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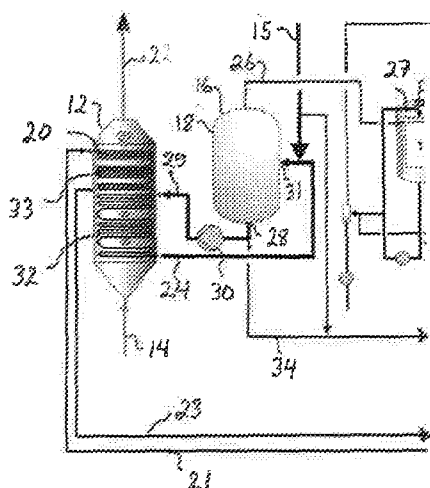


FIG. 1a

(57) Abstract: The invention relates to a method for recovering heat from flue gas generated at a power plant or biomass-based plant, such as a pulp mill, and for concentrating a liquid at a multiple-effect evaporation plant having a plurality of evaporation effects, in which the heating medium and liquid flow counter-currently. Flue gas from a combustion device is directed through a channel into an indirect contact with a liquid to be concentrated, wherein the liquid is heated with heat from the flue gas in a flue gas cooler having at least one indirect heat exchange stage. The heated liquid is extracted from the flue gas cooler and flashed in at least one flashing stage so as to produce flash cooled liquid and flash vapor. The vapor is used as a heating medium in an evaporation stage or stages of the multiple-effect evaporation plant. The flash cooled liquid is circulated into the flue gas cooler.



FLUE GAS HEAT RECOVERY METHOD AND SYSTEM

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method and system for recovering heat from flue gases generated in power and heat producing combustion devices. The flue gases are generated in the combustion devices of a power boiler, biomass mill or pulp mill, such as a recovery boiler.

[0002] In a pulp mill, black liquor which typically has a dry solids content of over 80% (eighty percent) and combustion air are fed into a furnace of a chemical recovery boiler for burning the black liquor and recovering chemicals therefrom. The flue gases generated in the combustion are led into an economizer of the recovery boiler. The economizer heats feed water for the boiler. After flowing through the economizer, the flue gases are cleaned. The feed water is led from the economizer to a steam-generating bank of the boiler and into a superheater for producing steam, which may have a pressure of more than 80 bar. The steam flows from the recovery boiler into a steam turbine for producing electricity. The steam discharged from the turbine is utilized for preheating the feed water flowing into the economizer.

[0003] If the temperature of the feed water flowing into the economizer is high (such as when efficient electricity production is desired and feed water preheating is used), the final temperature of the flue gases may remain high when the gases are discharged from

the economizer. The heat in the discharged flue gases is released to the atmosphere and the energy in the heat is lost.

[0004] New recovery boiler plants are also beginning to
5 apply a technique used at power plants for recovering heat from flue gas. The recovery is performed for generating hot water, but the heat can be utilized also for preheating combustion air. The flue gas coolers are located in flue gas ducts downstream of the
10 electrostatic precipitator and upstream of the fans. WO 02097243 discloses an arrangement in which the temperature of the water being led into the economizer of the recovery boiler is regulated by means of bleed steam of the turbine so that the flue gases exit the economizer
15 at a temperature of over 250°C. After being discharged from the economizer, the flue gases are cleaned in at least a hot electrostatic precipitator. The cleaned flue gases are cooled in a preheater for combustion air or in a preheater for feed water.

[0005] In addition to flue gases generated by a recovery
20 boiler, pulp mills have other combustion arrangements, such as a bark boiler and a lime kiln, which generate flue gases. Energy is produced in a pulp mill primarily from the combustion of black liquor in a recovery
25 boiler, bark and wood wastes in an auxiliary boiler, and oil or gas in a lime sludge reburning kiln. The energy released by burning the bark of raw wood material and organic matter in the black liquor is usually sufficient to satisfy the entire energy requirement of a pulp mill.
30 There are also pulp mills in which wood or bark is used

as fuel for the lime reburning kiln, either as such after drying or after drying and gasifying.

[0006] Patent application PCT/FI2011/050828 describes a process for recovering heat from flue gas generated at a biomass-based plant, such as a pulp mill or a stand-alone power boiler. In this process flue gas is directed from a combustion device through a flue gas cooler and a circulation liquid is heated in the flue gas cooler with heat from the flue gas. The heated circulation liquid is transported to a waste heat accumulator, where the liquid is flashed. Flash vapor is extracted from the waste heat accumulator, and it can be used as a process steam. The flash-cooled circulation liquid is returned from the waste heat accumulator into the flue gas cooler.

BRIEF DESCRIPTION OF THE INVENTION

[0007] There is a desire to improve heat recovery from flue gases generated in combustion devices at a biomass-based plant, such as a pulp mill or a power boiler plant. Flue gases are generated in combustion devices, such as in a recovery boiler, power boiler or lime kiln at the pulp mill or in a stand-alone power boiler. Combustion devices are often located at a mill or plant where different kind of liquids are concentrated by evaporation in several evaporation stages.

[0008] A method and system have been developed in which heat is recovered from flue gas, and the recovered thermal energy is utilized at a multiple-effect evaporation plant.

[0009] Large boilers have today still substantial energy losses in their flue gases. This is because the recovery of energy from low temperature flue gases has so far been seen as a non-profitable market. An example where
5 the present invention is beneficial is the recovery boiler or power boiler of the pulp and paper industry. It has so far been considered to be only beneficial to recover chemicals and burn leftovers, i.e. to treat the process residuals and effluent flows. Effluent flows are
10 the common name for any process flow when removing environmental load from a fluid flow. Examples of effluent flows are all industrial liquid flows that bring effluent load to the mill and its environment, such industrial liquid flows can be all flows going to
15 the effluent water treatment plant or other flows going directly to the surrounding environment, e.g. bio-based process flows, spent liquors of the pulp and paper industry, such as black liquor, APMP effluent, CTMP effluent, or residual flows when producing bio-fuels
20 (bio-ethanol etc.), or water-based residual flows when producing energy from wet biomass etc. These effluent flows can be efficiently treated in the method and system according to the present invention. The concentration of liquids is low, typically 2000-20000
25 mg-effluent/dm³-liquid, where mg-effluent can be a COD (Chemical oxygen demand) or BOD (biological oxygen demand) or any other salts, metals or non-process elements or toxics which are beneficial to be recovered even in smaller amounts like 100-2000 mg-effluent/dm³-
30 liquid. The system according to present invention can also advantageously be used as an evaporator or pre-

evaporator when the liquid concentration is higher than 20000 mg-effluent/dm³-liquid, hence the integrated multi-effect evaporator is also usable for liquors of higher concentrations in the range of 20000 to 500000 mg effluent/dm³-liquid, such as black liquor. However, the overall evaporation capacity is then reduced by a lower number of possible evaporator stages in the evaporator train because of the higher boiling point rises in each stage. Use as pre-evaporator is mainly dependent on the amount to be evaporated and final concentration and number of effects then needed. Alternatively, vapor can be transferred to an existing evaporator as shown in patent application PCT/FI2011/050828.

[0010] The method according to the invention is characterized by what is presented in the characterizing part of the independent claims 1 or 2. The system according to the invention is characterized by what is presented in the characterizing part of the independent claims 24 or 25. The flue gas is used either inside the lamellas or outside the lamellas (or outside or inside the tubes), for creating a vapor from the effluent flow to be used in the succeeding multi-effect evaporator train. The effluent liquid is fed into heat exchangers on the side of the wall opposite to the flue gas so that there is no direct contact between flue gas and effluent. The heated liquid is flashed in a flash tank. According an embodiment the heat exchangers are coupled either in counter-current, cross-current or co-current form with one or more successive flash reactor/s connected to the above mentioned heat exchangers.

[0011] According to another embodiment one evaporation unit or more evaporation units are connected in series (without a flash reactor) where the flue gas heat exchanger works as a normal evaporator, preferably as a falling film evaporator and where the flue gas is used instead of steam or vapor in the evaporator body outside the tubes or lamellas, or inside the tubes or lamellas, as the effluent liquid is fed at the side of the opposite wall as a falling film. Liquor having a higher concentration is produced.

[0012] The above described is particularly beneficial because of the low specific heat transfer duty (i.e. low heat flow, kW/m²), in the gas cooler due to the small temperature differences and simultaneous low heat exchanger coefficient, which is due to a low pressure gas-liquid heat exchange process. The low specific heat duty does not initiate fouling when heating difficult effluents, i.e. a low specific heat transfer duty, due to low heat transfer coefficients and a low temperature difference, is used as an advantage instead of a disadvantage in the above flue gas pre-concentrating stage.

[0013] Depending on effluent properties the flue gas heat produces clean steam or vapor that is used in the successive evaporator train in one or more stages.

[0014] Flue gas is directed from a combustion device into an indirect contact with a liquid to be concentrated in the multiple-effect evaporation plant. The liquid is an effluent flow described above. The liquid is heated with heat from the flue gas in a flue gas cooler having at least one indirect heat exchange stage. The heated

liquid is discharged from the flue gas cooler and flashed in at least one flashing stage so as to produce flash-cooled liquid with a higher concentration and flash vapor. The flashing is performed in a tank in
5 which the liquid is cooled to a predetermined process vapor temperature such as 110-150°C for first effect vapor and 90-110°C for front end effects and 50-90°C for backend train evaporator effects. The flash vapor from a first flashing stage is used as a heating medium in a
10 first effect stage of the multiple-effect evaporation plant (effect numbering according to the flow direction of the vapor) and a part of the flash-cooled liquid is directed to the multiple effect evaporation plant while the circulated liquid in the flue gas cooler is 5-1000
15 times the mass of the flashed vapor.

[0015] The novel method and system are very applicable and suitable for pre-concentrating different effluents, such as black liquor of a pulp mill.

[0016] In an embodiment, the at least one heat exchange stage of the flue gas cooler is formed of tubes, inside
20 which the liquid flows. When there are two or more heat exchange stages, they are placed preferably inside the same housing. The flue gas and the liquid may flow counter-currently, co-currently or cross-currently in
25 the flue gas cooler.

[0017] In an embodiment, the flue gas and the liquid flow counter-currently in the flue gas cooler having a first and a second heat exchange stage in a flow direction of the flue gas. In the first heat exchange stage the hot
30 flue gas is cooled by the liquid circulated from the first flashing stage and in the second heat exchange

stage the flue gas is further cooled by the liquid from another step of the evaporation plant. A part of the flash-cooled liquid from the first flashing stage is directed to the multiple effect evaporation plant, and in the second heat exchange stage the flue gas is typically cooled by the liquid from a subsequent flashing stage.

[0018] The point or place where the feed liquid is introduced into the system depends on the properties of the liquid, such as temperature and composition. When the vapor saturation temperature of the feed liquid is 110 degrees of Celsius or over and the flue gas and liquid flow counter-currently, and the saturation temperature in the first effect vapor is below 110°C, the feed liquid is preferably introduced into the liquid flow between the first heat exchange stage and the inlet to the first flashing stage. Thus the hot feed liquid is first cooled by flashing, and thus the temperature of the liquid is adequately low to cool the hot flue gas.

[0019] In an embodiment, the temperature of the feed liquid of the evaporation plant is between 50 and 110 degrees of Celsius and the flue gas and liquid flow counter-currently. Then a part or all of the feed liquid is fed into the second heat exchange inlet and/or into the discharge of the second heat exchange or into the liquid between the first flashing stage and the inlet of the first heat exchange stage, depending on the temperature of the feed liquid.

[0020] In an embodiment, the temperature of the feed liquid of the evaporation plant is low, i.e. below 50 degrees Celsius. When the flue gas and liquid flow

counter-currently, in the second heat exchange stage the flue gas is cooled by the feed liquid, which is further heated in the first heat exchange stage, after which the heated liquid is partly circulated to the first flashing
5 stage and partly to a subsequent flashing stage of the evaporation plant. Prior to the flue gas cooling the feed liquid is preheated by secondary heat from a last stage/effect or last stages/effects of the evaporation plant in the flow direction of vapor.

10 [0021] In the embodiments described above the flue gas cooling and liquid flashing take place in different devices. According to one alternative these steps may be carried out in one or more evaporator apparatuses, where the heat exchange surface is formed of tubes or
15 lamellas. The flue gas flow is not in contact with the liquid, and flows either inside or outside the lamella or inside or outside the tube surface. The liquid is flowing on the wall side opposite to the flue gas side as a falling film. In a normal evaporator body, flue gas
20 is used as a heating medium instead of steam or vapor. Then vapor is evaporated off from the liquid, while the flue gas is cooled. Thus the vapor is generated from the liquid without separate flashing. This evaporated vapor is used as a heating medium in a first evaporation stage
25 in a direction of the vapor flow. The vapor from successive flue gas -driven evaporator apparatuses is fed to the backend of the evaporator train.

[0022] In an embodiment, the flue gas is generated in a recovery boiler by burning black liquor from a pulping
30 process, and black liquor is pre-concentrated by the heat from the flue gas.

[0023] In an embodiment, the flue gas is generated in a power boiler.

[0024] In an embodiment, the flue gas heat according to this invention is used for producing vapor for a multi-stage flash evaporator.

[0025] Particles, such as crystals or lignin or non-process elements or heavy metal agglomerates, can be separated from the liquid at least in one point between the evaporation stages of the evaporation plant. This may be carried out in a separating apparatus, which may typically comprise one or more cyclones and /or decanter centrifuges. Other suitable separator devices can also be used.

[0026] It is preferable to split condensates formed during liquid evaporation at the evaporation plant into a relatively clean condensate and foul condensate by partitioning the heat exchange elements of the evaporation stages. The foul condensate is cleaned by steam stripping, which preferably uses vapor formed in the first evaporation stage, which is driven by the heat recovered from the flue gas.

[0027] It is possible to produce hot water with heat from vapor formed in a flashing stage of the liquid after the first flue gas -driven flashing or evaporator stage.

[0028] Generally the temperature of the flue gas being discharged from the economizer of the power or recovery boiler may be less than 200 °C. The invention will however work also at this temperature or higher. Normally the temperature of the flue gas is decreased in the new flue gas cooling, such as from 180°C to 125°C or even lower to 70°C particularly when using more than one

heat exchanger stage. Particularly at a low temperature flue gas heat recovery it is more favorable to evaporate a liquid with low boiling point rise to have more evaporation stages available for evaporation.

5 [0029] Advantages of the new method and system include:

[0030] - The low heat flow, kW/m^2 , in the flue gas cooler is advantageous for avoiding fouling when heating an effluent liquid, i.e. a low heat transfer rate, due to low heat transfer coefficients and a low temperature
10 difference, is used as an advantage instead of a disadvantage in a pre-concentrating stage.

[0031] - Flue gas heat can be used to its maximum.

[0032] - The low system pressure and fewer storage tanks make the new method and system cheaper, i.e. investment
15 costs/ t water (H_2O) evaporated will be much lower than for a black liquor evaporator train, in which the black liquor is concentrated to a final dry solids concentration for burning. This means that this solution will have competitive advantage compared to other
20 effluent treatment pre-evaporator alternatives, while 90-100% of the produced total condensate can be reused, i.e. almost the same as the exemplified evaporation range 10t/h to 1000 t/h. The advantages are hot reusable condensate, lower load and hence costs in the effluent
25 treatment plant, lower COD or BOD load to the environment, and a possibility to produce energy by burning the concentrate from the evaporator train.

[0033] Dedicated segregation and integrated stripping can be connected to the multiple-effect evaporation plant
30 using vapor from the flue gas heat recovery as a heating medium. It can be used to remove such components as:

residual sulfur, ions (metals and other NPE's); lignin, hemicellulose, furfurals, oxalate, methanol, ethanol, formiate, formic acids, acetate, acetic acids, fatty acids and other acids or carbon-based components.

5 Dedicated evaporation or pre-evaporation of effluents makes it possible to capture volatiles, like MeOH and VOCs, into secondary condensate for further cleaning and burning. The use of low-valued flue gas heat makes it cost-efficient to concentrate and remove low-

10 concentration components such as those mentioned above, which so far has not been possible with conventional effluent cleaning devices, nor feasible with alternative sophisticated separation methods, such as nanofiltration or osmosis or the like. It is worthwhile notifying that

15 when producing pure condensate for reuse the removed MeOH (methanol), VOCs (volatile organic compounds), TRS (total reduced sulfur compounds) or the like can be simultaneously used as biofuel. The biofuel captured from the effluent flow is absent from the environmental

20 BOD, COD load and instead taken into use as biofuel or as additional new bioenergy in a combined heat and power plant.

[0034] In an embodiment, the flue gas cooler and flash tank can be controlled to efficiently decrease energy

25 consumption. In addition, the pressure in the liquid circulation is controlled to prevent boiling in the system and minimize the power consumption in the flue gas cooler recirculation. The pressure in the flash tank is regulated by the flash vapor amount and the back flow

30 to the flue gas coolers. The flow is controlled with a circulation pump using inverters or valves.

[0035] An embodiment of the invention provides a possibility to build new equipment parallel with an old or a new flue gas duct. The flue gas cooler and flue gas duct are connected in parallel so that the total flue gas flow or part thereof may be led directly through the duct into the chimney. This may be necessary if the cooler is not able to receive flue gas for some reason, e.g. for overhaul. The parallel installation allows complete redundancy and ensures complete redundancy and thus improves the overall process safety and availability. This implementation gives also a possibility to shut down at any time the heat exchangers and thereto connected evaporators giving full access to perform process wide service or effect inside cleaning while the chimney flue gases are in continuous operation, and hence causing no disturbances to the rest of the processes in a pulp mill.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The process that has been developed is described in more detail with reference to the drawings, in which:

[0037] FIGURE 1a, 1b or 1c is a schematic illustration of an exemplary arrangement for recovering heat from flue gas according to the present invention.

[0038] FIGURE 2 is a schematic illustration of the basic components of one exemplary system in connection with which the present invention can be utilized.

[0039] FIGURE 3 a schematic illustration of the basic components of another exemplary system in connection with which the present invention can be utilized.

[0040] FIGURE 4 is a schematic illustration of an exemplary arrangement for recovering heat from flue gas according to the present invention.

[0041] FIGURE 5 is a schematic illustration of an exemplary arrangement for recovering heat from flue gas according to the present invention, and

[0042] FIGURE 6 is a schematic illustration of the basic components of one exemplary system in connection with which the present invention can be utilized.

10 DETAILED DESCRIPTION OF THE INVENTION

[0043] The exemplary systems illustrated in FIGURE 1a, 1b and 1c show arrangements of the present invention. The temperature of the feed liquid to be pre-concentrated or concentrated varies in these examples. In Figure 1a the temperature of the feed liquid (effluent) is above 110°C, in Figure 1b between 50°C and 110°C and in Figure 1c below 50°C.

[0044] Liquid, such as weak black liquor, is circulated in a flue gas cooler 12 and heated therein. The hot flue gas can be introduced through line 14 in Fig. 1a. The hot liquid is introduced through line 15 and flash-cooled in a flash stage, which is in the form of a flash tank 16 or vessel, and is then circulated into the flue gas cooler 12.

[0045] The flue gas cooler 12 has an outer housing 18 that contains a heat exchanger surface, such as heat pipes 20 or lamellas. The hot flue gas enters the lower part of the flue gas cooler through line 14 from a flue gas duct which receives the flue gas from the

combustion device (not shown), such a recovery boiler or power boiler. The flue gas indirectly exchanges its heat with liquid travelling counter-currently through the heat pipes 20 in the flue gas cooler. The cooled
5 flue gas is discharged from the top of the housing 18 and led through line 22 into the flue gas chimney. The heated liquid exits the flue gas cooler and is led through line 24 to the flash tank 16. The upper end of the flash tank has a vapor outlet line 26, and the
10 lower end has a liquid outlet 28 for the flash-cooled liquid. Flash vapor is directed through line 26 to an evaporator of the evaporation plant.

[0046] A portion of the cooled liquid is circulated into the flue gas cooler through line 29 by means of
15 pump 30. The flash tank has also an inlet 31 for heated liquid coming from the flue gas cooler.

[0047] In the embodiment of Fig. 1a the flue gas and the liquid flow counter-currently in the flue gas cooler having a first and a second heat exchange stage
20 32 and 33 in a flow direction of the flue gas. In the first heat exchange stage 32 the hot flue gas is cooled by the liquid circulated from the flashing stage 16. In the second heat exchange stage 33 the flue gas is further cooled by the liquid from a step of the
25 evaporation plant, which is led through line 21. Typically this step is a flashing stage subsequent to the first flashing stage in the flash tank 16. The liquid heated in the second heat exchange stage 33 is led through line 23 to the multiple-effect evaporation
30 plant for evaporation (Fig. 2).

[0048] A portion or a minor portion of the flash-cooled liquid from the flash tank 16 is directed through line 34 to the multiple-effect evaporation plant.

5 [0049] The point where the feed liquid is introduced into system depends on the properties of the liquid, such as temperature and composition. In the arrangement of Fig. 1a a very hot liquid is to be concentrated. The temperature of the feed liquid of the evaporation plant
10 is 110 degrees of Celsius or more. The hot feed liquid from line 15 is first cooled by flashing, and thus the temperature of the liquid is adequately low to cool the hot flue gas and to be fed to the evaporation plant.

[0050] The feed liquid is introduced through line 15
15 into the flash tank 16 together with the liquid flow in line 24 from the first heat exchange stage of the flue gas cooler. A large portion of the flash-cooled liquid is circulated into the flue gas cooler, and a portion thereof is directed to the evaporation plant through
20 line 34.

[0051] In the embodiment of Fig. 1b the temperature of the feed liquid of the evaporation plant is moderate, typically between 50 and 110 degrees of Celsius. This arrangement also has a two-stage flue gas
25 cooler and the flue gas and liquid flow counter-currently. The arrangement corresponds to that of Fig. 1a, but the point(s) of introducing feed liquid are different. The feed liquid can be led through line 35 to the liquid flow in line 24 between the first
30 flashing stage 16 and the first heat exchange stage 32, in which case the liquid is first heated and then

flashed in the flash tank 16. Simultaneously, a portion of the feed liquid can be led through line 36 to the second heat exchange stage 33 together with the liquid flow in line 23. If the temperature of the liquid is closer to 110°C than 50°C, the portion of the feed liquor can be led into the liquid flow discharged from the second heat exchange stage and directed to the evaporation plant through line 23.

[0052] In the embodiment of Fig. 1c the temperature of the feed liquid of the evaporation plant is low, i.e. below 50 degrees Celsius. This arrangement also has a two-stage flue gas cooler and the flue gas and liquid flow counter-currently. The arrangement corresponds to those of Fig. 1a and Fig. 1b, but the point of introducing feed liquid is different. The flue gas and liquid flow counter-currently, in the second heat exchange stage 33 the flue gas is cooled by the feed liquid fed through line 37. The liquid discharged from the second heat exchange stage is directed through line 38 and 29 to the first heat exchange stage 32. Then the heated liquid is led partly into the flash tank 16 through line 25 and partly to the evaporation plant through line 39, typically first into a subsequent flashing stage of the evaporation plant. The feed to evaporation plant in line 39 can in this case also be connected as in Fig 1b, line 34, that is after or before the circulation pump of the flash circuit. Flash vapor from the flash tank 16 is directed through line 26 to an evaporator 27 of the evaporation plant.

[0053] Fig. 2 shows an exemplary multi-effect evaporation plant in connection with which the present invention may be applied.

[0054] There is an eight-effect weak black liquor (cellulose pulp waste liquor) pre-evaporation plant with liquor flow: feed to effect 5- flash to effect 6 - flash to effect 7, evaporation in effect 8-7-6-5-4-3-2-1-product liquor. The heating vapor flows in the opposite direction, i.e. from effect 1 to effect 2 and so on. Similarly the vapors are introduced into the subsequent effects (lines 48) and finally the vapor from the last effect 8 is condensed in a surface condenser or condensers 49. Each of the effects preferably includes one or more lamella elements.

[0055] Heat is recovered from the flue gas in the arrangement according to Fig. 1b.

[0056] The black liquor flow is indicated by bold lines in FIGURE 2. The fed liquor, such as weak black liquor (or other cellulose pulp waste liquor) is led through lines 36 and 35 to the heat recovery system (flue gas cooling and flashing), in which it is heated and flashed. The flashed liquor from flash tank 16 is transferred through line 34 to a subsequent flashing in a tank 40. Then the liquor is passed via line 41 into evaporation effect 5, where the liquor flashes. Then the liquor is passed via line 42 to effect 6, where it is further flashed. From effect 6, the liquor is passed via line 43 to effect 7, where it is further flashed, then via line 44 to effect 8 for evaporation. The liquor is further evaporated in effects 7, 6, 5, 4, 3, 2 and 1, as indicated by line 45. The product

liquor in line 46 is withdrawn from effect 1, which is driven by flash vapor in line 26 from the flue gas heat recovery.

[0057] The above-described embodiment relates to an eight-effect evaporation plant. The invention can, in a similar manner, naturally also be applied to other kinds of evaporation plants having, for example, five, six or seven evaporation effects, or even more than eight effects.

[0058] In an embodiment, a portion of the liquid to be fed into the last effect 8 is used to cool the flue gas in the flue gas cooler 12. The liquid portion is transferred via line 21 to the second stage 33 of the flue gas cooler according to Fig. 1b. The heated liquid is returned to the evaporation plant via line 23 and combined with the liquor flow in line 34 from the flash tank 16. The combined flow is further flashed in tank 40, and fed via line 41 into effect 5 as described above. Warm water can be produced in a heat exchanger 47 with flash vapor in line 47' from flash tank 40.

[0059] Evaporated water vapor contains also some methanol, volatile organic sulfur and other volatile compounds. The evaporation plant has a known treatment system for condensate and non-condensable gases. Different volatile components may be separated as a result of this treatment. The system comprises segregating evaporation elements (lamellas), flash tanks, a surface condenser and a steam stripper. The vapors and condensate streams are fractionated and treated so that foul condensate (FC) and secondary condensate (SC) are formed. The foul condensate is

cleaned in a steam stripper 50. The secondary condensate is cleaned, if needed.

[0060] Fig. 3 shows an arrangement similar to that of Fig. 2, but the temperature of the feed liquid is lower, and it is led to the arrangement in a different way. The temperature is low, typically less than 50 °C. The heat recovery is shown in Fig. 1c and described above.

[0061] The cold liquid to be concentrated is first fed through line 57 into a surface condenser 49, in which secondary steam from the last evaporation effect 8 is condensed. Thus the liquid replaces cooling water normally needed in the condenser. Then a portion of the liquid is led via line 52 and further heated in heat exchangers 51 which are heated by secondary steam from evaporation effects 5-7, i.e. back-end evaporation effects. The preheated liquid is transferred via line 53 and 37 (Fig. 1c) into a flue gas cooler 12, where heat is recovered from the flue gas as described in Fig. 1c. The liquid heated with flue gas is passed via flash tank 40 into effect 5 and treated as described in connection of Fig. 2 above.

[0062] The other portion of the feed liquid discharged from the surface condenser 49 is led via line 54 directly into effect 8 for evaporation.

[0063] The evaporation plant is provided with a separator 55, in which particles, such as crystals or lignin or Non-process elements, silica, calcium, or heavy metal agglomerates, can be separated from the liquid at least in one point between the evaporation stages of the evaporation plant. This may be carried

out in a separating apparatus, which may typically
comprise one or more cyclones and/or decanter
centrifuges. The separated solids are conveyed in line
56 into the product liquid 46 to be discharged from the
5 plant for burning or a corresponding treatment. The
separated solids can also be directly discharged for
direct disposal. The separation can also advantageously
be performed in the front end of the evaporator train
that is when the liquid flow is clearly less than the
10 feed, e.g. 1/4-1/20 part of the feed, and then a higher
concentration of contaminants is reached helping to
form crystals or agglomerations of these, which are
then easily separated, since small liquid flows require
small separation equipment, such as for example 1/4 to
15 1/20 sized residence tanks, centrifuges, presses,
filters etc.

[0064] Fig. 4 shows another arrangement of an
embodiment of the present invention, in which the flue
gas cooler and the flue gas duct/chimney are connected
20 in parallel. It also shows some controls, which may be
used to control the system. The feeding of the feed
liquid, the cooling of the flue gas and the liquid flow
are arranged as in Fig. 1c, but the arrangement of Fig.
4 can be used also in other embodiments. Whenever
25 possible, the same reference numerals are used as in
Figs.1-3.

[0065] A control system, such as a computer processor
with non-transitory memory storing an executable
program having control algorithms for controlling the
30 flue gas heat recovery. Alternatively, the control
algorithms may be implemented manually by technicians

monitoring the pressure (PIC), temperature and other sensors monitoring the flue gas heat recovery system. The executable algorithms may perform the following procedures:

5 [0066] The pressure (PIC-2) in the circulation line 24 is controlled to be high enough to prevent boiling in the pipelines or flue gas coolers and minimize the power consumption in flue gas cooler recirculation.

[0067] By adjusting the pressure set point (PIC-2) based on the temperature of the liquid, the electrical consumption for the circulation pump can be minimized.

[0068] The controlling of the liquid flow includes regulating a pressure of the flash vapor 26 by adjusting the pressure set point (PIC-1) to achieve a predetermined minimum temperature of the flashed circulation liquid 61 returning into the flue gas cooler.

[0069] The circulating pump 63 is adjusted by controlling an inverter for the pump.

20 [0070] In Fig. 4 the flue gas cooler and the flue gas duct/chimney of the combustion device are connected in parallel so that the total flue gas flow or part thereof may be led directly through the duct into the flue gas chimney. No flue gas or a lower flow thereof is fed into the cooler. This may be necessary if the cooler is not able to receive flue gas for some reason, e.g. for overhaul. The parallel system can be installed without any change to the existing flue gas fan.

[0071] The flue gas duct 60 supplies flue gas from the combustion device, such as a recovery boiler. A fan 30 62 or like feeds the flue gas into the flue gas cooler

12. The flue gas duct 60 is connected to the flue gas chimney 64, so that the total flue gas flow or part thereof can be led by a fan 66 directly into the chimney bypassing the cooler 12. This may be necessary
5 because of a process malfunction or maintenance of the flue gas cooler.

[0072] Fig. 4 shows that the flue gas or a part of the flue gas is pumped with a fan 62 before or after the heat exchangers of the flue gas cooler 12 to
10 compensate the pressure drop in the flue gas cooling heat exchangers when flowing in the channel 67 into the chimney 64.

[0073] It is also possible to separate the flue gas or a part of the flue gas into a parallel flue gas cooling channel 65 and returned into main flue gas
15 channel 60 or chimney 64 after passing through the flue gas cooler 12. The flue gas can be pumped with a fan 62 that is placed before or after the heat exchangers to compensate the pressure drop in the flue gas cooling
20 heat exchangers. The cooled flue gas is returned into main flue gas channel 60 or chimney 64.

[0074] It is mostly advantageous to have the heat exchangers downstream of a dust separation stage such as a textile filter, cyclone, dust chamber, or an
25 electrostatic precipitator, since this reduces remarkably the dust load to the heat exchangers. The flue gas channel 60 and/or 65 may be provided with a dust separation device.

[0075] Fig. 5 shows an embodiment, in which no separate flash tank is needed, but the flue gas cooling and vapor generation are carried out in one or more
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evaporator apparatuses. Fig. 5 shows a two-stage flue gas cooler 70, in which heat exchangers I and II are located in the same housing 77 and connected in series with respect to flue gas. The heat exchangers are formed of several lamellas 71 arranged a distance apart from each other, but only one element is shown. Each lamella is formed of two substantially parallel plates which are connected at their edges to form a closed space. Alternatively, the heat exchange surface can be formed of tubes.

[0076] Hot flue gas is pumped by a fan 72 from a flue gas channel 73. The flue gas flows through the interior of the lamellas of the heat exchange stages I and II, and the cooled flue gas is discharged via line 74 into the flue gas channel 73. A distributor tray 76 is disposed above the lamellas and receives a liquor to be concentrated. The feed liquor is led via line 75 into the second heat exchange stage. The liquid flows through perforations of the tray and as a thin film along the exterior surface of lamellas. The liquid is evaporated with the heat from the flue gas, whereby vapor is generated. The evaporated liquid is collected at the bottom 78 of the housing. A portion of the liquid collected at the bottom is circulated through lines 84 to the distribution tray 76 in each stage. Liquid from the second stage II is led into the first heat exchange stage I, where it is heated with the hot flue gas. It is further evaporated. The liquid is discharged from the flue gas cooler 70 and led via line 79 to the multiple-effect evaporator plant, where it can be treated as shown in Fig. 3. The vapor produced

in the first heat exchange stage is led through line 80 and preferably used as a heating medium in a first evaporation stage 82 of the multiple-effect evaporation plant. The vapor from succeeding flue gas -driven evaporator stage II is led through line 81 to the backend of the evaporator plant, for instance into the evaporation effect 4 in Fig. 3. The above can also be implemented so that the liquid is fed into the heat exchange stage I instead of II. Other equipment embodiments of the above are possible as long as not violating the main principle of no direct contact between flue gas and evaporated liquid and evaporated vapor. The principle of no direct contact between the flue gas and vapor is crucial to secure maximum vacuum or pressure in the vapor side of heat exchangers I and II and also in the flash stages. Already a small gas leak can greatly reduce the efficiency. Gas leaking from the flue gas side to the vapor side is therefore not recommended and nor acceptable since it reduces the heat exchanger efficiencies.

[0077] Fig. 6 shows an exemplary multi-effect evaporation plant in connection with which the present invention may be applied. The arrangement is similar to that of Fig. 3, but the flue gas cooler is the cooler shown in Fig.5. The temperature of the feed liquid is for example below 50 °C.

[0078] Reference numerals are as follows:

- 12. Flue gas cooler
- 14. Hot flue gas
- 15. Hot feed liquid

16. Flash tank
18. Housing of flash tank
20. Heat pipes of flue gas cooler
21. Cooling liquid from evaporation plant to flue gas
5 cooler
22. Cooled flue gas
23. Heated liquid from flue gas cooler to evaporation
plant
24. Heated liquid from flue gas cooler to flash tank
- 10 25. Heated liquid from flue gas cooler to flash tank
26. Vapor outlet line of flash tank
27. Evaporator
28. Liquid outlet of flash tank
29. Flash-cooled liquid to flue gas cooler
- 15 30. Circulation pump
31. Liquid inlet of flash tank
32. First heat exchange stage of flue gas cooler
33. Second heat exchange stage of flue gas cooler
34. Flash-cooled liquid to evaporation plant
- 20 35. Feed liquid
36. Feed liquid
37. Feed liquid
38. Liquid from flue gas cooler
39. Heated liquid from flue gas cooler to evaporation
- 25 40. Flash tank
41. Flashed liquid flow
42. Liquor flow
43. Liquor flow
44. Liquor flow
- 30 45. Liquor flow
46. Product liquor from evaporation plant

- 47. Heat exchanger
- 47'. Flash vapor
- 48. Vapor from evaporators
- 49. Surface condenser
- 5 50. Steam stripper
- 51. Heat exchanger
- 52. Feed liquid
- 53. Preheated feed liquor
- 54. Feed liquid
- 10 55. Separator
- 56. Separated solids
- 57. Feed liquid
- 58. Cooling water
- 59. Warm water
- 15 60. Flue gas duct
- 61. Flashed liquid
- 62. Fan
- 63. Circulating pump
- 64. Flue gas chimney
- 20 65. Flue gas channel
- 66. Fan
- 67. Flue gas channel
- 70. Flue gas cooler
- 71. Lamellas
- 25 72. Fan
- 73. Flue gas channel
- 74. Cooled flue gas
- 75. Feed liquid
- 76. Distribution tray
- 30 77. Housing of flue gas cooler
- 78. Bottom of flue gas cooler

79. Heated liquid from flue gas cooler

80. Vapor

81. Vapor

82. Evaporator

5 83. Product liquor from evaporation plant

84. Liquor circulation line

[0079] As described above, the effluent feed point will change depending on flow properties. It can be feed to the back end of the MEE when it is beneficial to start evaporating effluents with a cold segregation phase before reaching the hot front end. If the feed flow is really cold (20-30 degrees of Celsius), it can be used as a sink in the cold end of the evaporation plant, i.e. as a cooling flow in the surface condenser and then it can be fed into the flue gas heat exchanger or partially warmed up by the back end vapor before feeding into the flue gas heat exchanger. The optional heat exchanger connections are numerous.

[0080] According to an embodiment, a flue gas cooling system having a flue gas cooler and a flash tank (Figs. 1a-1c) and a flue gas system having an evaporator (Fig. 5) are connected in series so that the flue gas is first cooled in one system and then in the other system. The systems can be connected in any order.

[0081] It is obvious to a skilled person that the pressure of the vapor discharged from the flue gas heat exchangers can be increased by a thermo-compressor, or any other form of compressing device, particularly when it is cost-efficient to raise the vapor pressure of any evaporator stage downstream of the flue gas heat exchanger stages.

[0082] The new solution could also be used as a pre-evaporator for black liquor or as a hybrid that evaporates e.g. black liquor in the front end of the evaporation plant and another liquid in the back end. A hybrid evaporator may be chosen if the liquid to be treated is a small effluent flow or a flow that is heat sensitive and contains e.g. some special enzymes or polymers that need to be concentrated below a certain maximum temperature.

5 [0083] The new integrated multiple-effect evaporation plant is suitable for all effluent flows but is most advantageous when recovering clean condensate from blow out flows or effluent flows that contain COD of 2000 mg/kg or higher concentrations, NPE's (non-process elements), small amounts of contaminants, heavy metals etc.

10 [0084] The new method and system are particularly advantageous for solutions having a low boiling point rise (BPR).

15 It can be advantageous to integrate a separator (e.g. 1 or more cyclones or/and decanter centrifuges) in the middle of the multiple-effect evaporation plant, i.e. in any transfer line point in between the first and last effects to separate particles, flakes or crystals etc. The flow of particles is then either transferred forward or backwards in the evaporation plant depending on the need and purpose. Non-process elements can be separated from the main recovery cycle. The separated concentrates are to be burned in a separate power boiler e.g. reducing significantly the risk of NPE

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disturbances in pulp bleaching or scaling in the evaporation plant and in other parts of the process.

[0085] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, it is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

CLAIMS:

1. A method for recovering heat from flue gas generated at a power plant or biomass-based plant, such as a pulp mill, and for concentrating a liquid at a multiple-effect
5 evaporation plant having a plurality of evaporation effects, in which the heating medium and liquid flow counter-currently, comprising:

directing flue gas from a combustion device through a channel into an indirect contact with a liquid to be
10 concentrated, wherein the liquid is heated with heat from the flue gas in a flue gas cooler having at least one indirect heat exchange stage,

extracting the heated liquid from the flue gas cooler and flashing in at least one flashing stage so as to produce
15 flash-cooled liquid and flash vapor, which vapor is used as a heating medium in an evaporation stage or stages of the multiple-effect evaporation plant,

directing a portion of the heated liquid into the multiple-effect evaporation plant before or after the
20 flashing, and

circulating flash-cooled liquid into the flue gas cooler.

2. A method for recovering heat from flue gas generated at a power plant or biomass-based plant, such as a pulp mill, and for concentrating a liquid at a multiple-effect
25 evaporation plant having a plurality of evaporation effects, in which the heating medium and liquid flow counter-currently, comprising:

directing flue gas from a combustion device through a channel into an indirect contact with a liquid to be concentrated, wherein the liquid is heated with heat from the flue gas so as to simultaneously evaporate vapor from the liquid in a flue gas cooler having at least one indirect heat exchange stage, and the evaporated liquid is extracted from the cooler, and directed to the multiple-effect evaporation plant, and the evaporated vapor is used as a heating medium for the multiple-effect plant in an evaporation stage or evaporation stages.

3. A method as in claim 1 or 2, wherein the at least one heat exchange stage is formed of tubes or lamellas, inside or outside of which the liquid flows, and the flue gas and the liquid flow counter-currently, co-currently or cross-currently.

4. A method as in claim 1 or 3, wherein the flue gas and the liquid flow counter-currently in the flue gas cooler having at least a first and a second heat exchange stage in a flow direction of the flue gas, whereby in the first heat exchange stage the hot flue gas is cooled by the liquid circulated from a first flashing stage and in the second heat exchange stage the flue gas is further cooled by a colder liquid circulated from a second flashing stage, the vapor side of which is connected to at least one later step in the evaporation plant, which step is working at a lower temperature than the first flashing stage.

5. A method as in claim 2 or 3, wherein the flue gas and the liquid flow counter-currently in the flue gas cooler having at least a first and a second heat exchange stage

in a flow direction of the flue gas, whereby in the first heat exchange stage the hot flue gas is cooled by the liquid circulated in the first heat exchange (evaporation) stage and said liquid coming from the second flue gas heat exchange stage, where the flue gas heat exchanger is directly fed by the feed liquid, or fed by a liquid from a step of the multiple-effect evaporation plant, which step is working at a lower saturated vapor temperature than the first heat exchange (evaporation stage) of the flue gas cooler.

6. A method as in claim 4, wherein a portion of the flash-cooled liquid from the first flashing stage is directed to the multiple-effect evaporation plant, and in the second heat exchange stage the flue gas is further cooled by a liquid from a subsequent flashing stage.

7. A method as in claim 1 or 2, wherein the flue gas after the first cooling stage is further cooled by a liquid from a last evaporator effect or last effects of the multiple-effect evaporation plant.

8. A method as in claim 1, wherein the vapor saturation temperature of the feed liquid of the evaporation plant is 110 °C or over, and the saturation temperature in the vapor flowing into the first effect of the multiple-effect evaporation plant is below 110°C, and the feed liquid is introduced into the liquid flow from the first heat exchange stage to the inlet of the first flashing stage.

9. A method as in claim 4, wherein the temperature of the feed liquid of the evaporation plant is between 50 and 110°C, then a part or all of the feed liquid is fed

to the second heat exchange inlet and/or to the discharge
of the second heat exchange or into the liquid flow
between the first flashing stage and the inlet of the
first heat exchange stage, depending on the temperature
5 of the feed liquid.

10. A method as in claim 4, wherein the temperature of
the feed liquid of the evaporation plant is below 50°C,
and in the second heat exchange stage the flue gas is
cooled by the feed liquid, which is further heated in the
10 first heat exchange stage, after which the heated liquid
is circulated into the first flashing stage and partly
into a subsequent flashing stage of the evaporation
plant.

11. A method as in claim 10, wherein before the flue gas
15 cooling a portion of the feed liquid is preheated by
secondary heat from a last stage or last stages of the
evaporation plant in the flow direction of vapor.

12. A method as in any of claims 1 to 11, wherein the
flue gas is generated in a recovery boiler by burning
20 black liquor from a pulping process, and black liquor is
pre-concentrated by the heat from the flue gas.

13. A method as in any of claims 1 to 12, further
comprising generating the flue gas in a power boiler.

14. A method as in any of claims 1 to 13, further
25 comprising separating particles, such as crystals or
lignin or non-process elements, silica, calcium or heavy
metal agglomerates, from the liquid in a point between
the evaporation stages of the evaporation plant.

15. A method as in any of claims 1 to 14, further comprising splitting condensates formed at the evaporation plant into a relatively clean condensate and foul condensate by partitioning the heat exchange
5 elements of the evaporation stages, and the foul condensate is cleaned by steam stripping.

16. A method as in any of claims 1 to 15, further comprising producing hot water with heat from vapor formed in a flashing stage of the liquid after the first
10 flashing stage or the evaporation stage of the flue gas cooler.

17. A method as in claim 1, wherein the controlling of the liquid flow between the flue gas cooler and a flash tank of the flashing stage includes regulating a pressure
15 drop of the flashed liquid to achieve a stable flash and regulating a pressure drop for flash vapor to achieve a predetermined minimum temperature of the flashed liquid, which is returned into the flue gas cooler.

18. A method as in claim 17, wherein a pump in a line
20 transporting the liquid from the flash tank into the flue gas cooler is adjusted by controlling an inverter for the pump.

19. A method as claims 1 to 2, wherein the flue gas or a part of the flue gas is pumped with a fan before or after
25 the heat exchangers of the flue gas cooler to compensate the pressure drop in the flue gas cooling heat exchangers when flowing in the channel into the chimney.

20. A method as in claim 1 or 2, wherein the flue gas or a part of the flue gas is separated from the main flue

gas channel into a parallel flue gas cooling channel, where the flue gas cooler is located, and returned into the main flue gas channel or chimney after passing through the flue gas cooler.

5 21. A method as in claim 1 or 2, wherein the flue gas or a part of the flue gas is separated from the main flue gas channel into a parallel channel and then pumped with a fan that is placed before or after the flue gas cooling heat exchangers to compensate the pressure drop in the
10 flue gas cooling heat exchangers and then returned into the main flue gas channel or chimney after passing through the flue gas cooler.

22. A method as in claim 1 or 2, wherein the vapor formed by heat from the flue gas is used to drive a multiple-
15 effect evaporation plant which is used as a pre-evaporator.

23. A method as in claim 1 or 2, wherein the pressure of the vapor formed by heat from the flue gas is increased by a thermo-compressor or another compressing device.

20 24. A system for recovering heat from flue gas generated in power and heat producing combustion devices at a power plant or biomass-based plant, such as a pulp mill, and for concentrating a liquid at a multiple-effect
evaporation plant having a plurality of evaporation
25 effects, in which the heating medium and liquid flow counter-currently, comprising:

a flue gas cooler, comprising an inlet for receiving flue gas from a combustion device and an outlet for discharging cooled flue gas; and

the flue gas cooler further comprising at least one indirect heat exchange stage, which has heat exchange surfaces formed by tubes or lamellas and in which the flue gas and liquid are brought into indirect contact with each other for transferring heat from the flue gas to the liquid, whereby at least one flashing stage is arranged in a flash tank, which is connected to the heat exchange stage of the cooler for transporting the heated liquid into the flash tank and flashed liquid further into the cooler, and which tank is connected to the multiple-effect evaporation plant for transporting flash steam, and a conduit is arranged for transporting liquid from the flue gas cooler or from the flash tank to the multiple evaporation plant for evaporation.

25. A system for recovering heat from flue gas generated in power and heat producing combustion devices at a power plant or biomass-based plant, such as a pulp mill, and for concentrating a liquid at a multiple-effect evaporation plant having a plurality of evaporation effects, in which the heating medium and liquid flow counter-currently, comprising:

a flue gas cooler, comprising an inlet for receiving flue gas from a combustion device and an outlet for discharging cooled flue gas;

the flue gas cooler further comprising at least one heat exchange stage, which has heat exchange surfaces formed by tubes or lamellas formed by two joined plates and in which the flue gas and liquid are brought into indirect contact with each other for transferring heat from the flue gas to the liquid for evaporating the liquid and

generating vapor, wherein the cooler is connected via conduits to the multiple-effect evaporation plant for transporting the evaporated liquid and vapor to the multiple-effect evaporation plant.

5 26. A system as in claim 23 or claim 24, wherein the flue gas cooler comprises a first and second heat exchange stage in a flow direction of the flue gas, wherein the second stage is connected to the multiple-effect
10 evaporation plant for transporting liquid to an indirect contact with the flue gas in the second stage.

27. Use of systems according to claim 24 and claim 25, wherein the systems are connected in series so that a flue gas is first cooled in one system and then in the other system.

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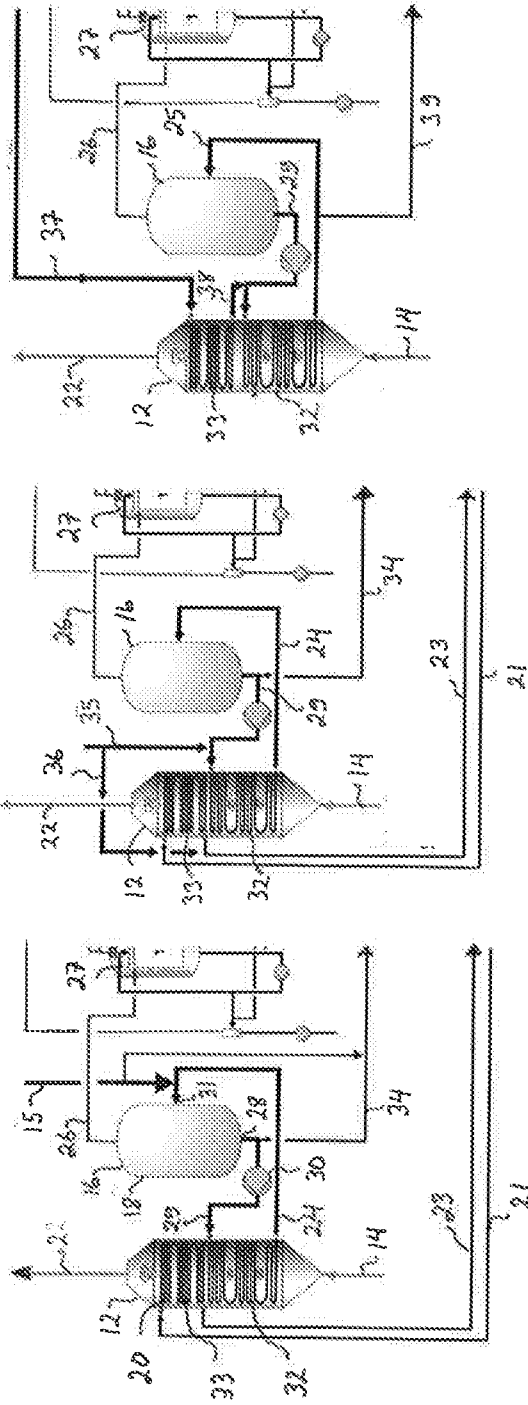


FIG. 1a

FIG. 1b

FIG. 1c

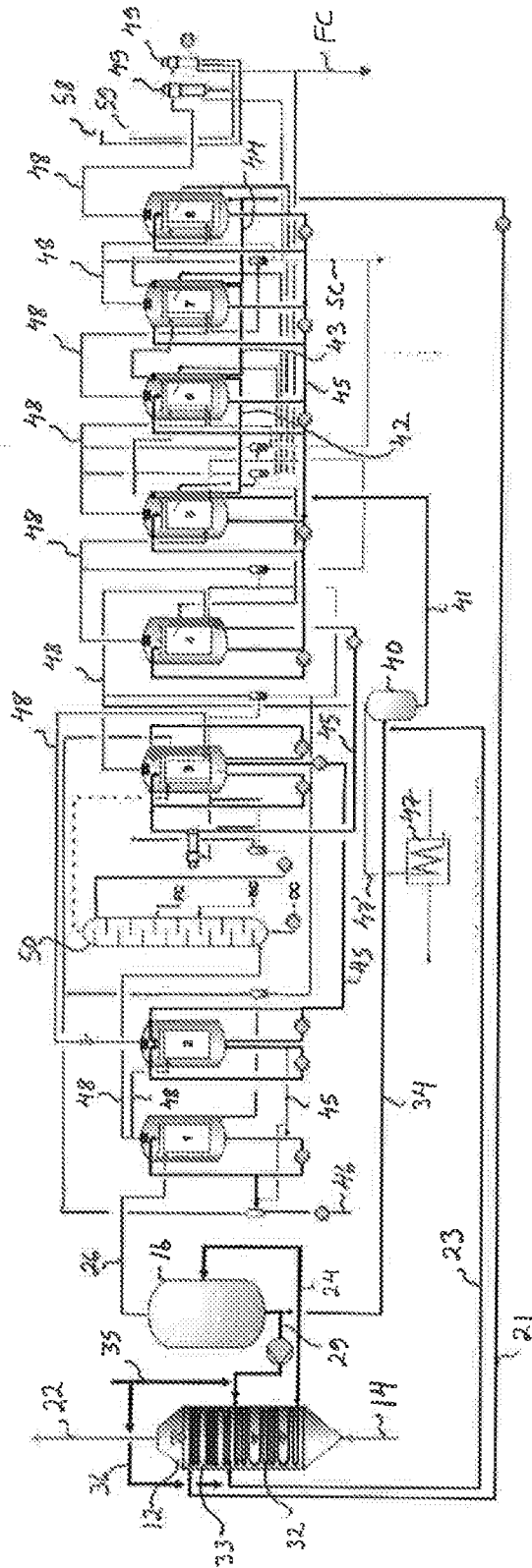


FIG. 2

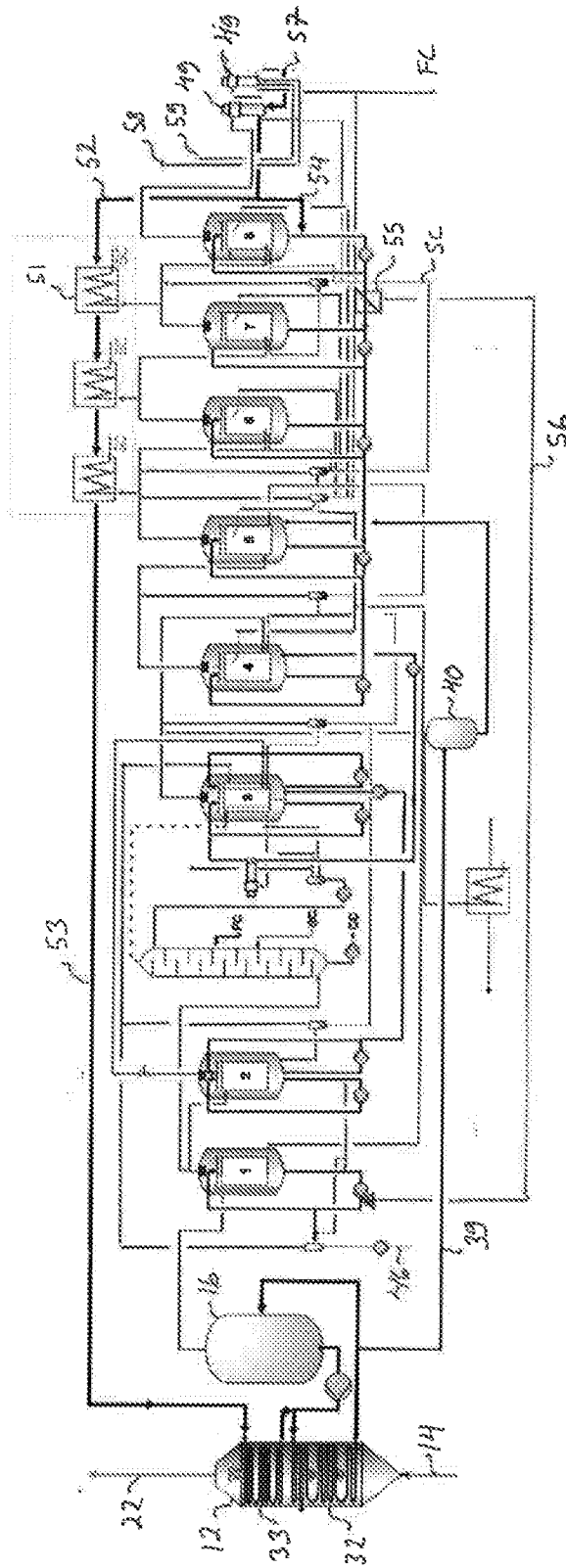


FIG. 3

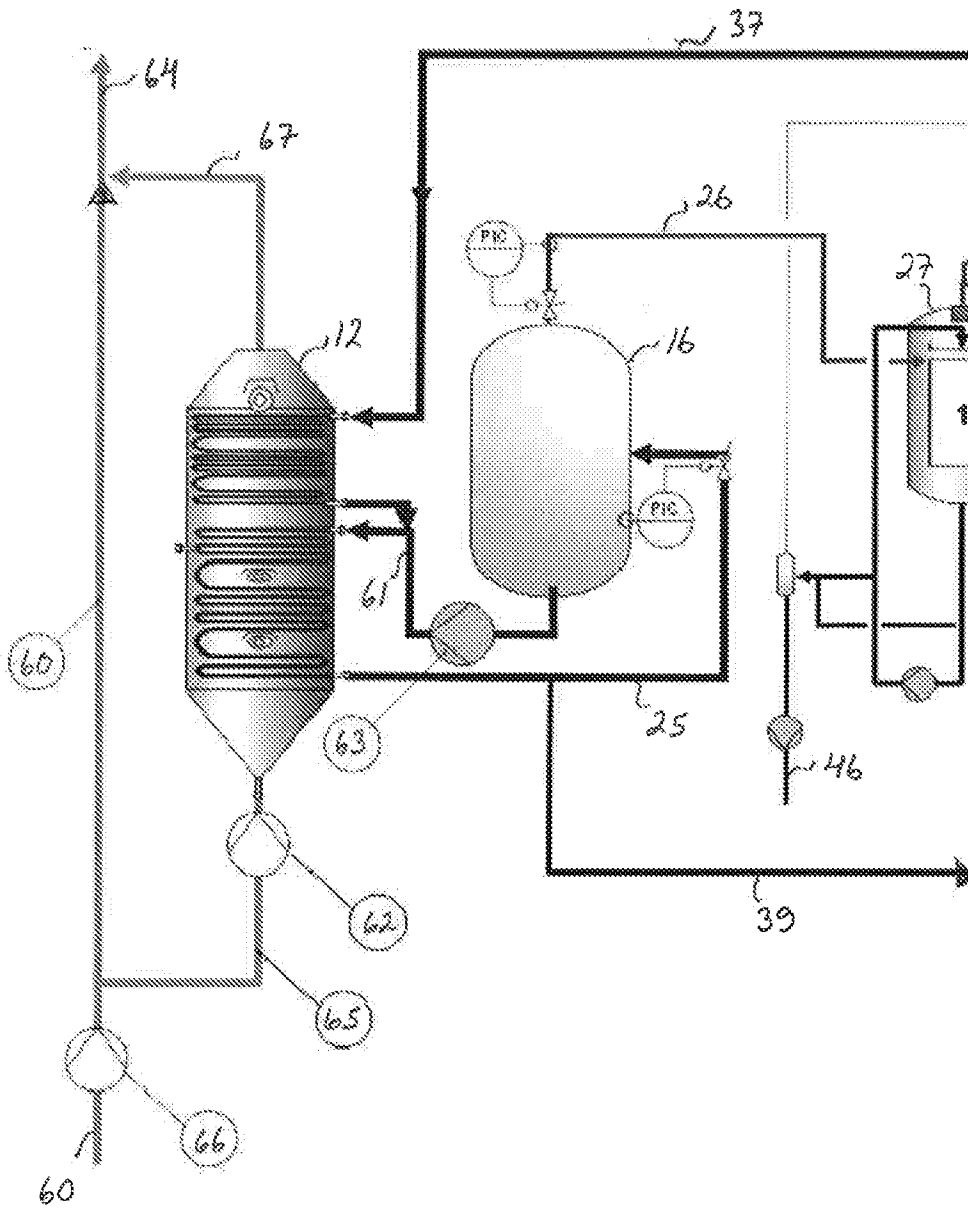


FIG. 4

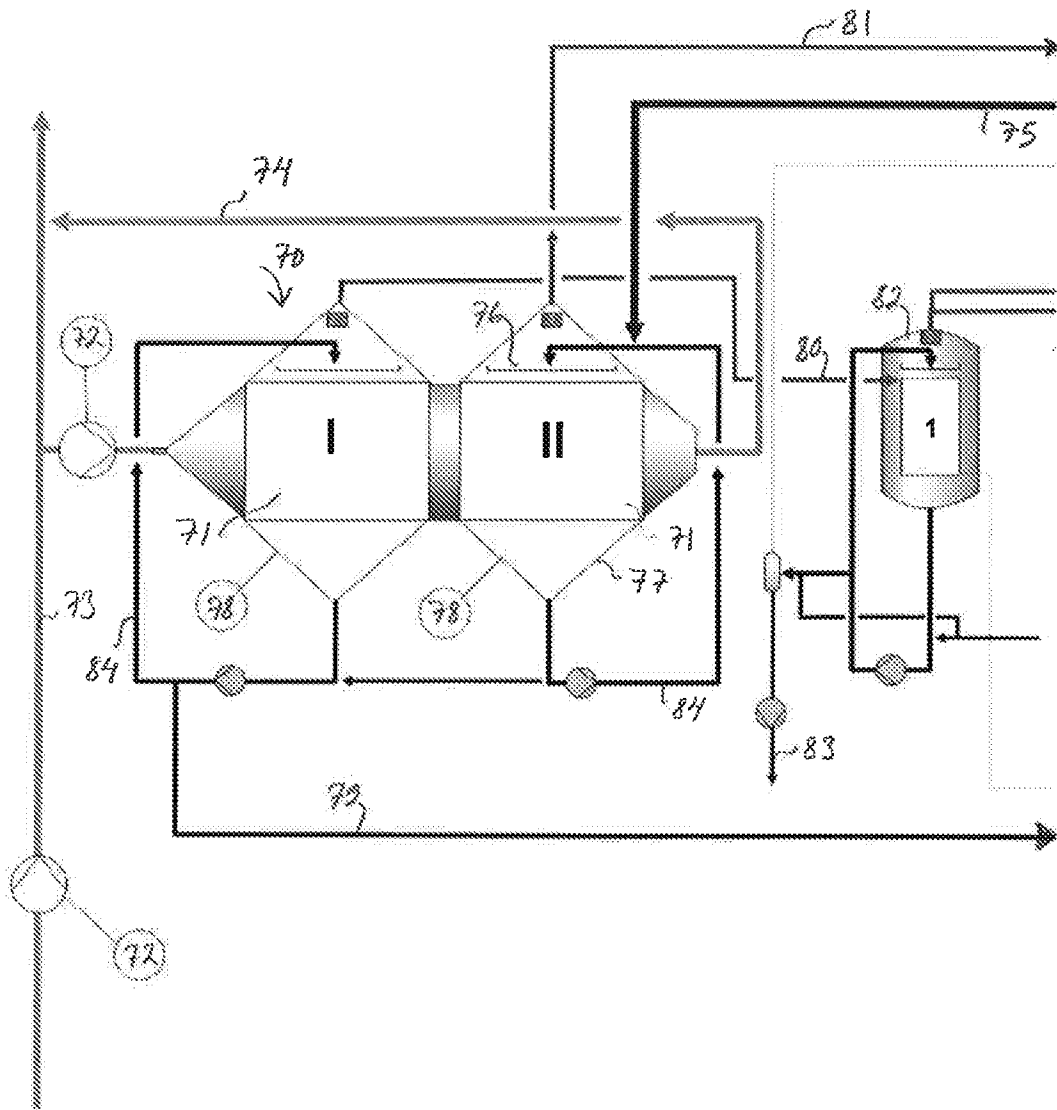


FIG. 5

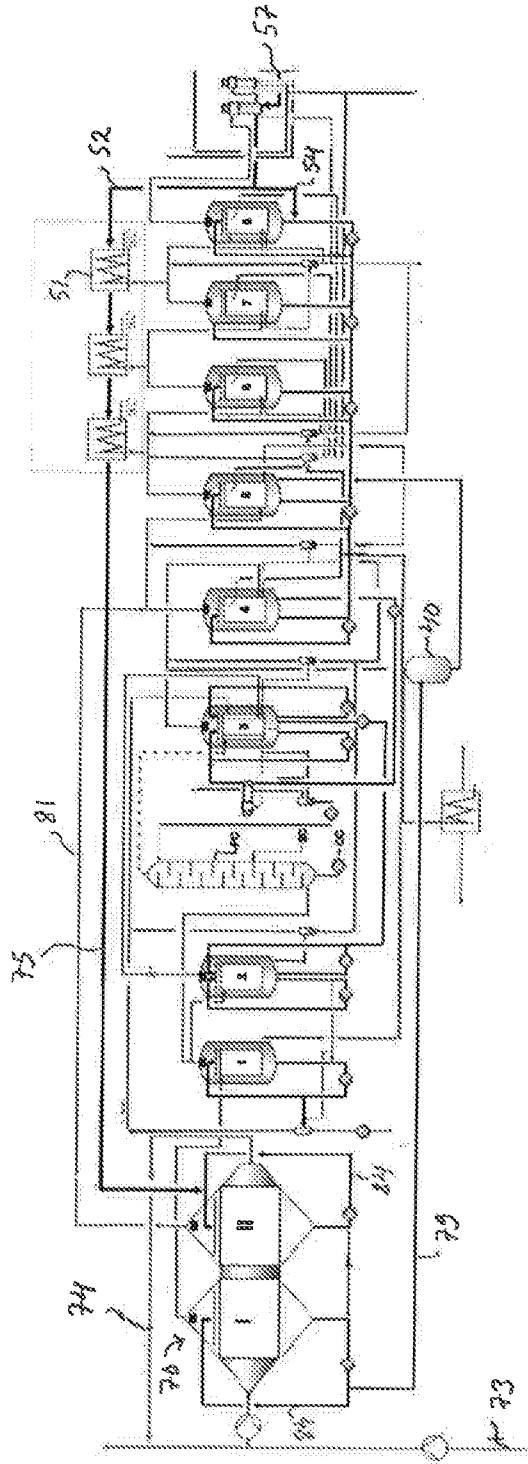


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050325

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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: B01D, D21C, F22B, F23G, F23J, F28D, Y20E

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)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20030070627 A1 (SULLIVAN EUGENE ET AL), 17 April 2003 (2003-04-17); paragraphs [0001], [0006]-[0016], [0025]-[0028], [0031], [0044], [0049]-[0050], [0071], [0073], [0076]; figure 2 --	1-27
T	WO 2012042107 A2 (ANDRITZ OY ET AL), 5 April 2012 (2012-04-05); whole document --	1-27
A	US 4909899 A (KIISKILAE ERKKI J), 20 March 1990 (1990-03-20); whole document --	1-27

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03-07-2013

Date of mailing of the international search report

04-07-2013

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2013/050325

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0042605 A1 (NIRO ATOMIZER AS), 30 December 1981 (1981-12-30); whole document --	1-27
A	US 3047362 A (SMITH EDMOND L), 31 July 1962 (1962-07-31); whole document -- -----	1-27

Continuation of: second sheet

International Patent Classification (IPC)

D21C 11/06 (2006.01)

B01D 1/00 (2006.01)

D21C 11/10 (2006.01)

F23G 5/46 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/FI2013/050325

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WO	2012042107	A2	05/04/2012	NONE		
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				FI	81141	B 31/05/1990
EP	0042605	A1	30/12/1981	AU	7195981	A 24/12/1981
				DK	266780	A 21/12/1981
				NZ	197477	A 30/04/1985
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				GB	889316	A 14/02/1962