Title: APPARATUS AND METHOD FOR THE PRESSURIZED SCRUBBING OF TOTAL REDUCED SULPHUR COMPOUNDS FROM KRAFT PULP MILL NON-CONDENSIBLE GASES

Abstract

A scrubbing process and apparatus for a pulp mill in which total reduced sulphur (TRS) compounds are scrubbed from non-condensable effluent gases (NCG). A scrubbing tower is fed by the NCG and by suitable alkaline liquid for chemical interaction with and binding to TRS compounds in the effluent gases. Packing within the tower disperses the suitable alkaline liquid into fine droplets. A comparatively high interior pressure and suitably high interior temperature are provided, and droplet dispersion is increased by means of increased packing height and diameter of the packing section and packing efficiency. Consequently the chemical interaction between the suitable alkaline liquid and TRS compounds in the NCG is comparatively increased whilst saturation humidity of the effluent gases exiting the tower is comparatively decreased, and evaporative cooling of the suitable alkaline liquid within the tower is comparatively reduced.
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APPARATUS AND METHOD FOR THE PRESSURIZED SCRUBBING OF TOTAL REDUCED SULPHUR COMPOUNDS FROM KRAFT PULP MILL NON-CONDENSIBLE GASES

This invention relates to an apparatus and method of removing total reduced sulphur (hereinafter referred to as "TRS") compounds from kraft pulp mill non-condensible gases (hereinafter referred to as "NCG"). In particular, the apparatus and method overcome various problems and inefficiencies practised in known systems by increasing the rate at which TRS compounds are removed from kraft pulp mill NCG and improving the removal efficiency of TRS compounds from kraft pulp mill NCG. The improved apparatus and method make possible lower costs of at least some items of capital equipment, and enable lower operating costs for some of the peripheral units typically associated with the scrubbing facility in a kraft pulp mill, as well as facilitating the reduction of maintenance expense of some of the apparatus associated with conventional kraft pulp mill scrubbing facilities.

BACKGROUND OF THE INVENTION

In the operation of conventional kraft pulp mills, NCG containing wood organics, air, moisture, and TRS are produced as a by-product. The TRS compounds most commonly encountered include hydrogen sulphide, methyl mercaptan, dimethyl sulphide, and dimethyl disulphide, all of which are known to be odorous and noxious primarily because the compounds have very low thresholds of odor detectability. In order to meet air quality regulations and objectives, it is necessary to collect the NCG emitted from various sources in kraft pulp mills into one or several systems for treatment either by incineration and/or modification by chemical reaction or absorption and adsorption to remove the TRS compounds. Hereinafter in the specification and in the claims reference to a "reaction" or a "chemical reaction" will include, as the context requires, not only such "pure" chemical reactions as that between hydrogen sulphide and white liquor, and that between methyl mercaptan and white liquor, but also
absorption and adsorption, such as occur, for example, when dimethyl sulphide and dimethyl disulphide are combined with white liquor, such latter reactions or phenomena arguably constituting physical chemical reactions or even physical reactions rather than pure chemical reactions. Similarly, "chemical efficiency" referred to hereinafter includes not only the efficiency of pure chemical reactions but also to the efficiency of the physical chemical reactions or physical reactions mentioned above as the context requires. It is also advantageous to remove the TRS compounds in the NCG from kraft pulp mill emissions for the reason that the TRS compounds that are recovered may be re-used in the kraft pulp mill process.

In conventional kraft pulp mills, NCG from one or more of the following emission sources listed below are collected for chemical treatment in a conventional header downstream of the emission sources:

- Batch digester evacuation vent (during liquor or chip fill)
- Batch digester depressurization vent (during end of batch digester blow)
- Continuous digester blow tank vent
- Batch digester hot water accumulator and/or secondary or tertiary condenser vent (batch blow NCG)
- Batch relief steam condenser vent
- Kamyr relief stream condenser vent
- Turpentine decanter and storage tank vent
- Evaporator hot-well or seal tank vent(s)
- Contaminated condensate tank vents (foul drains tank, foul, contaminated, and/or combined condensate tank)
- Condensate stripper overhead condenser vent
- Condensate stripper overhead decanter vent
- Stripper overhead liquid storage tank vent
- Brown stock washer vent
- Liquor storage tank vents (weak liquor, spill liquor, intermediate liquor, and strong liquor storage tank vents)
- Weak liquor filter vent
Black liquor oxidation vent (weak and/or strong liquor)

Sewer vents

The collected NCG are then drawn by a conventional fan, vacuum pump or steam ejector from the header and routed downstream to a conventional scrubbing column that has conventional NCG inlet and outlet and a conventional white liquor inlet and outlet. The NCG are pushed through the NCG inlet into the scrubbing column by a fan, vacuum pump or steam ejector located upstream of the scrubbing column, sucked into the scrubbing column by a fan, vacuum pump or steam ejector located downstream of the scrubbing column, or both pushed and sucked into the scrubbing column by a fan, vacuum pump or steam ejector located both upstream and downstream, respectively, of the scrubbing column. Conventional scrubbing systems operate at low pressures, typically in the range -0.5 to +0.5 psig.

Inside the scrubbing column, the NCG are then conventionally subjected to a minimal amount of heated white liquor, also known as cooking liquor (other alkali absorption media may be substituted or added) which is stored in a white liquor storage tank and supplied generally to the top of the scrubbing column by a conventional transfer pump. Conventionally, the presentation of the white liquor to the NCG is increased by dispersing or breaking-up the white liquor into tiny droplets using conventional packing and trays supported inside the scrubbing chamber. Typically, the columns are filled with packing that is not selected for optimum dispersion efficiency. Notably, conventional packing is typically characterized by (i) high HETP's (height equivalent to a theoretical plate) which results in a low level of interactions between the NCG and the white liquor; (ii) packing with high pressure drops, which require more energy to use; and/or (iii) a short packing height, which minimizes the extent of physical and chemical interaction between the NCG and the white liquor. A sprayer or an atomizer is used in some conventional scrubbing columns to increase the surface area of the white liquor in order to promote the interaction between the white liquor and the NCG. As those skilled in the technology are aware, the TRS compounds hydrogen sulphide and methyl mercaptan react rapidly with sodium hydroxide (a component of white liquor, which may also be used per se) and at high efficiencies of 99 percent or more. However, the TRS compounds dimethyl sulphide and dimethyl disulphide are known to react more slowly with sodium hydroxide and at low
efficiencies of 50 percent or less. Accordingly, the use of means to improve the white liquor/NCG interaction is encouraged.

The white liquor containing the TRS compounds is sometimes re-circulated around the scrubbing column for re-use, at which point the white liquor has a reduced capability to remove TRS from the NCG. Otherwise the spent white liquor exits the tower in response to sump level control and is returned to the storage tank or digesters by the use of a conventional return pump, and is usually eventually reconditioned for re-use in the kraft process. The scrubbed NCG conventionally exit the scrubbing column through the NCG outlet at the top of the scrubbing column after first passing through a conventional vertical chevron-type mist eliminator or separator to remove any droplets of white liquor entrained with the NCG. The NCG are then either vented into the atmosphere or sent downstream for cooling and dehumidifying in an optional conventional vent gas cooler, and then vented into the atmosphere or else incinerated and then vented into the atmosphere.

There are variations in the designs of NCG scrubbers used in conventional kraft pulp mill systems. There are conventional systems that make use of scrubbing columns in which the flow of white liquor and the NCG are countercurrent or cocurrent. These NCG scrubbing columns are subject to the common problems and inefficiencies associated with conventional kraft pulp mill NCG scrubbers, including not only the previously mentioned use of inefficient packing with high HETP’s (height equivalent to a theoretical plate), packing with high pressure drops, and the use of a short packing height. but also the use of a minimal amount of white liquor which is sometimes not enough to remove the TRS in the NCG and the use of white liquor that has been circulated around the column which has a reduced capability to remove TRS compounds from the NCG.

Other conventional NCG scrubbers operate using a “cross-flow” to scrub the NCG produced from kraft pulp mills. In the cross-flow systems, white liquor flows substantially perpendicular to the direction travelled by the NCG. Cross-flow systems experience the same common problems associated with other conventional kraft pulp mill NCG scrubbers and additionally are even more inefficient than conventional systems using countercurrent or
cocurrent flow and typically have relatively higher capital costs associated with their implementation.

Some conventional kraft pulp mill systems also make use of spray or fog towers wherein NCG fill a chamber and then a spray or an atomizer disperses white liquor into the chamber without the use of packing. Spray towers are inefficient because there is little contact between the white liquor and the NCG: fog towers have better efficiencies. However, the white liquor can tend to plug up the nozzle of such a sprayer or atomizer due to the tendency of white liquor to scale or cause corrosion of the nozzle of such a sprayer or atomizer, in turn due to the high velocity at which solids in the white liquor are typically sprayed. The fog created by such fog nozzles can very easily clog the mist eliminator. Further, the compressed air used for atomization inside the NCG scrubber will cause evaporative cooling of the liquid within the scrubber, possibly necessitating the provision of auxiliary heat.

Another kind of NCG scrubber used conventionally is the venturi scrubber which makes use of an eductor (instead of an ejector) to introduce the white liquor and NCG into a separator. When the white liquor is pumped into the separator, it draws with it the NCG. The white liquor and NCG are mixed together as they pass through the eductor and into the separator. Packing material and trays are not used in the separator. In the separator, the white liquor collects at the bottom while the NCG are removed from the top. The venturi scrubber is inefficient because the system does not offer sufficient time for the NCG and the white liquor to contact one another. All these conventional NCG scrubbers operate at low pressures, typically in the range -0.5 to +0.5 psig.

Although scrubber technology for removing TRS compounds from NCG emitted from kraft pulp mill operations is a relatively mature technology, having been in existence for many decades, yet there are aspects of the technology that continue to be problematic, as discussed above.

To summarize, conventional kraft pulp mill NCG scrubbers typically operate at relatively low chemical and thermal efficiency. Further, the combined choice of NCG scrubber operating
processes and apparatus has entailed operating and capital costs that are fairly severe, and have tended to be unacceptably high for those conventional design choices that do increase chemical or thermal efficiency to some extent. Finally, because the chemical efficiency of existing kraft pulp mill NCG scrubbers tends to be less than ideal, there is a risk that some TRS compounds may escape with the effluent gases into the atmosphere, causing atmospheric pollution, and, though of less importance, causing ring formation in the lime kiln when the poorly scrubbed NCG containing TRS are incinerated in the lime kiln before being vented into the atmosphere.

As mentioned, in a kraft pulp mill NCG scrubber, packing is employed to help disperse the white liquor droplets that are present in the scrubber to react with the TRS compounds and remove them from the NCG. On the one hand it might appear desirable to increase the dispersion of the droplets to improve the efficiency of their reaction with the TRS compounds in the NCG, but on the other hand, increased dispersion of the white liquor droplets in conventional NCG scrubbers would lead to two undesirable side effects, namely (i) an increased level of humidity in the NCG after they leave the scrubber (entailing higher dehumidification energy expenditure and consequent higher operating costs) and (ii) increased dispersion of the white liquor droplets, which would tend to increase the thermal losses and cause evaporative cooling of the white liquor, resulting in scaling of the scrubber apparatus, its packing, and various items of equipment downstream of the NCG scrubber. For the foregoing reasons, the conventional wisdom in NCG scrubber technology has been to steer away from increased white liquor droplet dispersion.

SUMMARY OF THE INVENTION

The invention provides an apparatus and method for removing TRS compounds from kraft pulp mill NCG before they are vented into the atmosphere, permitting re-use of the recovered sulphur in the kraft process. This invention in both apparatus and method implementations is in many respects similar to previously known systems described above; this specification will focus on the differences.

The applicant has significantly improved the chemical efficiency of such kraft pulp mill
NCG scrubbing operations by increasing dispersion of suitable alkaline liquid droplets (in defiance of the conventional wisdom that such increased dispersion is undesirable), by (i) increasing the packing height and diameter of the packing section or improving the dispersion-facilitating character of the packing or by providing other suitable dispersion means to increase the dispersion of the suitable alkaline liquid droplets in the scrubber, and (ii) increasing the operating pressure within the scrubber to increase the chemical and thermal efficiency of the scrubbing process. The latter increase in scrubber operating pressure prevents, mitigates or compensates for disadvantages that might otherwise arise from the former increase in dispersion of the suitable alkaline liquid droplets. The increased operating pressure according to the invention may be conveniently provided by a steam ejector that provides steam under pressure to the input NCG line leading into the scrubber. A pressure control loop comprising a pressure gauge and controlled valve on the effluent gas output side of the scrubber may be provided to maintain the scrubber operating pressure within set upper and lower limits. Provided the packing is high-efficiency packing, the specific choice is not critical; the packing may include suitable high-efficiency materials and configurations of various sorts, including trays. Suitable alkaline liquid may include but is not limited to oxidized or unoxidized white liquor, and in aqueous solution, such alkaline compounds as sodium hydroxide and sodium carbonate.

If the scrubber pressure is maintained adequately above the pressure levels found in conventional kraft mill NCG scrubbers (typically about -0.5 psig to +0.5 psig), then an increased packing height and diameter of the packing section with increased dispersion of suitable alkaline liquid droplets is not only tolerable but can be significantly beneficial, as the greater dispersion of droplets improves the surface area of suitable alkaline liquid available for reaction with the gases present in the scrubber, thereby increasing the overall chemical efficiency of the scrubbing process. However, thermal efficiency is not necessarily lost, as might be expected with increased suitable alkaline liquid droplet dispersion in a conventional low-pressure NCG scrubber, but at suitable operating pressures, thermal efficiency may be improved. The reason is that if a vent gas cooler is provided downstream of the NCG scrubber, the higher pressure at which the scrubber is operated reduces the saturation humidity in the scrubbed NCG leaving the scrubber, thereby resulting in significant energy savings, because less energy is required (as compared with conventional processes) to remove the reduced moisture from the
scrubbed NCG in the vent gas cooler. Note that it is highly desirable to dehumidify the scrubbed NCG after they leave the scrubber, because there may still be droplets of suitable alkaline liquid (carrying TRS compounds) entrained with the scrubbed NCG that have not been removed by the mist eliminator usually provided near the effluent gas outlet of the scrubber. The mist elimination being implemented after scrubbing to remove suitable alkaline liquid vapours as the scrubbed NCG are about to leave the scrubber. The reduced energy consumption required to dehumidify the scrubbed NCG downstream of the scrubber means that a smaller dehumidification unit (vent gas cooler) can be employed as compared to conventional apparatus, thus leading to potential savings in the capital cost of constructing the NCG scrubber and associated equipment.

The increased capacity and efficiency of the scrubber can accommodate alkaline liquid loading rates that are higher than those used in conventional systems. To process the NCG, it is expected that loading rates of up to about 40 gpm, or even more, per square foot of tower will be enabled by the use of the invention. Conventional loading rates are typically in the range of about 4 to 10 gpm.

The efficacy of the invention is enhanced if the operating temperature within the scrubber is kept higher than in conventional NCG scrubbers. An operating temperature in the range about 190 - 220° F will be usually preferred, although some variation from case to case may be expected, depending in part upon relative proportions of reactions occurring, volume of NCG being processed, and choice of operating pressure. By contrast, in conventional systems, operating temperatures in the range about 160 - 190° F are typical. The higher operating temperatures preferred according to the invention may be conveniently be provided by the steam ejector.

By designing a pressurized NCG scrubber and operating same with increased suitable alkaline liquid dispersion at pressures elevated relative to conventional processes, not only are chemical and possibly also thermal efficiencies in the operation of at least some apparatus improved, but there are a number of further benefits in using the process and apparatus according to the invention. By way of example, the amount of scaling formed on the packing and in suitable alkaline liquid conduits downstream of the NCG scrubber tends to be reduced relative
to conventional processes and apparatus by reason of the reduction in the extent of evaporative cooling of the suitable alkaline liquid. The lower the temperature of the spent suitable alkaline liquid exiting the NCG scrubber, the more serious a problem scaling tends to be. To optimize the avoidance of scale formation, the steam ejector or other source of pressure should be able to introduce into the scrubber sufficient water vapour (or equivalent) to maintain the cooking liquor at saturation humidity, so as to avoid any tendency of solids to precipitate out of the cooking liquor. Water vapour in the scrubber may be augmented from other sources if desirable. Other advantages associated with the apparatus and method of the invention include a reduction in ring formation in the lime kiln, and a reduced requirement for salt-cake makeup. Depending on the operating conditions used in the implementation of the invention, useful by-products (e.g., polysulphides) that could possibly contribute to an increase in pulp yields may be found in the spent suitable alkaline liquid which is recovered and re-used in the kraft pulp mill process.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic system layout chart and flowchart showing the flows of NCG and suitable alkaline liquid into and out of the scrubbing chamber of Figure 2 and relating same to the other constituent and peripheral elements of a kraft pulp mill NCG scrubbing system according to the invention.

Figure 2 is a schematic elevation view of a preferred embodiment of a scrubbing tower according to the invention.

DETAILED DESCRIPTION

The component elements of the kraft pulp mill NCG scrubber system illustrated in Figure 1 are conventional except as otherwise described. The flowchart symbols used in Figure 1 are conventional chemical engineering symbols. A description of conventional equipment is not included in this specification where such is not necessary to an understanding of the invention. For example, pressure safety valves are illustrated in Figure 1 but are not described herein except in this sentence; they may be of conventional design and are located at conventional places in
the system. Except as otherwise described herein, the individual components of the tower 14 of Figure 2, to be described below, including its interior components, may be of conventional design.

A preferred embodiment of a scrubbing tower suitable for use as a constituent element of the apparatus according to the invention is generally designated by reference numeral 14 in Figure 2. The scrubbing tower 14 is a vertical, generally cylindrical airtight vessel, which in a representative installation will be approximately thirty-five feet (approximately 10 m) in height and about three feet (about 1 m) in diameter. Tower 14 includes outer wall 11, seat 15, head 2, gas (NCG) inlet port 13, gas (NCG) outlet port 1, suitable alkaline liquid inlet port 20, spent suitable alkaline liquid outlet port 16, inspection/access ports 5 and 12, liquor inlet pipe nozzle 19, spray pipe nozzle 21, and sump level transmitter connection 17. The sump level transmitter connection is the attachment location for the sensor which detects the level of the suitable alkaline liquid in the sump.

Within tower 14 is packing support plate 18, packed section 9, liquid redistributor 10, liquid distributor/packing hold-down grid 8, suitable alkaline liquid inlet pipe 7, spray pipe 6 with spray nozzles 4, and mist eliminator 3. Note that packing section 9 extends above and below the redistributor 10, and is packed from top to bottom (i.e., from the underside of grid 8 to the upper surface of support plate 18) with suitable high dispersion efficiency packing material.

The particular shapes, dimensions and materials of the packing chosen for installation in the packing section 9 are variable within the designer's discretion but should be selected for optimal dispersion characteristics. Further, the overall length from top to bottom (i.e., the packing height) of the packing section 9 should be greater (at least approximately 20 ft., or at least about 6 m overall) than that of conventional scrubbing tower packing sections, again with the objective of improved suitable alkaline liquid droplet dispersion. Having regard to the foregoing, instead of a single redistributor 10 as illustrated in Figure 2, it may be desirable to have two or more such redistributors positioned at spaced intervals within the packing section 9, again in the interest of optimizing the dispersion of the falling suitable alkaline liquid droplets.
within packing section 9, with the objective of increasing the chemical interaction efficiency of the scrubbing process.

The NCG enters scrubbing tower 14 via inlet port 13, and after being scrubbed by the descending suitable alkaline liquid that flows into the packing section 9 via inlet port 20, exit the packed section 9 via packing hold-down grid 8 and continue their upward flow through the mist eliminator 3, where entrained droplets are trapped and collected. The mist eliminator 3 may be of conventional vertical or horizontal flow type. The scrubbed NCG exit the mist eliminator 3 and are vented from the scrubber at gas outlet 1, passing directly to the atmosphere or to a vent cooler 45 (Figure 1, not shown in Figure 2) that may be conventional in design, but for the reasons previously mentioned, may be of smaller dehumidification capacity than conventional vent coolers.

Referring now to Figure 1 of the drawings for a further understanding of the process according to the invention, non-oxidized or oxidized suitable alkaline liquid flows from a suitable alkaline liquid storage tank (not shown) through line (conduit) 30 to suitable alkaline liquid inlet 20 (Figure 2) on the scrubbing tower 14 under the control of flow control meter and valve subassembly (loop) 31. The suitable alkaline liquid flows to the liquid distributor/packing hold-down grid 8 within tower 14, from whence the suitable alkaline liquid is spread evenly over the top of the packed section 9 inside tower 14. The suitable alkaline liquid flows down the packed section 9 and contacts the rising gases emanating upward from gas inlet port 13. The packing within packed section 9 is present to provide adequate contact area for gas-to-liquid mass transfer. As mentioned above, the packing within packed section 9 is selected according to the invention to be dispersion-efficient, contributing by quantity and design to increased dispersion of suitable alkaline liquid droplets within the packing section 9.

NCG flow through line (conduit) 40 to an NCG ejector 42, which uses live steam from steam supply line 41 for motive force. The NCG ejector 42 provides system draft for pumping the gases from source via conduit 40 to the scrubber 14. The ejector 42 discharges the gases through line 43 directly to gas inlet port 13 (Figure 2) located near the bottom of the scrubber 14. From gas inlet port 13, the NCG flow upward past the gas-permeable packing support plate
or grid 18 and thence vertically upwards through the packed section 9, where they contact the descending suitable alkaline liquid counter-currently.

From gas outlet 1, the scrubbed NCG flow through line 44 to the optional vent gas cooler 45. The vent gas cooler 45 is a tubular heat exchanger that dehumidifies the scrubbed NCG. From the vent gas cooler 45, the scrubbed NCG flow through outlet line (conduit) 46 and then either though line 47 to atmosphere via a high stack vent (not shown) or through line 48 for further downstream treatment by incineration. Liquid effluent from vent gas cooler 45 may flow by gravity into a stand pipe which is an enlarged section of pipe for the purpose of providing residence time for the level transmitter.

The consumed suitable alkaline liquid exiting the bottom of the packed section 9 collects in the bottom sump of scrubber 14 and exits at spent liquor outlet 16 (Figure 1). The spent suitable alkaline liquid flows through line 32 to the suitable alkaline liquid return pump 33 from whence it is pumped through return line 34 back to a suitable alkaline liquid storage tank (not shown). The suitable alkaline liquid level in the scrubber 14 is maintained by level control loop 35, comprising a level monitor and associated line valve.

Scrubbing system pressure is provided and maintained by NCG steam ejector 42 and is controlled in the system by pressure control loop 49 comprising a conventional pressure gauge and associated line valve. The steam ejector 42 used in the apparatus according to the present invention will typically produce much more steam than the steam ejectors used in conventional NCG scrubbers. The use of such a higher capacity steam generator 42 in conjunction with the control loop 49 keeps both the operating pressure (preferably in the range 5 to 10 psig, but tolerably at pressures somewhat outside this range) and operating temperature in the system according to the invention appreciably higher than that in conventional systems, and helps to minimize evaporative cooling of the suitable alkaline liquid which causes scaling.

Note that conventional systems do not use steam ejectors to increase pressure or temperature in the NCG scrubber but rather to provide system draft to draw the NCG into the scrubber. Accordingly, steam ejectors used in conventional systems are typically not very
powerful and do not use sufficient steam to prevent evaporative cooling in the scrubber. Evaporative cooling is accordingly very common in conventional systems (which as a consequence keeps the temperature in conventional NCG scrubbers relatively low, increases the tendency of the suitable alkaline liquid to cause scale, keeps the rate of the desired chemical reactions relatively low, and renders the reactions less efficient than can be provided by a system according to the invention).

Variants and modifications of the process and apparatus described will occur to those skilled in the technology. The scope of the invention is not limited to the specifics of what has been described and illustrated but is determined by the appended claims.
WHAT IS CLAIMED IS:

1. For a pulp mill in which TRS compounds are scrubbed from non-condensible gases (NCG) in an NCG scrubbing apparatus having (i) a scrubbing vessel (tower) fed by the NCG and by suitable selected alkaline liquid for reaction with and binding to TRS compounds in the NCG, and (ii) packing within the tower for dispersing into fine droplets alkaline liquid in the tower; the improvement characterized in that the tower in operation provides a comparatively high interior pressure and suitably high interior temperature, and droplet dispersion is increased by means of increased dimensions of the packing section and increased packing efficiency, whereby the reaction between alkaline liquid and TRS compounds in the NCG is comparatively increased whilst saturation humidity of the effluent gases exiting the tower is comparatively decreased, and evaporative cooling of alkaline liquid within the tower is comparatively reduced.

2. The improvement of claim 1, wherein the operating pressure within the tower is maintained in the range about 1 to about 20 psig.

3. The improvement of claim 1, wherein the operating pressure within the tower is maintained in the range about 5 to about 10 psig.

4. The improvement of any of claims 1 to 3, wherein the operating temperature within the tower is maintained in the range about 190 to about 220 °F.

5. The improvement of any of the previous claims, wherein the operating pressure and temperature within the tower are maintained within selected ranges by a comparatively high-capacity steam ejector providing pressurized steam to the tower via an NCG input line feeding NCG into the tower.

6. The improvement of claim 5, wherein the operating pressure within the tower is maintained within selected range by the steam ejector in conjunction with pressure
control apparatus comprising a gauge for measuring the internal pressure within the scrubbing apparatus and a control valve responsive to the gauge for opening the effluent gas exit from the tower when the gauge senses an internal pressure above a maximum threshold and closing the effluent gas exit from the tower when the gauge senses an internal pressure below a minimum threshold.

7. The improvement of claim 5 or 6, wherein the steam ejector or other suitable means for injecting water vapour into the scrubber maintains the suitable alkaline liquid in the scrubber at saturated humidity so as substantially to prevent evaporation of the suitable alkaline liquid sufficient to precipitate solids out of the suitable alkaline liquid.

8. The improvement of any of the previous claims, wherein the packing efficiency is increased at least in part by selecting high-efficiency packing materials.

9. The improvement of any of the previous claims, wherein the loading rate of alkaline liquid and the processing rate of NCG are selected to be commensurate with the increased capacity and efficiency of the tower.

10. The method of operating an NCG scrubber as defined in any of the previous claims.
### A. CLASSIFICATION OF SUBJECT MATTER

**IPC** 6 D21C 11/08 B01D 53/48

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)**

**IPC** 6 **D21C** **B01D**

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

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

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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| Y        | US 5 450 892 A (GAUTREAUX JR WILSON T)  
19 September 1995  
see column 2, line 40 - line 47  
see column 5, line 1 - line 11  
see column 6, line 45 - line 54; table IV | 1-4,8-10 |
| Y        | US 4 431 617 A (FARIN WILLIAM G)  
14 February 1984  
see column 5, line 14 - line 38  
see column 7, line 1 - line 40  
see column 9, line 34 - column 10, line 49 | 1-4,9,10 |

Further documents are listed in the continuation of box C.

**X** Patent family members are listed in annex.

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**Date of the actual completion of the international search**

29 December 1998

**Date of mailing of the international search report**

14/01/1999

**Name and mailing address of the ISA**

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**Authorized officer**

Bernardo Noriega, F
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<th>Relevant to claim No.</th>
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| Y        | DATABASE PAPERCHEM  
THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY, ATLANTA, GA, US  
access number AB5508951,  
MALINOWSKI, T. ET AL: "Prevention of Malodorous Gaseous Emissions from Kraft Pulp Mills"  
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