einen Vanadiumpentoxid umfassenden Katalysator enthaltenden Kontaktstufe (6_1) mit einer Temperatur von wenigstens 450°C und besonders bevorzugt von wenigstens 470°C zugeführt wird.

8. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Kontaktgas der ersten Kontaktstufe (6_1) mit einem Druck von 1 bis 30 bar und besonders bevorzugt von 3 bis 12 bar zugeführt wird.

9. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Schwefeldioxidgehalt, das volumetrische SO_2/O_2-Verhältnis, der Eintrittsdruck und die Eintrittstemperatur des der ersten Kontaktstufe (6_1) zugeführten Kontaktgases derart gewählt sind, dass sich in der Kontaktstufe (6_1) eine Temperatur einstellt, welche unterhalb der zu einer Schädigung des Katalysators führenden Temperatur, aber oberhalb der Arbeitstemperatur des Katalysators liegt.

10. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der ersten Kontaktstufe (6_1) 2 bis 4 weitere Kontaktstufen (6_2, 6_3, 6_4, 6_5) nachgeschaltet sind, die vorzugsweise zu einem oder zwei Kontakten (2, 3), zusammengefasst sind.

11. Verfahren nach Anspruch 10, **dadurch gekennzeichnet, dass** das aus der ersten bis vorletzten Kontaktstufe (6_1, 6_2, 6_3, 6_4) austretende Prozessgas ggf. nach Führung durch einen Zwischenabsorber (4) mit Sauerstoff vermischt, auf eine für die nächste Kontaktstufe (6_2, 6_3, 6_4, 6_5) geeignete Eintrittstemperatur eingestellt und der jeweils nächsten Kontaktstufe (6_2, 6_3, 6_4, 6_5) zugeführt wird.

12. Verfahren nach Anspruch 10 oder 11, **dadurch gekennzeichnet, dass** das aus der letzten Kontaktstufe (6_5) austretende Prozessgas einem Absorber (5) zugeführt wird.

13. Verfahren nach einem der Ansprüche 10 bis 12, **dadurch gekennzeichnet, dass** aus dem aus der ersten Kontaktstufe (6_1) austretenden Prozessgas und/oder aus einem oder mehreren aus der zweiten bis letzten Kontaktstufe (6_2, 6_3, 6_4, 6_5) austretenden Prozessgasen zumindest ein Teilstrom abgezogen und dieser Teilstrom mit dem Ausgangsgas vor dessen Eintritt in die erste Kontaktstufe (6_1) und/oder mit dem zur Verbrennung von elementarem Schwefel zur Herstellung des schwefeldioxidhaltigen Ausgangsgases eingesetzten Verbrennungsgas vermischt und/oder direkt dem Schwefelofen (1) zugeführt wird.

14. Verfahren nach einem der Ansprüche 10 bis 12, **dadurch gekennzeichnet, dass** dem aus dem Zwischen- (4) und/oder Endabsorber (5) austretenden Prozessgas zumindest ein Teilstrom abgezogen und dieser Teilstrom mit dem Ausgangsgas vor dessen Eintritt in die erste Kontaktstufe (6_1) und/oder mit dem zur Verbrennung von elementarem Schwefel zur Herstellung des schwefeldioxidhaltigen Ausgangsgases eingesetzten Verbrennungsgas vermischt und/oder direkt dem Schwefelofen (1) zugeführt wird.

15. Verfahren nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** nur ein Kontakt (2) mit nachgeschaltetem Absorber (5) vorgesehen ist, dem aus einer Kontaktstufe (6_1, 6_2, 6_3) austretenden Prozessgas vor und/oder nach der Absorptionsstufe (5) ein Teilstrom abgezogen und dieser Teilstrom mit dem Ausgangsgas vor dessen Eintritt in die erste Kontaktstufe (6_1) und/oder mit dem zur Verbrennung von elementaren Schwefel zur Herstellung des schwefeldioxidhaltigen Ausgangsgases eingesetzten Verbrennungsgas vermischt und/oder direkt dem Schwefelofen (1) zugeführt wird.

16. Verfahren nach einem der Ansprüche 10 bis 15, **dadurch gekennzeichnet, dass** das der ersten Kontaktstufe (6_1) zugeführte Kontaktgas aus 90 bis 95 Vol.-% Schwefeldioxid, 3 bis 7 Vol.-% Sauerstoff, 0,01 bis 5 Vol.-% Schwefeltrioxid und 0 bis maximal 5 Vol.-% Stickstoff oder einem anderen Inertgas besteht.

17. Anlage zur Herstellung von Schwefelsäure, Oleum oder flüssigem Schwefeltrioxid, insbesondere zur Durchführung eines Verfahrens nach einem der Ansprüche 1 bis 16, mit wenigstens einem Kontakt (2, 3) umfassend wenigstens eine Kontaktstufe (6_1) zur Umsetzung eines Schwefeldioxid enthaltenden Ausgangsgases mit Sauerstoff zu Schwefeltrioxid und wenigstens einem Absorber (5), **dadurch gekennzeichnet, dass** der Eintrittsbereich der ersten Kontaktstufe (6_1) über eine oder mehrere Rezirkulationsleitungen (17, 18) mit dem Austrittsbereich einer oder mehrerer Kontaktstufen (6_1, 6_2, 6_3, 6_4, 6_5) und/oder mit dem Austrittsbereich eines oder mehrerer Absorber(s) (4, 5) verbunden ist, und dass ein Schwefelofen (1) mit einer Verbrennungskammer zur Verbrennung von elementarem Schwefel

mit technischem Sauerstoff oder Luft mit dem Austrittsbereich einer oder mehrerer Kontaktstufen (6_1, 6_2, 6_3, 6_4, 6_5) und/oder mit dem Austrittsbereich eines oder mehrerer Absorber(s) (4, 5) verbunden ist.

18. Anlage nach Anspruch 17, **dadurch gekennzeichnet, dass** die wenigstens eine Rezirkulationsleitung (17, 18) von dem Austrittsbereich des ersten Kontakts (2) zu dem Eintrittsbereich der ersten Kontaktstufe (6_1) führt.

19. Anlage nach Anspruch 17 oder 18, **dadurch gekennzeichnet, dass** diese 3 bis 5 Kontaktstufen (6_1, 6_2, 6_3, 6_4, 6_5), vorzugsweise zusammengefasst in einem oder zwei Kontakten (2, 3), aufweist.

Revendications

1. Processus pour produire de l'acide sulfurique, de l'oléum ou du trioxyde de sulfure liquide, dans lequel un gaz d'amorçage contenant du dioxyde de soufre réagit au moins partiellement avec de l'oxygène moléculaire dans au moins un contact (2, 3) comprenant au moins une étape de contact (6_1) afin de former du trioxyde de soufre, et dans lequel le gaz contenant le trioxyde de soufre produit est introduit au sein d'un absorbeur (4, 5) et y est converti en acide sulfurique, **caractérisé en ce qu'**un gaz d'amorçage avec une teneur en acide sulfurique allant de 80 à 99,99 % en volume et possédant une teneur en oxygene allant de 0,01 à 10 % en volume et avec un taux volumétrique du dioxyde de soufre par rapport à l'oxygène de plus de 8 : 1 est fourni au premier stade de contact (61).

2. Processus selon la revendication 1, **caractérisé en ce qu'**un gaz de contact fourni au premier stade de contact (6_1) possède une teneur en dioxyde de soufre de plus de 90 % en volume.

3. Processus selon la revendication 1 ou la revendication 2, **caractérisé en ce que** le taux volumétrique du dioxyde de soufre par rapport à l'oxygène du gaz de contact fourni au premier stade de contact (6_1) est de plus de 10 : 1.

4. Processus selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un gaz de contact fourni au premier stade de contact (6_1) est constitué de 90 à 95 % en volume de dioxyde de soufre, de 3 à 7 % en volume d' oxygene, et de 0 à un maximum de 5 % en volume d'azote ou d'un autre gaz inerte.

5. Processus selon la revendication 4, **caractérisé en ce que** le gaz de contact est produit par combustion de soufre élémentaire à l'aide d'oxygène de tonnage.

6. Processus selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le premier stade de contact (6_1) inclut un catalyseur comprenant du pentoxyde de vanadium.

7. Processus selon la revendication 6, **caractérisé en ce que** le gaz de contact est fourni au premier stade de contact (6_1), qui inclut un catalyseur comprenant du pentoxyde de vanadium, à une température d'au moins 450 °C, et particulièrement de préférence d'au moins 470 °C.

8. Processus selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le gaz de contact est fourni au premier stade de contact (6_1) à une pression allant de 1 à 30 bar, et particulièrement de préférence de 3 à 12 bar.

9. Processus selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la teneur en dioxyde de soufre, le taux volumétrique de SO_2 par rapport à O_2, la pression d'entrée et la température d'entrée du gaz de contact fourni au premier stade de contact (6_1) sont choisies de sorte que dans le stade de contact (6_1) une température est obtenue, qui est inférieure à la température qui entrainera des dommages du catalyseur, mais supérieure à la température de fonctionnement du catalyseur.

10. Processus selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**en aval du premier stade de contact (6_1), de 2 à 4 nouveaux stades de contact (6_2, 6_3, 6_4, 6_5) sont fournis, qui sont de préférence combinés en un ou deux contacts (2, 3).

11. Processus selon la revendication 10, **caractérisé en ce que** le gaz de procédé sortant du premier à l'avant dernier stade de contact (6_1, 6_2, 6_3, 6_4) est mélangé avec de l'oxygène, possiblement après le passage à travers un absorbeur intermédiaire (4), est ajusté à une température d'entrée convenable pour le prochain stade de contact (6_2, 6_3, 6_4, 6_5) et est fourni respectivement au prochain stade de contact (6_2, 6_3, 6_4, 6_5).

12. Processus selon la revendication 10 ou la revendication 11, **caractérisé en ce que** le gaz de procédé sortant du dernier stade de contact (6_5) est fourni à un absorbeur (5).

13. Processus selon l'une quelconque des revendications 10 à 12, **caractérisé en ce qu'**à partir du gaz de procédé sortant du premier stade de contact (6_1) et/ou à partir d'un ou de plusieurs des gaz de procédé sortant du second au dernier stade de contact (6_2, 6_3, 6_4, 6_5) au moins un courant partiel est retiré, et ce courant partiel est mélangé au gaz d'amorçage avant que celui-ci n'entre dans le premier stade de contact (6_1) et/ou avec le gaz de combustion utilisé pour la combustion du soufre élémentaire pour la production du gaz d'amorçage contenant du dioxyde de soufre et/ou est fourni directement au bruleur à soufre (1).

14. Processus selon l'une quelconque des revendications 10 à 12, **caractérisé en ce qu'**à partir du gaz de procédé sortant de l'absorbeur intermédiaire (4) et/ou de l'absorbeur final (5) au moins un courant partiel est retiré, et ce courant partiel est mélangé au gaz d'amorçage avant que celui-ci n'entre dans le premier stade de contact (6_1) et/ou avec le gaz de combustion utilisé pour la combustion du soufre élémentaire pour la production du gaz d'amorçage contenant du dioxyde de soufre et/ou est fourni directement au bruleur à soufre (1).

15. Processus selon l'une quelconque des revendications 1 à 9, **caractérisé en ce que** seulement un contact (2) avec l'absorbeur en aval (5) est fourni, à partir du gaz de procédé quittant une étape de contact (6_1, 6_2, 6_3) un courant partiel est retiré avant et/ou après l'étape d'absorption (5), et ce courant partiel est mélangé au gaz d'amorçage avant que celui-ci n'entre dans le premier stade de contact (6_1) et/ou avec le gaz de combustion utilisé pour la combustion du soufre élémentaire pour la production du gaz d'amorçage contenant du dioxyde de soufre et/ou est fourni directement au bruleur à soufre (1).

16. Processus selon l'une quelconque des revendications 10 à 15, **caractérisé en ce que** le gaz de contact fourni à la première étape de contact (6_1) consiste de 90 à 95 % en volume de dioxyde de soufre, de 3 à 7 % en volume d'oxygène, de 0,01 à 5 % en volume de trioxyde de soufre, et de 0 à 5 % maximum en volume d'azote ou un autre gaz inerte.

17. Usine pour la production d'acide sulfurique, d'oléum ou de trioxyde de soufre liquide, en particulier pour réaliser un procédé selon l'une quelconque des revendications 1 à 16, avec au moins un contact (2, 3) comprenant au moins une étape de contact (6_1) afin de faire réagir un gaz d'amorçage contenant du dioxyde de soufre avec de l'oxygène pour obtenir du trioxyde de soufre, et au moins un absorbeur (5), **caractérisée en ce que** la région d'entrée de la première étape de contact (6_1) est connectée à la région de sortie d'une ou de plusieurs étapes de contact (6_1, 6_2, 6_3, 6_4, 6_5) et/ou à la région de sortie d'un ou de plusieurs absorbeurs (4, 5) à travers un ou plusieurs conduits de recirculation (17, 18) et qu'un bruleur à soufre (1) avec une chambre de combustion pour la combustion du soufre élémentaire à l'aide d'oxygène de tonnage ou d'air est connecté à la région de sortie d'une ou de plusieurs étapes de contact (6_1, 6_2, 6_3, 6_4, 6_5) et/ou à la région de sortie d'un ou de plusieurs absorbeurs (4, 5).

18. Usine selon la revendication 17, **caractérisée en ce qu'**au moins un conduit de recirculation (17, 18) à partir de la région de sortie du premier contact (2) mène à la région d'entrée de la première étape de contact (6_1).

19. Usine selon la revendication 17 ou la revendication 18, **caractérisée en ce que** celle-ci inclut de 3 à 5 étapes de contact (6_1, 6_2, 6_3, 6_4, 6_5), de préférence combinées en un ou deux contacts (2,3).

Fig.1

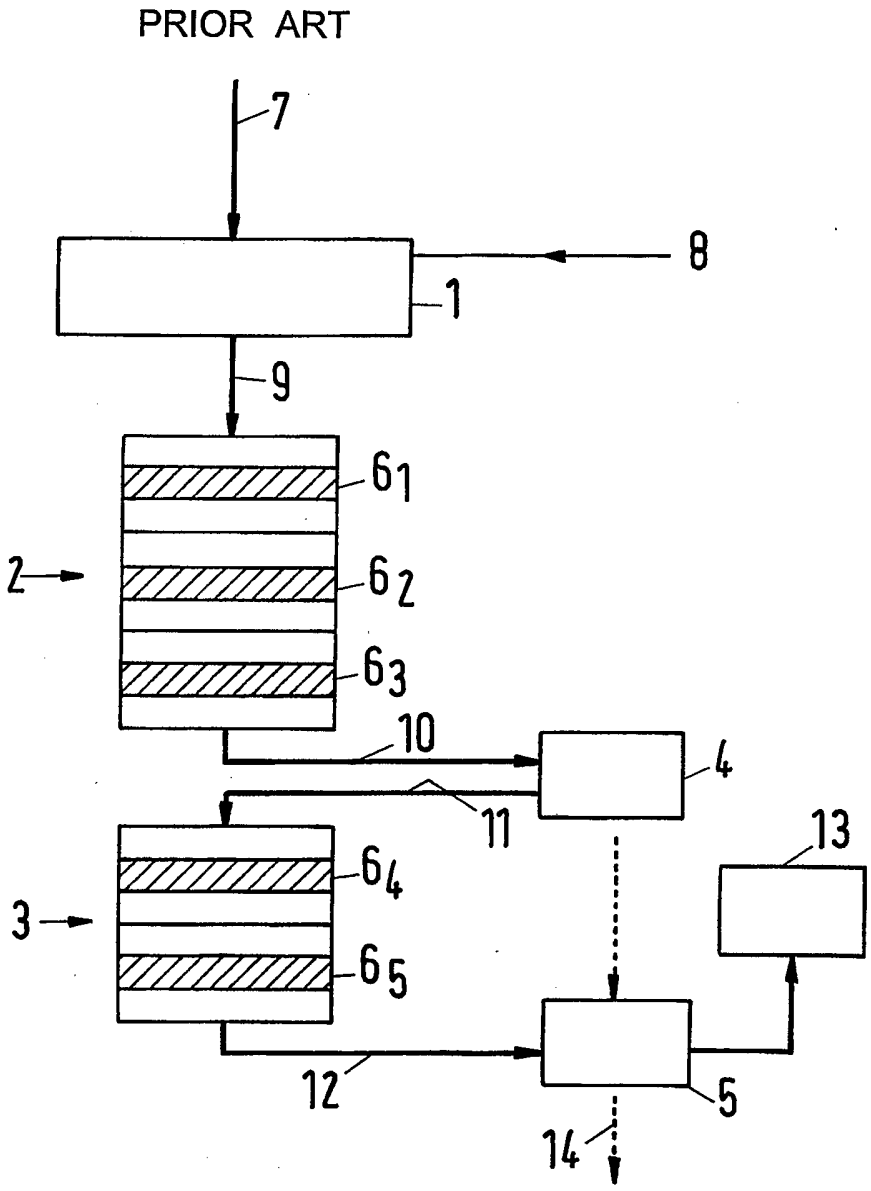


Fig. 2

PRIOR ART

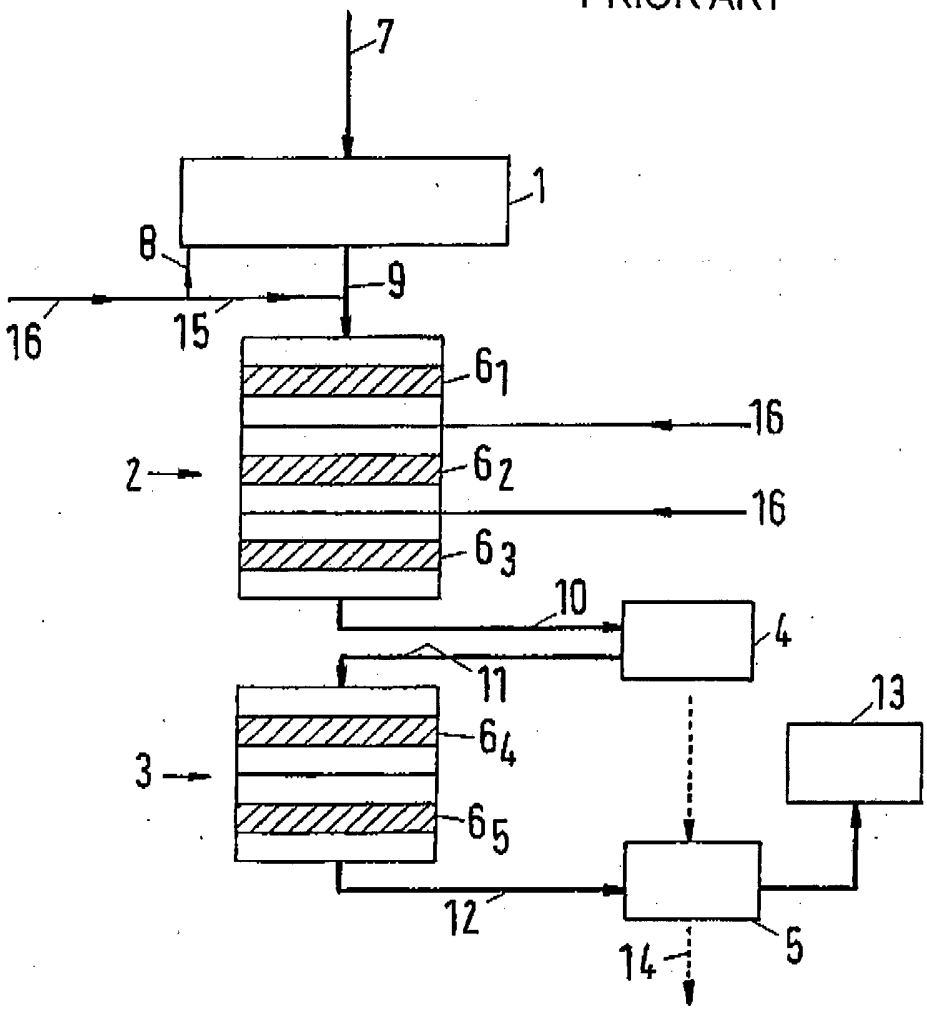


Fig.3

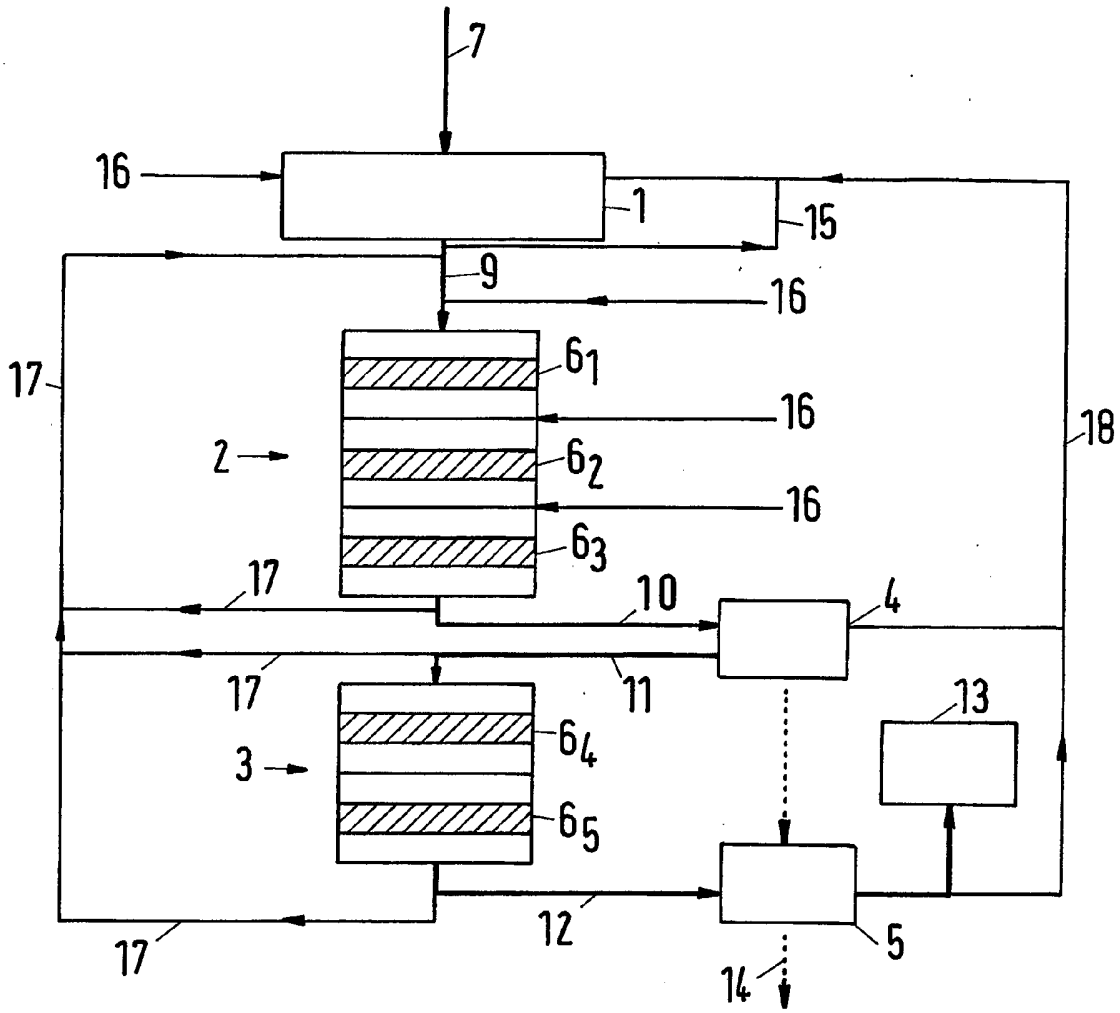


Fig.4

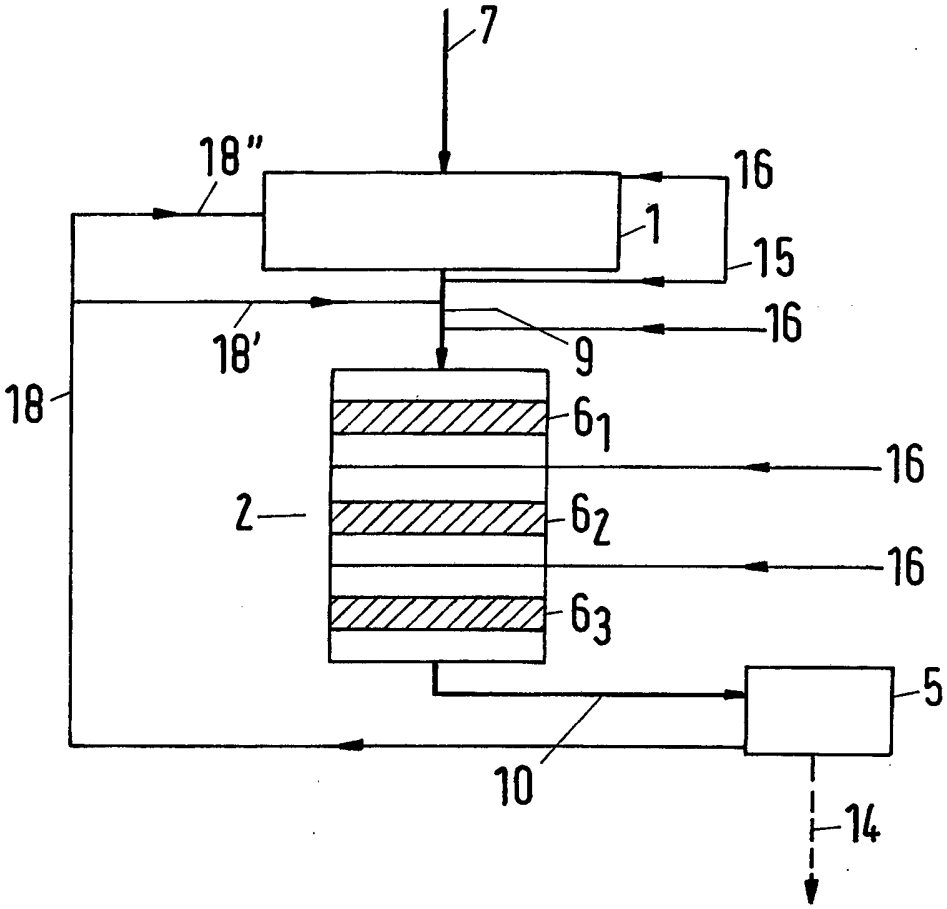
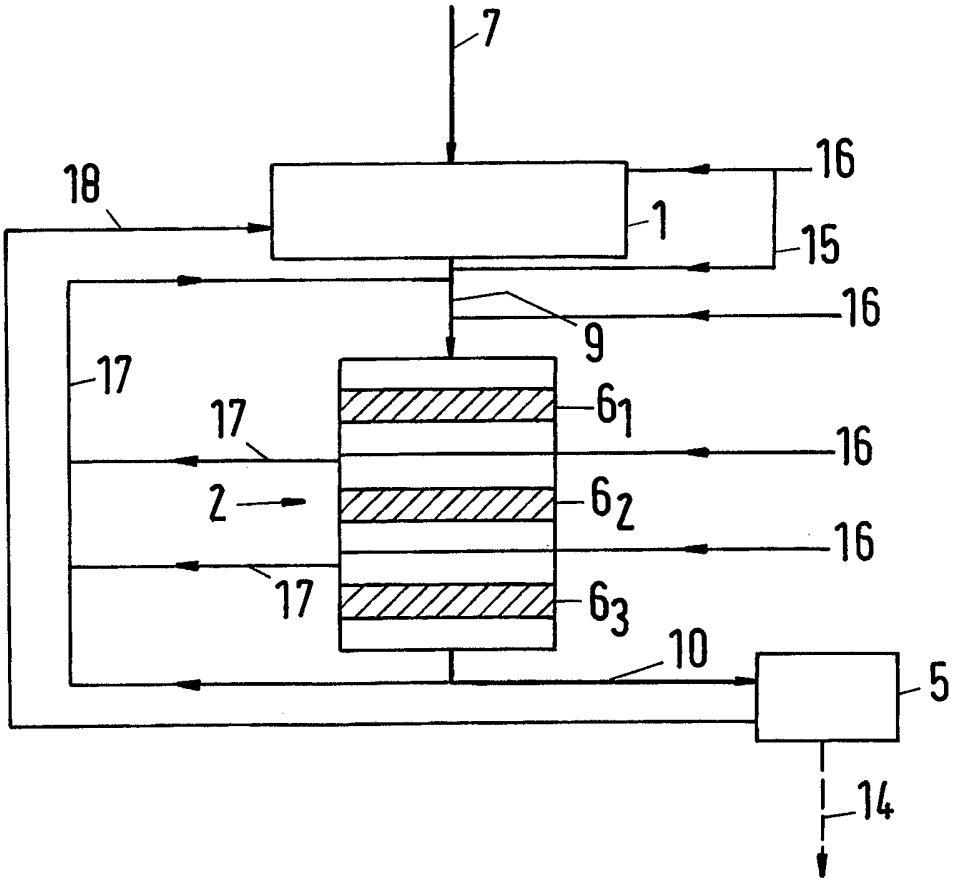


Fig.5



REFERENCES CITED IN THE DESCRIPTION

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SZABADALMI IGÉNYPONTOK

1. Eljárás kénsav, óleum vagy folyékony kéntrioxid előállítására, amelynek során kéndioxidot tartalmazó kiindulási gázt molekuláris oxigénnel legalább részben reagáltatunk legalább egy kontaktban (2, 3), amely legalább egy kontakt fokozatot (6_1) tartalmaz, kéntrioxid előállításához, és amelyben az előállított kéntrioxid tartalmú gázt bevezetjük egy abszorberbe (4, 5) és ott kénsavvá alakítjuk, azzal jellemezve, hogy az első kontakt fokozatba (6_1) egy kontakt gázt vezetünk, amelynek kéndioxid tartalma 80-99,99 tf% és oxigén tartalma 0,01-10 tf%, és a kéndioxid oxigénhez mért térfogataránya nagyobb, mint 8:1.

2. Az 1. igénypont szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozatba (6_1) bevezetett kontakt gáz kéndioxid tartalma több, mint 90 tf%.

3. Az 1. vagy 2. igénypont szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozatba (6_1) bevezetett kontakt gázban a kéndioxid oxigénhez mért térfogataránya nagyobb, mint 10:1.

4. Az előző igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozatba (6_1) bevezetett kontakt gáz összetétele 90-95 tf% kéndioxid, 3-7 tf% oxigén és 0 – legfeljebb 5 tf% nitrogén vagy egyéb inert gáz.

5. A 4. igénypont szerinti eljárás, azzal jellemezve, hogy a kontakt gáz elemi kén technikai oxigénnel történő elégetésével van előállítva.

6. Az előző igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozat (6_1) vanádium-pentoxidot tartalmazó katalizátort foglal magában.

7. A 6. igénypont szerinti eljárás, azzal jellemezve, hogy a kontakt gázt legalább 450°C , különösen előnyösen legalább 470°C hőmérsékleten vezetjük be az első kontakt fokozatba (6_1), amely vanádium-pentoxidot tartalmazó katalizátort foglal magában.

8. Az előző igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy a kontakt gázt 1-30 bar, különösen előnyösen 3-12 bar nyomáson vezetjük be az első kontakt fokozatba (6_1).

9. Az előző igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozatba (6_1) bevezetett kontakt gáznál a kéndioxid tartalmat, a SO_2/O_2 térfogat arányt, a bevezetési

nyomást és a bevezetési hőmérsékletet úgy választjuk meg, hogy az első kontakt fokozatban (6_1) elért hőmérséklet alacsonyabb a katalizátort károsító hőmérsékletnél, de magasabb a katalizátor üzemi hőmérsékleténél.

10. Az előző igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozattól (6_1) áramlási irányban 2-4 további kontakt fokozat (6_2, 6_3, 6_4, 6_5) van kapcsolva, amelyek előnyösen egy vagy két kontakttá (2, 3) vannak kombinálva.

11. A 10. igénypont szerinti eljárás, azzal jellemezve, hogy az első – utolsó előtti kontakt fokozatot (6_1, 6_2, 6_3, 6_4) elhagyó termékgázt oxigénnel keverjük, esetleg egy köztes abszorberen (4) átvezetve, a következő kontakt fokozathoz (6_2, 6_3, 6_4, 6_5) megfelelő bevezetési hőmérsékletre állítjuk és bevezetjük rendre a következő kontakt fokozatba (6_2, 6_3, 6_4, 6_5).

12. A 10. vagy 11. igénypont szerinti eljárás, azzal jellemezve, hogy az utolsó kontakt fokozatot (6_5) elhagyó termékgázt egy abszorberbe (5) vezetjük.

13. A 10-12. igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy az első kontakt fokozatot (6_1) elhagyó termékgázból és/vagy a második – utolsó kontakt fokozatot (6_2, 6_3, 6_4, 6_5) elhagyó termékgázok közül egy vagy több termékgázból legalább egy részáramot leválasztunk, és ezt a részáramot elkeverjük a kiindulási gázzal, mielőtt az belép az első kontakt fokozatba (6_1) és/vagy azzal az égető gázzal, amelyet az elemi kén elégetéséhez használtunk a kéndioxidot tartalmazó kiindulási gáz előállításához és/vagy közvetlenül a kén égetőbe (1) vezetjük.

14. A 10-12. igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy a köztes abszorbert (4) és/vagy a végső abszorbert (5) elhagyó termékgázból legalább egy részáramot leválasztunk, és ezt a részáramot elkeverjük a kiindulási gázzal, mielőtt az belép az első kontakt fokozatba (6_1) és/vagy azzal az égető gázzal, amelyet az elemi kén elégetéséhez használtunk a kéndioxidot tartalmazó kiindulási gáz előállításához és/vagy közvetlenül a kén égetőbe (1) vezetjük.

15. Az 1-9. igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy csak egy kontaktot (2) szerelünk fel, áramlási irányban egy abszorberrel (5), a valamely kontakt fokozatot (6_1, 6_2, 6_3) elhagyó termékgázból leválasztunk egy részáramot az abszorpciós fokozat (5) előtt és/vagy után, és ezt a részáramot elkeverjük a kiindulási gázzal, mielőtt az belép az első kontakt fokozatba (6_1) és/vagy azzal az égető gázzal, amelyet az elemi kén elégetéséhez használtunk a kéndioxidot tartalmazó kiindulási gáz előállításához és/vagy közvetlenül a kén égetőbe (1) vezetjük.

16. A 10-15. igénypontok bármelyike szerinti eljárás, azzal jellemezve, hogy az első kontakt

fokozatba (6_1) bevezetett kontakt gáz összetétele 90-95 tf% kéndioxid, 3-7 tf% oxigén, 0,01-5 tf% kéntrioxid és 0 – legfeljebb 5 tf% nitrogén vagy egyéb inert gáz.

17. Berendezés kénsav, óleum vagy folyékony kéntrioxid előállítására, különösen az 1-16. igénypontok bármelyike szerinti eljárás megvalósítására, amely tartalmaz legalább egy kontaktot (2, 3), amely legalább egy kontakt fokozatot (6_1) tartalmaz, kéndioxidot tartalmazó kiindulási gáz oxigénnel történő reagáltatásához kéntrioxid előállításához, és legalább egy abszorbert (5), azzal jellemezve, hogy az első kontakt fokozat (6_1) bevezető szakasza össze van kapcsolva egy vagy több kontakt fokozat (6_1, 6_2, 6_3, 6_4, 6_5) kivezető szakaszával és/vagy egy vagy több abszorber (4, 5) kivezető szakaszával, egy vagy több visszavezető vezetéken (17, 18) keresztül, és hogy egy, égető kamrával ellátott kén égető (1), amely elemi kén technikai oxigénnel vagy levegővel történő elégetésére szolgál, össze van kapcsolva egy vagy több kontakt fokozat (6_1, 6_2, 6_3, 6_4, 6_5) kivezető szakaszával és/vagy egy vagy több abszorber (4, 5) kivezető szakaszával.

18. A 17. igénypont szerinti berendezés, azzal jellemezve, hogy legalább egy visszavezető vezeték (17, 18) vezet az első kontakt (2) kivezető szakaszától az első kontakt fokozat (6_1) bevezető szakaszához.

19. A 17. vagy 18. igénypont szerinti berendezés, azzal jellemezve, hogy 3-5 kontakt fokozatot (6_1, 6_2, 6_3, 6_4, 6_5) tartalmaz, előnyösen egy vagy két kontaktban (2, 3) kombinálva.