

Improved Rotating Packed Bed Columns

Description

TECHNICAL FIELD

[0001] The present disclosure concerns an improved rotating packed bed column,
5 which can be modular and easy to assemble and has a compact design, without
sacrificing performance.

BACKGROUND ART

[0002] The present invention concerns, in particular, a rotating packed bed column for
separating gases from liquids. Packed beds are known in the art specially for gas-liquid
10 contacting applications, e.g., air or flue gas with water, as well as for
absorption/desorption processes, e.g., the absorption of a particular gas from an
exhaust gas. The performance of packed bed columns is proportional to the porosity
of the material used for the packing. In general, in terms of design and performance,
what matters most is the total surface area of the packed bed and the column height.

15 [0003] In general, the operation of a packed bed column is based on the fact that a gas
and a liquid are directed through stationary packed beds in counter-current flow
direction to one another. A higher separation efficiency can be obtained in a counter-
current-flow process compared to co-current-flow process.

[0004] Rotating packed beds usually consist of a packing and a shaft, to which the
20 packing is connected, through which gas and liquid are passed through. Some designs
feature a counter-current flow of gas and liquid in a radial direction. The preferred
embodiment of the subject invention is a radial flow of liquid from shaft to column
wall, while the gaseous fluid passes the packing in an axial direction, e.g., from bottom
of the packing upwards. The result is a so-called "crossflow" heat and mass transfer
25 regime.

[0005] The rotation of the packed bed on the shaft allows for increasing the velocity
of the liquid through the packing and, because of the resulting turbulence, to increase
heat and mass transfer of the process such that the total volume of the packed bed for
a given performance may be smaller compared to that of a stationary packed column.

[0006] Currently, the rotating packed bed design does not allow different treatment sections in one column without risking liquid entrainment from one section to the other.

5 [0007] In addition, the motor that drives the rotating shaft is installed at the bottom, thus increasing in the height of the overall column. Also, placing the motor and/or the gear underneath, creates difficulties in accessibility for maintenance and increased mechanical enforcement requirements for the column sump.

10 [0008] Also, current rotating packed bed columns are designed to treat the gas with just one type of liquid. It is, however, advantageous to allow for different gas treatment services in one single column, thus minimizing the number of columns and improving the overall cost and space requirements of the complete system.

15 [0009] Accordingly, an improved rotating packed bed column capable of treating gases with more types of liquids would be welcome. Also welcome would be a system capable of aligning a drive shaft in a reliable manner. Finally, it would be also desirable that the system is capable of saving plot space allowing installation of the rotating packed bed column without occupying too much space.

SUMMARY

20 [0010] In one aspect, the subject matter disclosed herein is directed to a rotating packed bed column that comprises a plurality of packed bed modules arranged to form a column. Each packed bed module comprises a rotating wheel, and a first and a second inlet, connected to respective first and second conduits, to convey one or more liquids, to allow liquid injection into the rotating wheel, so as to perform heat or mass transfer between liquid and gas phase. The rotating packed bed column also comprises a driving arrangement, having a driving motor, and a shaft arrangement, comprising a
25 rotating shaft, mechanically connected to the driving motor. The rotating shaft comprises module shaft elements connected by couplings and adapted to transfer the torque to the packed bed modules for the operation of the rotating wheel

[0011] Each packed bed module is adapted to be connected to the rotating shaft, independent of the other packed bed modules.

30 [0012] In another aspect, the subject matter disclosed herein concerns a fan module

for conveying gas, arranged on top of the packed bed modules. The fan module may comprise an induced draft fan capable of collecting and discharging the gaseous by-product resulting from the reactions that take place in the packed bed modules.

5 **[0013]** Another aspect, disclosed herein is a chimney tray module for gas and liquid separation, for collecting and containing the water accumulated during the process, to avoid any percolation of liquid down. The chimney tray module may comprise a plurality of chimneys, and each chimney may have a cap plate to prevent the liquid droplets from the rotating wheel arranged above to fall through the chimney below.

10 **[0014]** In another aspect, the subject matter disclosed herein concerns that each packed bed module is defined by a double wall. The double wall has an inner wall, which contains the rotating wheels, an outer wall, and a recycling outlet from the outer wall. In the double wall, between the inner wall and the outer wall, the rinsing water coming from the packed bed module arranged above flows and comes out from the recycling outlet.

15 **[0015]** A further aspect of the present disclosure is drawn to the fact that the driving motor is arranged at the top of the rotating packed bed column. The driving arrangement may comprise a planetary gear, which mechanically connects the driving motor, the rotating shaft, and the induced draft fan, to transfer the rotating torque from the driving motor to the rotating shaft and the induced draft fan at a desired speed.

20 **[0016]** In another aspect, the subject matter disclosed herein concerns that the fan module is arranged at the top of the rotating packed bed column and comprises an integrated induced draft fan. Also, the fan module may comprise guide vanes, arranged below the integrated induced draft fan, and the guide vanes are configured to direct the flow of the gaseous by-product resulting from the reaction that takes place in the
25 packed bed modules. The fan module may also comprise a demister device, to minimize the erection height of the rotating packed bed column and the rotating shaft length.

30 **[0017]** In another aspect, the subject matter disclosed herein concerns that the first and the second inlets and the respective first and second conduits may be arranged to allow a liquid injection from the top and the bottom with respect to the rotating wheel.

[0018] A further aspect of the present disclosure is drawn to the fact that each of the packed bed modules may comprise the liquid distributor to minimize wear/wash-out from droplets. Also, the shaft arrangement may comprise one or more bearings, to support the rotation of the rotating shaft about a rotation direction, to operate the
5 packed bed modules.

[0019] In one aspect, the subject matter disclosed herein is directed to a shaft arrangement comprising a bore, by which it is possible to lift the rotating shaft, a split supporting ring to allow the (dis-)assembly; and adjustment rings, each one coupled to a respective packed module.

10 BRIEF DESCRIPTION OF THE DRAWINGS

[0020] A more complete appreciation of the disclosed embodiments of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

15 Fig. 1 illustrates a schematic sectional view of an improved rotating packed bed column according to a first embodiment.

Fig. 1A illustrates a detail of a packed bed module of the improved rotating packed bed column according to Fig. 1.

Fig. 1B illustrates a schematic sectional view of a portion of the improved rotating
20 packed bed column according to Fig. 1.

Fig. 2 illustrates a top view of the rotating packed bed column, according to the first embodiment.

Fig. 3 illustrates a cross section of a chimney tray module of the improved rotating packed bed column according to the first embodiment.

25 Fig. 4 illustrates a lateral section, along the line A-A, of the chimney tray module of Figure 3.

Fig. 5 illustrates a fan module of a rotating packed bed column, according to a second embodiment.

Fig. 6 illustrates a top sectional plan view of the shaft arrangement of a further embodiment of the third rotating packed bed column.

Fig. 7 illustrates a lateral section of part of Fig. 6.

Fig. 8 illustrates a lateral section of the further embodiment of the third rotating packed
5 bed column.

Fig. 9 illustrates a top view of Fig. 8.

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] According to one aspect, the present subject matter focuses on rotating packed beds, which are devices used to segregate fluids, such as air or flue gas with water.
10 The packed bed modules are arranged to form a column. The motor for operating the system is installed on top of rotating packed bed equipment and it is connected to a planetary gear. Otherwise the motor may directly drive the shaft to simplify the mechanical connections. Liquid segregation occurs by installing a chimney tray module with a shaft protected from liquids. The chimney tray module is able to collect
15 liquids percolating from above. The shaft alignment of the module wheels is done using ex-center disks to allow in-place adjustment. Gears are also provided to drive ex-center disks. Sliding or rolling supports are also provided at the wheel perimeter to unload the shaft for large wheel diameters. These sliding or rolling supports are configured such that the wheel diameters are larger than the shaft diameters. This
20 configuration allows reducing vibrations that otherwise will cause system instability.

[0022] In the following, similar parts will be described with the same reference number.

[0023] Referring now to the drawings, Figs. 1, 1A, 1B, and 2 show a sectional lateral view and a top view, respectively, of an embodiment of the rotating packed bed column
25 1. In particular, the rotating packed bed column 1 comprises a plurality of packed bed modules 2, which are piled up, so that one or more of the packed bed module 2 is on top of another packed bed module 2 and one or more of the packed bed modules 2 are below another packed bed module 2, to form a tower.

[0024] An optional fan unit 3 is arranged on top of piled modules 2. The rotating packed bed column 1 comprises also an optional chimney tray module 4, a driving motor 5, and a shaft arrangement 6. The shaft arrangement 6 has a rotating shaft 61, supporting thrust bearings 62, which allow for a self-supporting design of each packed bed module 2, and radial bearings 63. The rotating shaft 6 is assembled from the shaft elements 61 for each module with couplings 610 in between to allow for the transmission of rotating forces.

[0025] Each packed bed module 2 comprises a packed bed containment case 21, and a rotating drum or wheel 22, containing the packed bed 27. Also, each packed bed module 2 has a first inlet 23 and a second inlet 24, respectively connected to a first 25 and a second 26 conduit. The first 23 and the second 24 conduits are arranged to allow the liquid injection from the top and from the bottom of the wheel 22, to allow a balanced wheel design, which is achieved by a vertically centered mounting point of the wheel and the shaft, to minimize reinforcement needs. In addition, in terms of design, such an arrangement enables the realization of wheels 22 having higher heights.

[0026] Through such first 25 and second 26 conduits the same fluid is typically injected. However, advantageously, the arrangement also allows the injection of two different fluids into the packed bed 27, allowing for two treatment steps in a single wheel. In any case, the gaseous fluid entering the overall column system at the bottom passes through the wheel packing 22, in axial direction, causing a crossflow heat and mass transfer arrangement of liquid and gaseous fluids.

[0027] The gaseous fluid can be constituted by any gas, deriving, for instance, by combustion products, such as power plant or gas turbine off-gases and industrial processes combustion products, but also low-pressure process gases like natural gas subject to sweetening could be addressed.

[0028] In the embodiment at issue, the packed bed column 1 also comprises three packed bed modules 2 and one chimney tray module 4. Two packed bed modules 2 are interposed between a fan unit 3, arranged above, and the chimney tray module 4, arranged below. The third packed bed module 2 is arranged below the chimney tray module 4. In other embodiments, the number and the arrangement of the packed bed

modules 2 can change, allowing high design flexibility, as well as allowing treatment of the gas with different types of fluids within the same column 1.

5 **[0029]** Referring in particular to Fig. 1A, each packed bed module 2 comprises a wheel liquid distributor 28, which features a small traveling distance of the droplets from the distributor outlet to the wheel inlet, to minimize wear/wash-out from droplets. Because the liquid distributor 28 is not an integral part of the shaft, sealing requirements are avoided and, moreover, the deep insertion of the liquid distributor into the wheel improves the control over liquid distribution in the packing.

10 **[0030]** Referring to Fig. 2B, each packed bed module 2 is an autonomous element, capable of operating when operated by the shaft arrangement 6. The packed bed wheel module 2 consists of a containment frame that at the same time forms the outer hull of the module as better defined below. The frame is furthermore the support for the rotating packed bed wheel 22. Via bearings, the wheel position is fixed within the frame. The rotating shaft 61 ends can be connected to the adjacent modules 2 by
15 suitable couplings. The frame furthermore has means to collect fluids that exit the packed bed module 2 above by means of a double wall or outer hull 29, which forms a “pocket” to collect liquid rinsing down the wall. The double wall 29 is formed by an inner wall 291 and an outer wall 292. The inner wall 291 serves at the same time as the impingement wear surface for the droplets exiting the rotating wheel 22.

20 **[0031]** Finally, the rotating packed bed module 2 contains the liquid distributor and associated the first 25 and second 26 conduits. The rotating wheel 22 as such is assembled mainly from a rotating shaft 61, a rotating cage (an eight-segment cage top view is shown in Fig. 8, indicated with the reference number 8) to contain the rotating packed bed column 1 itself. Utility connections to allow lubrication of the bearings
25 will be implemented when wheel design requires.

30 **[0032]** Still referring to Fig. 1B, a portion of the rotating packed bed column 1 made of two packed bed modules 2 is shown. Each packed bed module 2, as mentioned, has the lateral double wall structure 29, through which the rinsing water flows before reaching an outlet for being recirculated by an appropriate circuit, connected to a recycling outlet 293 from the outer wall 292. The water that comes out from the

recycling outlet 293 of one rotating packed bed module 2, which, as mentioned, comes from the rotating packed bed module 2 arranged above, is then recycled.

5 [0033] The fan unit 3, which in the present embodiment is arranged at the top of the packed bed column 1, comprises a containment case 31 and three or more lateral support beams 32, in the present embodiment arranged at 120° with respect to each other, to support the fan unit 3, and to absorb the possible vibrations generated. Also the support beams 32 allow supporting the weight of the fan unit 3 itself. To those knowledgeable in the art, it is obvious that the number of beams and their size is also dependent upon the column dimensions and associated dynamic loads from the wheels
10 operation.

[0034] The fan unit 3 also comprises an integrated induced draft fan 33, arranged into the containment case 31. The induced draft fan 33 has the function of transporting the gaseous fluid through the packing by generating an “induced” draft as a driving force, as better explained below.

15 [0035] Referring also to Figs. 3 and 4, the chimney tray module 4, as mentioned above, is interposed between two packed bed modules 2. In some embodiments, more than one chimney tray module per column can be installed, depending on liquid segregation needs.

20 [0036] The chimney tray module 4 comprises a containment case 41, which forms the outer protection of the rotating packed bed column 1 with the packed bed containment case 21, and a plurality of ducts or chimneys 42 that allow the passage of the gaseous fluid from the space below the tray. For collecting and containing the water accumulated during the process, the containment case 41, the ducts 42, and the tray plate 421 form a basin, so as to avoid any entrainment of the liquid falling down from
25 the above for gravity into the liquid of the wheel below. The size of the chimneys 42 depends on the specific operating conditions and also the required residence time of the liquid. In general, standard design guidelines are available and commonly applied for their design.

30 [0037] The chimney tray module 4 does not have rotating parts and, in fact, is decoupled from the rotating shaft 61. It allows for the shaft to pass through the tray, featuring a shaft sleeve 422 that is connected to the tray bottom 421. The tray bottom

421 is a plate and part of the supporting structure of the chimney tray module 4. As can be seen, all of the parts of the chimney tray module 4 are not connected to the rotating shaft 61. In some embodiments, bearings are included (not shown in the figure) to prevent possible mechanical vibrations to propagate through the rotating
5 packed bed column 1, and to ease the rotation of the rotating shaft 61.

[0038] The chimney tray module 4 also comprises deflection plates 423 that form sort of a sleeve around the shaft, arranged at the bottom, below support 64 covering also the coupling to the adjacent module's support 65, to prevent any liquid from rinsing down the shaft passage and prevent the couplings from direct liquid impingement.

10 **[0039]** Still referring to Fig. 4, the shaft arrangement 6 comprises a lower shaft support 64, and an upper shaft support 65 both fixed to the container case 41, and to the shaft sleeve 422. The rotating shaft 61 is arranged through said lower and upper shaft supports that could optionally feature shaft bearings, allowing a more stable rotation. Without the bearings, the chimney tray module 4 is not affected by the rotation of the
15 rotating shaft 61.

[0040] Each chimney 42 has a cap plate 43 that prevents liquid droplets falling down from the wheel 22 above the chimney tray module 4 to fall through the chimney 42 into the space below. The chimney tray module 4 allows liquid accumulation and improves the liquid segregation.

20 **[0041]** The driving arrangement 5 comprises a driving motor 51. The driving motor 51 is arranged at the top of the rotating packed bed column 1 and, in particular, over the fan module 3. Also, the driving arrangement comprises a planetary gear 52, which mechanically connects the driving motor 51 to the rotating shaft 61 and to the induced draft fan 33, so as to transfer the rotating torque generated by the driving motor 51 to
25 the rotating shaft 61 and to the integrated induced draft fan 33, for them to rotate at the desired speed. Alternatively, the two different speeds can also be realized by gear types different from the preferred planetary gear type solution shown.

[0042] Other embodiments can operate without the planetary gear 52. In such cases, the speed is adjusted by the driving motor 51.

30 **[0043]** The operation of the rotating packed bed column 1 is as follows.

[0044] When the liquid fluid enters into one of the packed bed module 2, it reaches the packed bed 27, where the packing material is included. The packed bed 27 rotates, causing horizontal liquid motion with high velocity due to the centrifugal force (see Fig. 1, arrow B). The gaseous stream flowing vertically upwards through the column 1 is collected and discharged by the fan module 3, following the path indicated by arrows C and F (see Fig. 1), thus crossing the packed bed modules 2 and the chimneys 42, passing through the chimney openings between chimney and cap plates 43. The liquid (typically, but not necessarily, water or a solvent for trace component removal out of the gaseous fluid) is collected in the basin of the chimney tray module 4, when the latter is below one or more packed bed modules 2 (see arrow D, Fig. 1), otherwise it rinses down to the bottom (see arrow E), where also the gaseous fluid inlet is located. In some embodiments, the liquid piping where through the liquids flow is part of the shaft bearing support structure of the rotating packed bed module 2.

[0045] The driving motor 51 drives the rotating shaft 61, which is supported by the thrust supporting bearings 62 and driven by the radial bearings 63 in the rotation direction according, for instance, to the arrow R to operate all the packed bed modules 2. The speed of the rotating shaft 61 is determined by the planetary gear 52.

[0046] At the same time, the driving motor 51 operates the fan module 3, by rotating the induced draft fan 33, that allows the extraction of the gaseous by-product of the reaction that take place into the packed bed modules 2 from the rotating packed bed column 1 (see Fig. 1, arrow C).

[0047] The planetary gear 52 also enables the induced draft fan 33 operating parameters which has a rotary speed from 700 to 2000 RPM.

[0048] Referring to Fig. 5, it is shown a detail of a second embodiment of a rotating packed bed column 1. In particular, the fan module 3 comprises guide vanes 34, arranged below the integrated induced draft fan 33. The guide vanes 34 have the function of directing the flow gaseous by-product resulting from the reaction (e.g., air). The guide vanes 34 are fixed to the structure of the fan module 3 and in general of the rotating packed bed column 1.

[0049] In addition, the fan module 3 comprises a demister device 35, placed between the lower shaft support 64 and the container casing 41, to minimize the erection height and the rotating shaft 61 length.

5 [0050] Referring now to Figs. 6-9, a further embodiment of the shaft arrangement 6 is illustrated, which is adapted to adjust the alignment of the packed bed modules 2, to which the rotating shaft 61 provides the distribution of the rotating torque for the operation of each module.

10 [0051] In particular, the shaft arrangement 6 further comprises a bore 611 to enable mounting of a lifting lug, by which it is possible to connect a crane or similar and lift the rotating shaft 61 in case of need, or to lift the whole module in case the rotating packed bed column 1 has to be disassembled.

15 [0052] The shaft arrangement 6 also comprises a split supporting ring 612 to allow the disassembly in place, and replacement of the upper supporting thrust bearings (axial and radial). The supporting thrust bearings 62 are adapted to allow the shaft arrangement 6 to self-support. The shaft arrangement 6 comprises frame structure 66 to accommodate the shaft bearings.

20 [0053] Optionally the frame structure 66 could be designed from adjustable beams. Then, one beam is built from two steel profiles connected with bolts/nuts and one profile is featuring slotted holes, to allow alignment of the rotary shaft 6. A preferred solution is to have no adjustable beams for the support structure but an adjustable shaft support in the center.

25 [0054] The shaft supports 64, 65 of the shaft arrangement 6 comprise two adjustment rings 67, 68 each. Each adjustment ring 67, 68 is a circular disk with eccentric bore, respectively indicated with the reference numbers 671 and 681. In particular, the circular disk 68 fits into the bore 671 of the circular disk 67, while the circular disk 67 fits into the shaft support ring housing 661, which is part of the frame 66.

30 [0055] Each bore 671 and 681 of the two adjustment rings 67, 68 is designed to be at the same time a seat that can carry the weight of the wheel of the relevant packed bed module 2. The bore 681 of adjustment ring 68 also provides the support/seat for bearings 63. Each of the adjustment rings 67, 68 can be freely rotated for shaft

alignment in axial direction. By the distortion, or relative rotation, of the adjustment rings 67, 68 orientation to each other and the frame 66, the adjustment ring bore 681 can be displaced in lateral direction. The eccentricity of the adjustment rings bores 671 and 681, chosen during support design, defines the maximum displacement from centerline that can be reached to carry out the adjustment. After the alignment of two adjacent shaft elements, the movement can be stopped by fastening the bolted clamping rings 76, causing compression of the rings to their seat (the adjustment ring 68 is fastened against ring bore 671, and the adjustment ring 67 is fastened against shaft support ring housing 661). At each packed bed module 2 upper support 65, the adjustment ring 68 also supports the supporting thrust bearing 62.

[0056] As it can be seen from Fig. 6, the adjustment rings 67 and 68 bores are not centric with regard to their outer ring's centerline. Adjustment ring 67 is arranged in the shaft supports 64, 65 frame.

[0057] As the upper support 65 with the thrust bearing 62, carries the weight of the rotating packed bed wheel 22, means are foreseen to hydraulically lift the eccentric disks 67, 68 from their supporting surface/seat. Therefore, each eccentric disk is featuring a hollow section 71 that has a bore to allow injection of a fluid. To prevent spillage of the injection fluid, gaskets 72 are foreseen. By injecting a fluid, for example, hydraulic oil into the hollow sections 71, each eccentric adjustment ring 67 can be lifted from its seat. By using gears or a lever mounted into lever bores 73 of the eccentric adjustment ring 67, so the adjustment ring 67 can be rotated.

[0058] Adjustment of the shafts is done when the column 1 is assembled. To ease rotation of the eccentric ring 67, particularly for larger wheel diameters, gears 74 might be attached to the adjustment ring 67. Each gear 74 rotates only one of the eccentric rings 67. When the correct position is reached, the position of the eccentric ring 67 is fixed using locking screws 75 and clamping rings 76.

[0059] An advantage of the solutions described is that modular elements can be easily disassembled if needed, by simply disconnecting the modules from each other. In particular this comes into effect when critical wear parts of the column, like the wheel liquid exit impingement area at the column wall, have to be repaired. Also, the transport of larger columns is simplified. Because of the modular design, the transport

height can easily be reduced to less than common truck transport limitations of 4 m. The presence of a plurality of standalone shaft elements 61, which are free to be combined, permits the packed bed columns of being modular, e.g. in assembling multiple wheels. Finally, with a portfolio of different modules (packed bed wheel,
5 chimney tray, integrated induced draft fan), column systems can easily be customized to feature different number and sequences of modules. Thus, the flexibility of adjusting the equipment arrangement to different applications is maximized.

[0060] Another advantage of the solution is that the induced draft fan has a design that allows removal at the top and ease of access for maintenance.

10 **[0061]** Another advantage of the solution is that the packed column arrangement allows using different liquid fluids in one column arrangement.

[0062] While aspects of the invention have been described in terms of various specific embodiments, it will be apparent to those of ordinary skill in the art that many modifications, changes, and omissions are possible without departing from the spirit
15 and scope of the claims. In addition, unless specified otherwise, the order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments.

[0063] Reference has been made in detail to embodiments of the disclosure, one or more examples of which are illustrated in the drawings. Each example is provided by
20 way of explanation of the disclosure and not by limitation of the disclosure. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present disclosure without departing from the scope or spirit of the disclosure. Reference throughout the specification to "one embodiment" or "an
25 embodiment" or "some embodiments" means that the particular feature, structure or characteristic described in connection with an embodiment is included in at least one embodiment of the subject matter disclosed. Thus, the appearance of the phrase "in one embodiment" or "in an embodiment" or "in some embodiments" in various places throughout the specification is not necessarily referring to the same embodiment(s). Further, the particular features, structures or characteristics may be combined in any
30 suitable manner in one or more embodiments.

[0064] When elements of various embodiments are introduced, the articles "a", "an",

“the”, and “said” are intended to mean that there are one or more of the elements. The terms “comprising”, “including”, and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements.

Improved Rotating Packed Bed Columns**CLAIMS**

1. A rotating packed bed column (1), comprising:
5 a plurality of packed bed modules (2) arranged to form a column, wherein each packed bed module (2) comprises a rotating wheel (22), and a first (23) and a second (24) inlet connected to respective first (25) and second (26) conduits, to convey one or more liquids to allow liquid injection into the rotating wheel (22) to perform heat and/or mass transfer between liquid and gas phase;
10 a driving arrangement (5), comprising a driving motor (51); and
a shaft arrangement (6) comprising a rotating shaft (61) mechanically connected to the driving motor (51), wherein the rotating shaft (61) comprises one or more shaft elements (61) connected by couplings (610) to transfer torque to the packed bed modules (2) to operate the rotating wheel (22);
15 wherein each packed bed module (2) is adapted to be connected to the rotating shaft (61) independently of the other packed bed modules (2).
2. The rotating packed bed column (1) according to claim 1, further comprising a fan unit (3) for conveying gas arranged on top of the packed bed modules
20 (2), comprising an induced draft fan (33) configured to collect and discharge gaseous by-product resulting from reactions that occur in the packed bed modules (2).
3. The rotating packed bed column (1) according to any one of the preceding claims, further comprising a chimney tray module (4) for gas and liquid
25 separation for collecting and containing the water accumulated during the process, to avoid any percolation of liquid down.
4. The rotating packed bed column (1) according to any one of the preceding claims, wherein the driving motor (51) is arranged at the top of the rotating
30 packed bed column (1).
5. The rotating packed bed column (1) according to any one of the preceding claims when depending on claim 2, wherein the driving arrangement (5)

comprises a planetary gear (52), which mechanically connects the driving motor (51), the rotating shaft (61) and the induced draft fan (33), to transfer the rotating torque from the driving motor (51) to the rotating shaft (61) and the induced draft fan (33) at a desired speed.

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6. The rotating packed bed column (1) according to any one of the preceding claims, when depending on claim 2, wherein the fan unit (3) is arranged at the top of the rotating packed bed column (1) and comprises an integrated induced draft fan (33).

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7. The rotating packed bed column (1) according to the preceding claims, wherein the fan module (3) comprises guide vanes (34), arranged below the integrated induced draft fan (33), the guide vanes (34) configured to direct the flow gaseous by-product resulting from the reaction that takes place in the packed bed modules (2).

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8. The rotating packed bed column (1) according to any one of the preceding claims, when depending on claim 2, wherein the fan unit (3) comprises a demister device (35) to minimize the erection height of the rotating packed bed column (1) and the rotating shaft (61) length.

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9. The rotating packed bed column (1) according to any one of the preceding claims, wherein the first (23) and the second (24) inlets and the respective first (25) and second (26) conduits are arranged to allow a liquid injection from top and bottom with respect to the rotating wheel (22).

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10. The rotating packed bed column (1) according to any one of the preceding claims, wherein each one of the packed bed modules (2) comprises a liquid distributor (28) to minimize wear/wash-out from droplets.

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11. The rotating packed bed column (1) according to any one of the preceding claims,
wherein each packed bed module (2) is defined by a double wall (29), having an inner wall (291), which contains the rotating wheels (22),

an outer wall (292), and
and a recycling outlet (293) from the outer wall (292),
wherein in the double wall (29), between the inner wall (291) and
the outer wall (292), the rinsing water coming from the packed bed module
5 (2) arranged above, flows and comes out from the recycling outlet (293).

12. The rotating packed bed column (1) according to any one of the
preceding claims, wherein the shaft arrangement (6) comprises one or more bearings
(62, 63) to support the rotation of the rotating shaft (61) about a rotation direction (R)
10 to operate the packed bed modules (2).

13. The rotating packed bed column (1) according to any one of the
preceding claims, when depending on claim 3, wherein the chimney tray module (4)
comprises a plurality of chimneys (42), and each chimney (42) has a cap plate (43) to
15 prevent the liquid droplets from the rotating wheel (22) arranged above to fall through
the chimney (42) below.

14. The rotating packed bed column (1) according to any one of the
preceding claims, wherein the shaft arrangement (6) comprises:
20 a bore (611), by which it is possible to lift the rotating shaft (61);
a split supporting ring (612) to allow assembly and disassembly of the shaft
arrangement (6); and
adjustment rings (67, 68), each one coupled to a respective packed module
(2).
25