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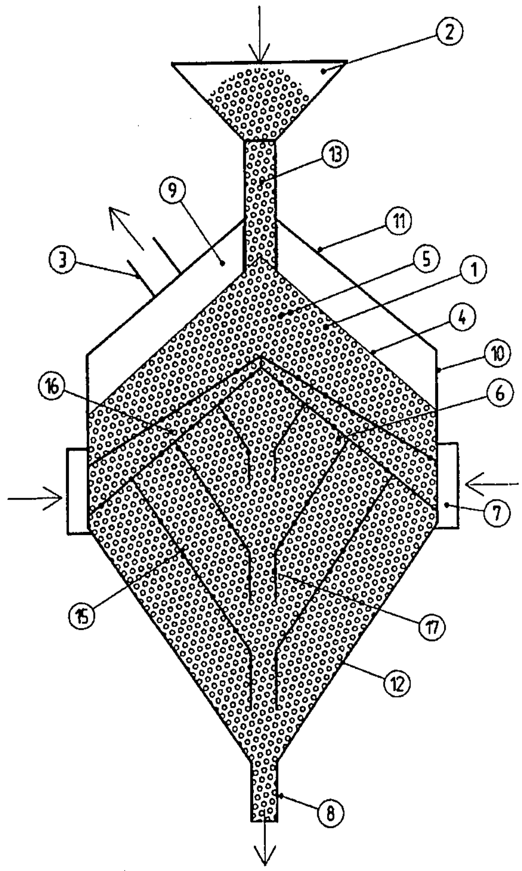
(54) Title: A METHOD TO CONSTRUCT A COUNTER FLOW PROCESS

(57) Abstract

The invention describes a counter flow process, where an efficient contact is received between a solid, granular material (5) and a liquid or gas. The solid material is fed continually from above, forming a slide cone and is then moved downward through a set of concentric funnels (15) which create an even flow velocity of the granular material (5) over the cross section of the bed (1).



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TITLE:

A method to construct a counter flow process.

BRIEF DESCRIPTION:

The present invention concerns a method to get an efficient contact between a solid material in the form of grains and a liquid or a gas. The process is performed in a closed vessel. The solid material is fed continually from the top whereby a slide cone upper surface is formed and the material continues to move downwards in a uniform motion. Simultaneously, a liquid or a gas passes upwards in an equally even movement. So, an efficient counter flow process is achieved.

BACKGROUND TECHNIQUE:

In many industrial processes, a continuous chemical reaction between a solid material and a liquid or a gas is brought about.

In the Swedish patent 8401478-6 it is described, among other things, how chemical reactions are brought about between a basic, solid material and harmful continuents in flue gases. The gases are led though a layer of granular limestone where the harmful sulfur dioxide, chlorhydric acid, fluorhydric acid, etc. reacts with surface of the stone, forming harmless products.

In other processes, a reaction is desired between for instance a substance that is dissolved or emulsified in a liquid and a solid material. Even in this case, the granular material is brought in contact with the liquid to reach the desired process on the surface of the solid material. Naturally the highest possible efficiency of the process is preferred. The chemical process should run as completely and as fast as possible with a minimum consumption of solid material. The ideal counter flow process implies that the liquid or the gas is fed continually and evenly through a bed of the solid material of even thickness, that it is then led off the bed after the passage and that fresh solid material is fed at the surface, where the liquid or the gas is led off the bed and that this solid material is transported evenly downwards in the bed and is led off at the bottom surface of the bed. The liquid or the gas is thus introduced along the bottom surface of the bed where the solid material has been exposed for the longest time for the reaction and they leave the bed at the upper surface where fresh material is fed continuously. Of course, the efficiency and the rapidity of the process will be increased if the surface of the bed is made as large as possible.

THE INVENTION:

Surprisingly it has now appeared that an almost ideal counter flow process can be brought about in a simpler matter. In a closed vessel, the solid granular material is fed from a hopper above the vessel centrally through a hole or a slit. When the material moves continually down in the vessel, it simply flows out over the upper surface, the position and form of which is determined by the slide angle of the material. The liquid or the gas is fed evenly distributed under this surface at a distance from the surface that corresponds to the depth of the solid bed that is necessary to perform the chemical reactions. The liquid or the gas flows through the bed against the top surface and is evacuated from the space above the bed out from the closed vessel. Under the part of the bed that is participating in the reaction, the spent, solid material is moved downwards in such a way that the flow through the bed of granular material and fluid is as even as possible.

The invention will be described more precisely in the enclosed claims, in a more detailed description below and by help of drawings enclosed on which:

figure 1 shows a cross section of the vessel a

figure 2 shows a method to let in the liquid or gas into the process and

Figure 3 shows a situation with two funnels ,15, for illustrating the different terms in the formula.

Closer description of the invention:

Naturally, the closed vessel, fig. 1, can be designed in many, different ways. A common and efficient design is described below.

The vessel, fig.1, consists of a vertical, cylindrical part, 10. Upwards the cylindrical part ,10, is connected to an upper conical part ,11, with the thin end upwards, and downwards to another lower conical part ,12, with the thin end downwards. The solid, granular material ,5, is filled centrally at the upper part of the upper conical part ,11, through a feed tube ,13, from a hopper ,2, above the upper conical part ,11. The feed tube ,13, which is preferably mounted vertically is extending some distance down into the vessel ,fig 1. Naturally, the feed method can vary. For instance, the feed tube ,13, can be substituted to several feed tubes ,13. The reason the tubes ,13, should protrude down into the vessel ,fig. 1, is that the vessel is automatically filled as the solid granular material ,5, moves away from the mouth of the tube ,13. If the tube ,13, is designed as a telescope, the top level of the bed ,1, can easily be varied. In any case, there shall always be an open upper space ,9, that is free of solid material ,5, between the vessel wall on the top surface ,4, of the bed ,1. This open space ,9, allows the solid material ,5, to slide without obstacles over the top surface, 4, of the bed ,1.

Now, depending of the slide angle of the solid granular material ,5, an upper surface ,4, sloping out and down from the feed tube ,13, is formed on the solid reaction bed ,1. The solid material ,5, is distributed over the bed ,1, in the same rate as the material ,5, in the bed ,1, moves downward. Now the liquid or gaseous material shall be led to the bed ,1, evenly distributed over a surface in the bed giving a reaction zone of the preferred thickness. Normally, the thickness of the bed ,1, is equal over the whole area. Deviations can be necessary, for instance, if the grain sizes of the granulate ,5, varies as the larger grains easily concentrate towards the periphery of the slide cone. However, the main factor governing the distance from the upper surface ,4, of the bed ,1, is then necessary extent of chemical reaction.

The inflow of liquid or gas should be disturbed over as large area as possible without forming too much obstacle to the downward flow of solid, granular material ,5. This could for instance be accomplished by mounting tubes with nozzles ,14, as spokes from a ring chamber ,7, around the cylindrical part ,10, of the vessel upwards towards the center of the reaction chamber. The slopes of the spokes should be chosen such that the thickness of the reaction zone that is equal to the distance between the spokes and the upper surface ,4, is the chosen. Specially in case the fluid is gas, the tubes ,14, can be exchanged to long hoods ,16, which leave an open space free from granular material ,5, on their lower side and leave open channels for the gas. The cross section of the hoods ,16, can for instance have a U or a half circular form. The liquid or the gas that is led in flows through the reaction bed ,1, towards the upper space ,9, over the upper surface ,4, and is led away through the exhaust ,3, in the wall of the vessel.

The granular material ,5, that moves down towards the area ,6, where liquid or gas enters the bed has now finished the chemical reaction and shall be transported out of the bed. This transport out of the bed must be done in such a way that the flow of the solid material ,5, through the bed ,1, is as even as possible over the total area in order to utilize the solid material ,15, as efficiently as possible.

Fig 1, shoves among others a number of concentric funnels ,15, that are mounted under the reaction bed. The granular material ,5, is now conducted by the funnels ,15, towards the center of the reaction chamber and out of it at its bottom through an outlet ,8. The diameter of the bottom openings in the funnels ,15, and the length of the outlet tubes ,17, determines the distribution of the flow between the different funnels ,15, and, if the right dimensions are chosen, the flow of solid material ,5, through the bed ,1, will be quite even.

On figure 3 a situation with two funnels ,15,15', is illustrated. Here,

D_t is the diameter of the lower, bigger funnel (15),

d_t is the diameter of the upper, smaller funnel (15'),

d_i is the inner diameter of the outlet tube (17') of the upper, smaller funnel (15'),

d_y is the outer diameter of the outlet tube (17') of the same funnel (15')

d_n is the inner diameter of the outlet tube (17) of the lower bigger funnel (15),

l_f is the distance from the bottom end of the outlet tube (17') from the smaller funnel (15') to the outlet (17) of the bigger funnel (15),

All dimensions are given in meters. Now, the following formula gives the condition for an even flow in these two funnels ,15,:

$$d_t^2 \times ((2 \times l_f \times \text{constant} + d_n)^2 - d_y^2) = d_i^2 \times (D_t^2 - d_t^2)$$

The value of the constant is constant for every type of granular material ,5, but varies with different materials ,5, from 0,12 to 0,21. The right value for a certain granular material ,5, must be determined with an experiment. Once the value of the constant is determined, any type and dimension of funnel bed design can be calculated.

In reaction beds with large upper surfaces ,4, it may be a problem that the natural slide angle and thus the depth of bed varies. For this reason a number of concentric rings can be mounted around the feed tube ,13, protuding a small measure down in the upper surface ,4, of the bed ,1, thus controlling the upper level of the bed ,1.

CLAIMS:

1. A method to construct a counter flow process in a system with a solid, granular material (5) and a liquid or a gas c h a r a t e r i z e d b y

a hopper (2), situated above a closed reaction vessel (fig.1) with a vertical, cylindrical part (10) and a lower conical part (12) which tapers downwards from the central part (10) and the granular material (5) is moved by gravity from the upper hopper (2) down to the center of the cylindrical part (10) and flows freely from the center out towards the cylindrical walls of the vessel over a surface (4) which is created by the slide angle of the granular material (5), and that the material (5) is continuously mowed downwards and out at the outlet (8),

the liquid or the gas being introduced in the bed (1) evenly distributed along a surface into the bed (1) of the granular material (5) which lies below the top surface (4) of the granular material bed (1) in such a way that the planned thickness of the reaction zone is formed and then led out of the bed (1) above the top surface (4) and

the flow velocity of the granular material (5) downwards in the vessel being controlled to be even over the cross section of the bed (1).

2. A method to construct a counter flow process according to claim 1 c h a r a t e r i z e d b y

the flow of granular material (5) in the bed (1) under the reaction zone being controlled by a number of concentric, circular funnels (15) with conical surfaces that are parallel to the lower conical part (12) of the reaction vessel and upper ends lie immediately below the reaction zone and end downwards with a tubular outlet (17)

3. A method to construct a counter flow process according to claim 2 c h a r a t e r i z e d b y

the distance from the bottom end of the outlet tube (17') from one funnel (15) to the outlet (17) of the next, lower funnel (15) being chosen from the formula:

$$d_t^2 \times ((2 \times l_f \times \text{constant} + d_n)^2 - d_y^2) = d_i^2 \times (D_t^2 - d_t^2)$$

where

D_t is the diameter of the lower, bigger funnel (15),

d_t is the diameter of the upper, smaller funnel (15'),

d_i is the inner diameter of the outlet tube (17') of the upper, smaller funnel (15'),

d_y is the outer diameter of the outlet tube (17') of the same funnel (15')

d_n is the inner diameter of the outlet tube (17) of the lower bigger funnel (15),

l_f is the distance from the bottom end of the outlet tube (17') from the smaller funnel (15') to the outlet (17) of the bigger funnel (15),

all dimension in meters and the value of the constant varies with different materials from 0,12 to 0,21.

4. A method to construct a counter flow process according to claim 1-3 c h a r a t e r i z e d b y
the feed tube (13) ending downwards towards the upper surface (4) of the bed (1).

5. A method to construct a counter flow process according to claim 4 c h a r a t e r i z e d b y
the tube (13) being telescopic.

6. A method to construct a counter flow process according to any of the preceding claim s c h a r a t e r i z e d b y
the liquid or gas being fed under the reaction zone from a ring chamber (7) around its cylindrical part (10) through tubes with nozzles (14) and said tubes being arranged like spokes inwards and upwards from the ring chamber (17) to the center of the vessel.

7. A method to construct a counter flow process according to claim 6 c h a r a t e r i z e d b y
the liquid or the gas being fed under the reaction zone (6) from the ring chamber (7) through V-shaped or semicircular hoods that are open downward allowing gas or liquid to flow through without being filled with granular material (5).

FIG. 1

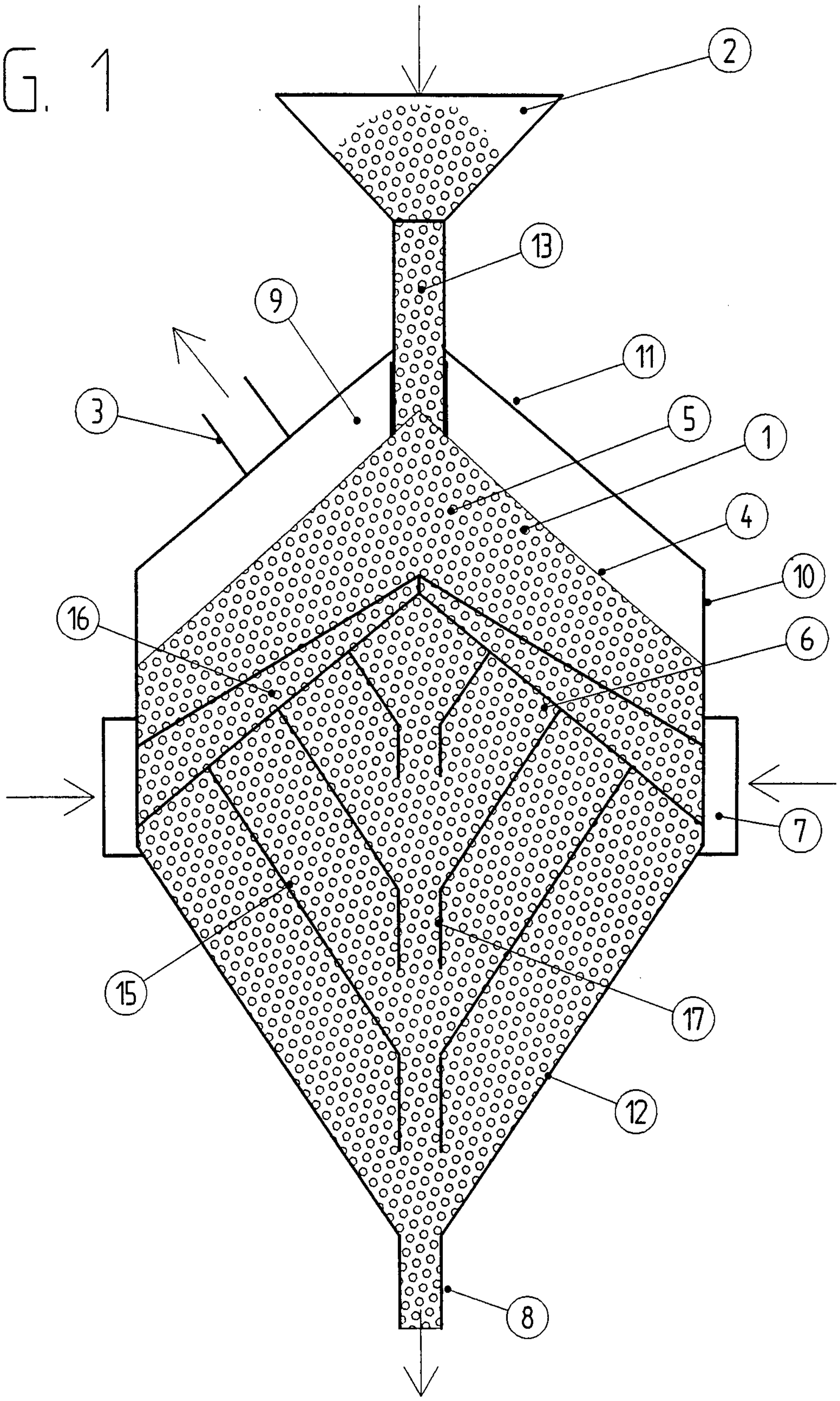


FIG. 3

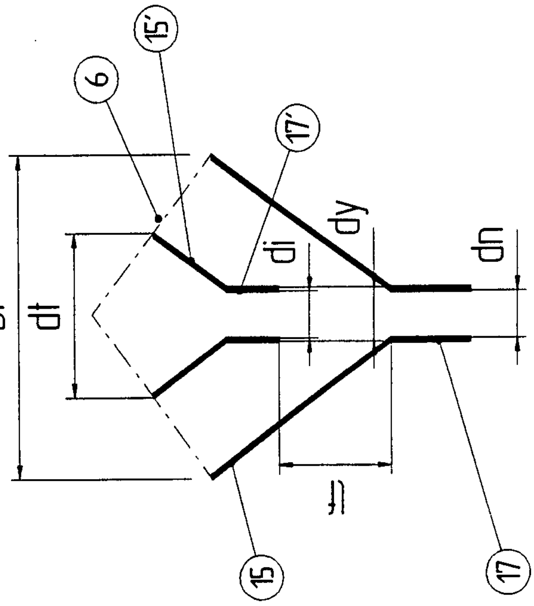
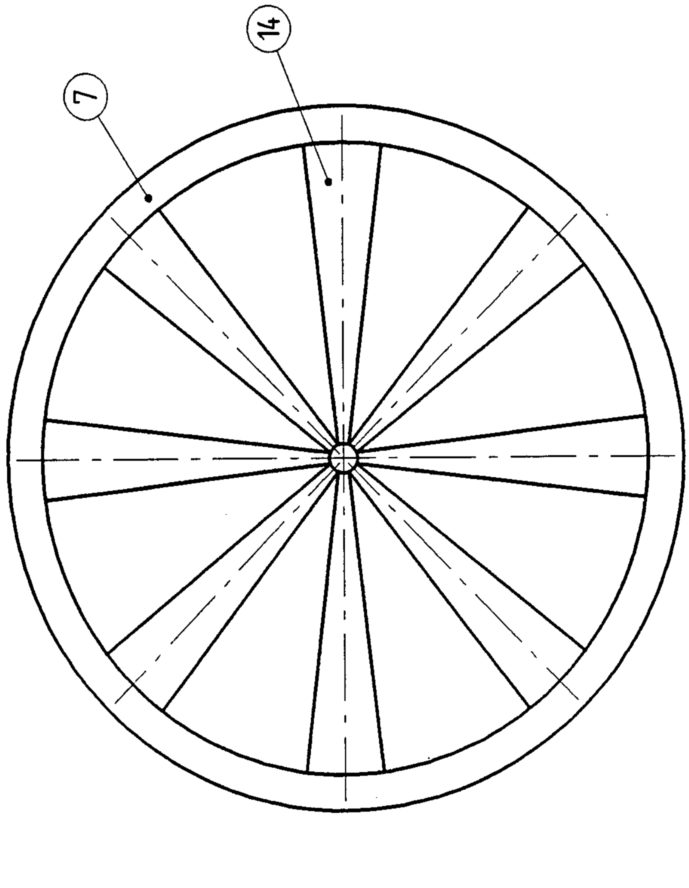


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00653

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B01J 8/12
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B01J

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

SE,DK,FI,NO classes as above

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

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9102586 A1 (NYMIC ANSTALT), 7 March 1991 (07.03.91), figure 1	1
A	DE 4129167 C1 (NYMIC ANSTALT, SCHAAN, LI), 10 December 1992 (10.12.92), figure 1	1
A	EP 0205866 A1 (SULZER ESCHER WYSS GMBH), 30 December 1986 (30.12.86), page 3, column 4, line 37 - column 4, line 46	1,2

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

31/07/96

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