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(54) **Title:** METHOD OF GENERATING STEAM AT A DIGESTER PLANT OF A CHEMICAL PULP MILL

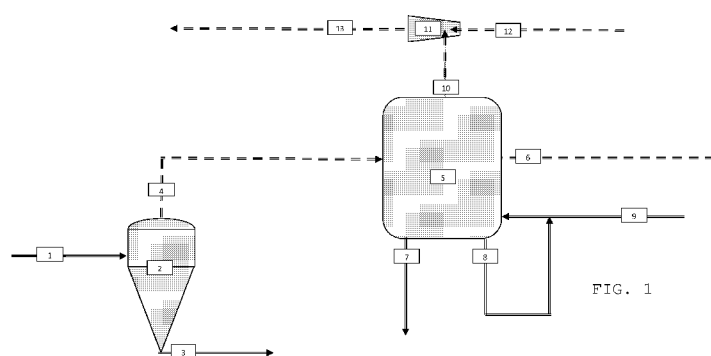


FIG. 1

(57) **Abstract:** The present invention relates to a method of generating steam at a digester plant of a chemical pulp mill. In the method, a) black liquor is discharged from the digester at a first temperature and first pressure; b) black liquor is treated in at least one flash tank for generating flashed black liquor and flash steam, which is at a second temperature and a second pressure that are lower than said first temperature and pressure, c) the flashed black liquor is led from the flash tank to further treatment, d) the flash steam from step b) is led into an indirect heat exchange contact in a reboiler with clean liquid for boiling the liquid and producing steam having a third temperature and third pressure, which are lower than the second temperature and second pressure, whereby the flash steam is condensed, e) the steam flow generated in the reboiler is led from step d) to further use, and f) in step d) foul condensate and clean condensate are generated, and at least a portion of the clean condensate is led into the clean liquid flow to be used in the reboiler in step d).

METHOD OF GENERATING STEAM AT A DIGESTER PLANT OF A CHEMICAL PULP MILL

- 5 The present invention relates to a method of generating steam by utilizing the secondary energy of black liquor at a digester plant of a chemical pulp mill.

Prior art utilizes a fiberline system with a chip bin, where wood chips or other cellulosic material is steamed and liquid is admixed therein for forming a slurry, after which
10 the slurry is pressurized (this section is also referred to as a feed system), fed into a treatment vessel or treatment vessels (which may be an impregnation vessel, a pre-hydrolysis process or other vessels), whereafter follows a digester (this section is also referred to as a cooking system). At present, at least one black liquor flow is discharged from the cooking system (typically at a temperature of 120-170°C). Dis-
15 charged black liquor stream or streams can be used as a heat source for "preheating" white liquor, other black liquor flows and/or other liquid flows being led to feed and cooking systems. The discharged black liquor stream (or streams) is then led to a pre-evaporation system, i.e. into one or more flash tanks, where flash steam is formed from the hot black liquor, which flash steam contains steam and other gases.
20 In flashing the black liquor is typically cooled to a temperature of approximately 100-120°C. After this the black liquor is cooled in an indirect heat exchanger to a temperature of approximately 80-100°C and led into an evaporation system of the recovery zone. The thus generated flash steam can be used at another location in the pulping process. Flash steam can e.g. be used for direct preheating of chips in a chip
25 bin prior to cooking.

The above described flashing process, although being used successfully in conventional continuous digesters, has the disadvantage that the generated flash steam contains in addition to steam volatile compounds, e.g. turpentine, metanol and sulfur
30 compounds, which are not desirable in wood chip pre-steaming. Typically wood chips are steamed at atmospheric or slightly higher pressure, the target temperature of the wood chips typically being approximately 100 °C. At this temperature the volatile compounds entrained in flash steam are not condensed, but they are concentrated to the upper part of the chip bin, wherefrom they are collected and treated. The
35 treatment is typically combustion in a dilute non-condensable gas (NCG) system of the mill. This collection and treatment system becomes especially significant when the used flash steam contains volatile compounds, including sulfur compounds,

which have a disadvantageous impact for the environment, including detrimental odor. In addition, an explosion risk exists, if explosive gases entrained in flash steam in an excess amount are introduced into low concentration gases.

- 5 For the latter reason, it is advantageous to use in the chip bin such a steam source that minimizes or eliminates the introduction of volatile compounds into the chips steaming process.

10 In US-patent 6,346,166 the amount of steam obtained by flashing black liquor is increased (e.g. by at least 10%) as the temperature and pressure of liquor being discharged from the flash tank decrease and the concentration of liquor increases by operationally coupling a jet ejector to a steam discharge outlet of the flash tank. Steam at a higher pressure is introduced to the jet ejector from another source, whereby a mixture of flash steam and another steam is formed, which can be used in
15 chip pretreatment. A problem of this process is, however, that the steam mixture contains volatile compounds originating from the flash steam, which were described in the above.

US-patent 6,722,130 discloses a system for producing clean steam from black liquor.
20 First the pressure of the black liquor is decreased for producing a second black liquor having a higher concentration and black liquor vapor, which is condensed to condensate. This condensate is heated with the first black liquor and flash-evaporated for producing clean steam to be used in a chip bin.

- 25 Known solutions offer various systems for producing cleaner steam for the needs of a digester plant and for improving the energy economy of a chemical pulp mill.

Publication US 6,176,971 discloses a system for producing clean steam for use in a chip bin. Substantially clean usable steam is produced from mill water by reboiling it
30 with heat obtained from hot waste liquor (e.g. black liquor) in a kettle reboiler. The clean steam discharged from the reboiler is pressurized (by e.g. an eductor, a fan or a compressor).

US-patent application 2010/0236733 discloses a process where two black liquor
35 streams are discharged from the digester. One of the black liquor streams discharged from the digester is flashed, whereby flashed black liquor and flash steam are generated, and the other black liquor stream is evaporated using live steam as

heating medium, whereby steam needed in the digester process and evaporated black liquor are generated. Flash steam generated in the flashing of the second black liquor stream discharged from the digester is led into at least one heat exchanger, preferably a reboiler, into an indirect heat exchange contact with clean liquor being evaporated for producing clean steam that is used for steaming chips.

The above solutions have often been used in the attempt to avoid using flash steam in a chip bin, because it causes odor problems and an explosion risk. Therefore reboiler solutions are favored, comprising for instance a kettle reboiler or a vapor reboiler. A kettle reboiler is an indirect tube heat exchanger, in which hot black liquor discharged from the digester flows through the reboiler tubes, heating clean liquid. Thereby steam is generated, which can be used in the chip feed system of the digester plant. A disadvantage of a kettle reboiler is that the dry-solids content of black liquor does not increase therein, which increases evaporation of water at the evaporation plant and thus impairs the energy economy of the chemical pulp mill.

A vapor reboiler can be a vertical tube heat exchanger, in which the heating flash steam flows inside the tubes and the liquid being boiled flows as a thin film on the outer surface of the tubes. A problem with a vapor reboiler is that in certain cases, especially in winter, it is not always possible to generate an adequate amount of steam required for chip treatment, such as in a chip bin, but low pressure steam from the mill has to be used in addition. This can take place by feeding live steam directly into the chips.

Another problem with a vapor reboiler is indirect heat exchange, i.e. a certain ΔT has to prevail over the heat transfer surface, typically 2 -10 °C. Therefore, the pressure and temperature of a flash tank, such as a flash cyclone, producing flash steam for the vapor reboiler, are to be higher compared to a situation devoid of a vapor reboiler. Then the black liquor exiting the flash cyclone is hotter and it has to be cooled more prior to leading it to further treatment. Thereby an unnecessarily abundant amount of hot water can be generated.

A third problem with a vapor reboiler is smaller amount of flash steam generation in a preceding flash cyclone (due to its higher pressure demand). Then the dry-solids content of black liquor exiting the flash cyclone is lower and thus requires more evaporation in further treatment compared to a situation devoid of a vapor reboiler.

A fourth problem with a vapor reboiler is increased amount of condensate formed from flash steam compared to a situation devoid of a vapor reboiler. Unless this condensate can be used partially e.g. for pulp washing, it has to be cleaned before letting into the water system.

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From the above it becomes obvious that when a vapor reboiler is used, the secondary heat of black liquor can be less utilized for heating chips, whereby the use of live steam is increased and the need for cooling waters is increased and the energy economy of the mill is impaired.

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In a vapor reboiler heating steam, typically flash steam of black liquor, is passed into indirect heat exchange relationship with "clean" liquid free of volatile compounds for heating the liquid to a temperature higher than its boiling point or to flashing point for producing odorless steam that is substantially free from volatile compounds. The liquid can typically be condensate from a black liquor evaporator, demineralized water, boiler feed water or adequately clean water fraction. The clean steam produced in the reboiler contains a substantially smaller amount of non-condensable gases than vapor produced by direct flashing of black liquor, which is also used as heating steam. A vapor reboiler acts as a distiller, where heating steam is segregated into clean condensate and foul condensate. The flash steam is fed from below to part of the tubes wherein the steam flows upwards, whereby naturally more easily condensed components, such as steam, are condensed. The condensate formed in these tubes is relatively clean water, still containing some methanol. This condensate can be used e.g. in pulp washing in cases when this condensate is considered adequately clean. When the steam has flown through said tubes, it is directed to flow downwards through a second set of tubes. Thus, the steam flowing in these tubes contains a larger percentage of volatile impurities, whereby a so-called foul condensate is formed requiring cleaning. Typically the amount of foul condensate is less than 25% of the total amount of condensate formed in a vapor reboiler. The fouler condensate is led to further treatment and finally cleaned, usually by steam stripping.

At present, abundantly of clean condensates are formed at a chemical pulp mill (e.g. at the evaporation plant), which can be used e.g. for chemical pulp washing. Also bleaching and washing techniques have developed and their washing water demand has decreased. Therefore, cleaner condensate coming from a vapor reboiler does not necessarily find a suitable object of application in a modern chemical pulp mill.

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- An object of the present invention is to avoid the above mentioned problems of a vapor reboiler and to provide an improved and alternative method of producing clean steam by means of a vapor reboiler for e.g. steam pretreatment of wood chips by utilizing the secondary heat of black liquor coming from the digester as efficiently as possible and thus decreasing the use of live steam. An object is to intensify the operation of a vapor reboiler so that the use of fresh water of the mill can be decreased and/or the use of clean water available can be intensified. One object is also to improve the overall energy economy of a chemical pulp mill.
- 10 According to an embodiment, the present invention provides a method of generating steam at a digester plant of a chemical pulp mill, in which method
- a. black liquor is discharged from the digester at a first temperature and a first pressure;
 - b. the black liquor is treated in at least one flash tank for producing flashed
15 black liquor and flash steam at a second temperature and a second pressure, which are lower than the first temperature and first pressure;
 - c. the flashed and cooled black liquor is led from the flash tank to further treatment
 - d. the flash steam is led from stage b. into indirect heat exchange contact with
20 clean liquid in a vapor reboiler for boiling the liquid and producing steam having a third temperature and third pressure, which are lower than the second temperature and second pressure;
 - e. the steam formed in stage d. is led from the reboiler into an ejector, wherein also a second steam flow is led having a fourth pressure and a fourth temperature, which are higher than said third pressure and third temperature,
25 whereby a third steam flow is formed having a fifth pressure and a fifth temperature, which are higher than said third pressure and third temperature in stage d.; and
 - f. the third steam flow formed in stage e. is led e.g. for pretreatment of comminuted fibrous material, such as wood chips, prior to digester treatment. According to a preferred embodiment the method further comprises the steps of:
 - g. leading the cleaner condensate formed in stage d. back into the vapor reboiler to its clean liquid side; and
 - 35 h. leading a fouler condensate formed in stage d. to further treatment.

In stage g) clean condensate is preferably circulated in such an amount that the fresh water consumption at the mill can be decreased. At least 20%, typically at least 50%, e.g. 50–80% or 60–80% of the clean condensate is led back into the vapor re-boiler to the clean liquid side.

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Typically the pressure and amount of the second steam being led into the ejector in stage e) is adjusted according to the steam requirement for the pretreatment of fibrous material, such as chips. In summer conditions this amount may be zero and correspondingly in winter conditions the limiting maximum amount may be the temperature of black liquor exiting stage b), which temperature cannot be decreased under the temperature required for further treatment.

The new solution is advantageous especially when, in cold weather conditions, such as in winter, the temperature of the chips is very low, e.g. -15°C , which means that the chips are even frozen. Then the steam consumption is high in order to heat the chips. Under winter conditions the flash steam is typically not adequate for heating the chips, but live low pressure steam must be added into the chip bin in current process solutions.

Decreasing the pressure in the flash tank and increasing the pressure of the steam produced in the reboiler typically allows flashing evaporation of hot liquors such that the temperature of the produced steam is lower and the amount of steam higher than in prior art methods. For instance, the temperature of the steam and liquid in the flash tank can be decreased by means of the invention by at least 5°C compared to prior art (without an ejector). Simultaneously the amount of produced gas (steam) can typically increase by at least 10%, preferably by at least 20% and in some cases by more than 40% compared to prior art.

According to an embodiment the black liquor discharged from the digester is flashed in two stages. The temperature of the black liquor exiting the first flashing can be below 145°C . Also the cooking temperature can be low (the temperature of the black liquor exiting the digester is low, i.e. $120\text{--}145^{\circ}\text{C}$). This is typical for instance when pulp is cooked in the digester to a high Kappa number (typically Kappa number over 50 for soft wood and over 25 for hard wood). The temperature of the black liquor can be lower than usual also when the production is low in view of the volume of the digester. At present, hard wood is typically cooked at low cooking temperatures.

A purpose of the invention is to intensify the operation of a vapor reboiler so that the use of fresh water at the mill can be decreased and/or the use of clean water available can be intensified. Thus, the present invention also relates to a method of generating steam at a digester plant of a chemical pulp mill, in which method

- 5 a) black liquor is discharged from the digester at a first temperature and a first pressure;
- b) the black liquor is treated in at least one flash tank for producing flashed black liquor and flash steam at a second temperature and a second pressure, which are lower than the first temperature and first pressure;
- 10 c) the flashed black liquor is led from the flash tank into further treatment;
- d) the flash steam is led into indirect heat exchange contact with clean liquid in a vapor reboiler for boiling the liquid and producing steam having a third temperature and third pressure, which are lower than the second temperature and second pressure, and the flash steam is condensed;
- 15 e) the steam flow formed in the reboiler is led from stage d) to further use, such as for pretreatment of comminuted cellulosic fiber material prior to treatment in a digester, and
- f) foul condensate and clean condensate are formed from the flash steam, and at least a portion of the clean condensate is led into the clean liquid flow to be used in
- 20 stage d).

In the present new method, odorless steam e.g. for steam pretreatment of chips is produced by flashing black liquor discharged from the digester and condensing the flash steam in a reboiler/reboilers, which exchanges heat in the reboiler/s indirectly

25 with "clean" liquid free from volatile compounds for heating the water to a temperature higher than its boiling point or to a flashing point for producing clean and odorless steam free of volatile compounds. The clean steam produced in the reboiler contains a substantially smaller amount of non-condensable gases than steam produced by direct flashing of black liquor.

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As described in the above, in vapor reboilers the condensate can be divided based on cleanliness into various fractions, which typically include so-called clean condensate and foul condensate. In a tube vapor reboiler the flash steam is fed as heating steam from below to part of the tubes wherein the steam flows upwards, whereby

35 naturally more easily condensed components, such as steam, are condensed. The condensate formed in these tubes is relatively clean water, still containing e.g. some methanol. When the steam has flown through said tubes, it is directed to flow down-

wards through a second set of tubes. Thus, the steam flowing in these tubes contains by percentage more volatile impurities, whereby a foul condensate is formed, which requires cleaning. The volume of foul condensate may vary within certain limits set by the tube arrangement, depending on the operator's requirements for the cleanliness of the clean condensate. Typically the volume of foul condensate is approximately 10–25%, e.g. 17% of the total amount of condensate in the reboiler. According to the invention, clean condensate is used as feed liquid for a vapor reboiler.

The present invention is not limited to the user of a tube-type vapor reboiler. but the heat transfer surface can be formed of something else than a tube, e.g. a plate. A preferred reboiler has a construction where the condensate can be divided into different fractions based on cleanliness.

The use of clean condensate in a reboiler decreases the fresh water consumption at the mill and the energy efficiency is improved. The temperature of clean condensate is typically over 100 °C, which is considerably higher than the temperature of typically used mill water (e.g. 65 °C). Thus, heating of feed water to be reboiled consumes less energy, and more steam to be used in chips treatment can be produced and thus the amount of live steam can be decreased.

When an ejector is coupled to steam discharge of a reboiler in the way described in the above, less amount of process steam for the ejector is needed compared to a situation where the feed water of the reboiler is colder mill water.

As feed liquid for a vapor reboiler, e.g. cleaned condensate from a black liquor evaporation plant has been used, but the present invention acts in quite a novel way using as feed water the reboiler's own condensate, generated in the vapor side, to at least partially replace liquid introduced from outside the reboiler.

Although the term flash tank is used in this description, the term also used by professionals in the field, a person skilled in the art also knows that the term covers any apparatus, wherein the pressure of hot, pressurized liquid is decreased and liquid is allowed to evaporate, typically very fast, in a closed container for producing a source of steam and liquid at a lower temperature.

The invention is described in more detail with reference to the accompanying figures, of which

Figure 1 is a schematic illustration of a preferred embodiment according to the present invention for carrying out the method of the invention, and

Figure 2 is a schematic illustration of a preferred embodiment according to the present invention using a tube vapor reboiler.

Fig. 1 illustrates a system for generating steam at a digester plant and for treating black liquor such that the heat economy of the cooking process is improved.

Figure 1 illustrates a coupling according to an embodiment of the invention. The temperature of the black liquor exiting the digester (not shown) is approximately 165 °C and the solids content 12-17 %. The black liquor has typically been pressurized in the digester to a pressure of 500 - 1500 kPa (5 - 15 bar) (abs) and its temperature corresponds to the temperature of digester treatment (approximately 110° - 180° C). The black liquor is typically flashed in two-stage flashing in two flash tanks. In the flash tank the pressure of the black liquor is decreased for producing flash steam and for producing flashed black liquor, the solids-content of which increases in the flashing. Flash steam from the first stage (not shown) flows into a steaming vessel (not shown) in the chip feed system, where the chips coming from the chip bin (not shown) are heated to a temperature of approximately 120 °C. The black liquor is cooled in the first flashing stage to a temperature of approximately 143 °C and led via line 1 to a flash tank 2. In the second flashing stage the black liquor is flashed to a temperature of approximately 106 °C. The generated flash steam is then at approximately 104 °C, due to the increase in the boiling point caused by the solids of the black liquor. From the flash tank 2 the black liquor is led via line 3 to further treatment.

Flash steam generated in the flash tank 2 is led via line 4 into a vapor reboiler 5. The flash steam is condensed onto the heat surfaces of the vapor reboiler 5. The formed cleaner condensate is led via line 8 into line 9, via which the vaporizable liquid is added into the vapor reboiler to its clean side for generating steam. The formed steam is led via line 10 into an ejector 11, to the side of lower pressure. Via line 12 the ejector 11 receives steam at a higher pressure.

The construction of the flash tank 5 is substantially conventional and it has a feed line 1 for hot pressurized black liquor, a discharge line 4 for flash-evaporated vapor, and a discharge line 3 for cooled black liquor at a lower pressure. Flash tanks are

usually operated so that the pressure prevailing in them is lower than the pressure of black liquor fed therein. Flash tanks are containers designed for this purpose, which facilitate the pressure decrease of hot, pressurized black liquor, whereby liquid, typically water, is vaporized from the black liquor very quickly, into steam, whereby also
5 the concentration of waste cooking chemical and the products of a cooking reaction (dissolved solids) is increased. In this quick evaporation the formed steam is discharged into the steam discharge line 4 at a pressure prevailing in the tank 2, e.g. 100-400 kPa (1 - 4 bar) (abs) and a saturation temperature corresponding to the prevailing pressure, e.g. 100° - 140° C. After flash evaporation the black liquor settles onto the bottom of the tank 2, from where it is discharged via line 3. Typically
10 the black liquor is led into an evaporation system.

The flash steam is led via line 4 into a reboiler 5, wherein the energy contained therein is recovered. The vapor reboiler 5 can be a vertical tube heat exchanger, in
15 which the heating steam flows inside the tubes and the liquid being boiled flows as a film on the outer surface of the tubes, as described in connection with Fig. 2. Clean condensate is accumulated onto the bottom of the reboiler. The clean condensate in line 8 is circulated into the feed water line of the reboiler, into which also mill water can be introduced via line 9. At least a portion, at least 20%, typically over 50%, such
20 as 50–80% or 60–80%, of the clean liquid is formed by the clean condensate of the reboiler from line 8. The foul condensate is led via line 7 to be cleaned e.g. to a stripping plant. The non-condensable gases are introduced to their treatment system via line 6.

25 The flash steam 4 is set in an indirect heat exchange contact with "clean" liquid free of volatile compounds for heating the liquid to a temperature exceeding its boiling point for producing clean steam. The flash steam is condensed inside the tubes as described in the above, while clean liquid boils on the outer surface of the tubes for producing clean steam.

30 The steam is discharged from the reboiler 5 via line 10, which line is provided with an ejector 11. The ejector receives steam from the reboiler, the pressure of which steam is increased in order to provide a pressure and a temperature that are better adequate for heating the chips in the bin (not shown) where the steam is led via line 13. By
35 means of the ejector the amount of steam produced in the flash tank can be increased.

Steam in line 13 is advantageously used for steaming wood chips. The pressure required for this steam is typically determined based on the pressure requirements of the final object of application in chip steaming. According to the present invention, however, increasing the pressure of the steam in line 10 by means of an ejector 11 to a desired pressure level (in line 13) facilitates the production of steam in line 10 at a lower pressure. Thereby, the flash tank 2 and reboiler 5 can be operated at a lower temperature, whereby in accordance with the invention more steam can be produced in the flash tank and the reboiler, at a lower steam temperature. Thereby, also the temperature of the black liquor being discharged from the flash tank into line 3 is lower and the solids content higher.

A steam jet ejector is a nozzle device utilizing the venturi-effect, which device utilizes the energy contained in the steam either i) for generating a vacuum, or ii) for increasing the pressure of a gas, or iii) for a combination of points i) and ii). An ejector typically comprises or consists of a substantially cylindrical housing having a high pressure feed opening (feed opening for fluid acting as driving power), a low pressure feed opening (suction feed opening) and a discharge opening (discharge opening for mixed fluid). Typically, a flowing substance (e.g. steam) at a high pressure is led from the high pressure feed opening into the venturi nozzle, which increases the velocity of the flowing substance while the pressure thereof is decreased according to the Bernoulli law principles. Pressure decrease draws the flowing substance that is at low pressure to the low pressure feed opening, whereby the flowing substance at low pressure is mixed with a high pressure flowing substance as they flow through a throat nozzle. The mixed flowing substance at a pressure between the original pressures is discharged via the discharge opening.

By using a conventional steam jet ejector for intensifying the use of flash steam, the pressure of the flash tank can be decreased so that the black liquor is flash evaporated to a temperature of e.g. approximately 100-108 °C. Thereby, the total amount of available flash steam is increased, and a less amount of valuable live steam is required. The "high pressure" steam used as driving power of the steam jet ejector can be low pressure live steam or high pressure live steam. Additionally, the need for cooling the black liquor being transferred to the evaporation plant is decreased or eliminated and the amount of black liquor to be evaporated is decreased at least to some extent.

The clean steam produced in the reboiler contains a substantially smaller amount of non-condensable gases than steam produced by direct flashing of black liquor.

Clean steam in line 13 is preferably used for wood chips preheating by means of steam, e.g. in a chip bin. When this steam is used for treating chips, a less amount of volatile compounds are generated for collection and treatment by the NCG-system of the mill, since said steam does not bring volatile compounds into the pre-steaming process.

Fig. 2 illustrates a vapor reboiler coupling in more detail. Hot black liquor discharged from the digester (not shown) and having a temperature of typically 120-180 °C and a solids content of typically 12–17 % is discharged via digester screens and is led possibly via a first flash tank (not shown) and along line 40 into a flash tank 42. The flashed black liquor is led via line 44 to the evaporation plant of the mill, where the black liquor is concentrated to a high solids content prior to combustion in a recovery boiler.

The flash steam is led via line 46 into a reboiler 41, wherein the energy contained therein is recovered. The vapor reboiler 41 is a vertical tube heat exchanger, in which the heating steam flows inside the tubes and the liquid being reboiled flows as a film on the outer surface of the tubes. The flash steam from line 46 is fed from below to part of the tubes, a first set of tubes 20, wherein the steam flows upwards, whereby naturally more easily condensed components, such as steam, are condensed. The condensate formed in these tubes is relatively clean water, still containing some methanol. Clean condensate is accumulated onto the bottom of the reboiler 22. When the steam has flown through said tubes 20, it is directed to flow downwards through a second set 24 of tubes. Thus, the steam flowing in these tubes contains a larger percentage of volatile impurities, whereby a foul condensate is formed, which requires cleaning and is accumulated in chamber 26. Typically the amount is approximately 10–25%, e.g. 17% of the total amount of condensate in the reboiler. The foul condensate is cleaned usually by steam stripping whereto it is led via line 28. The non-condensable gases are introduced to their treatment system via line 36.

The flash steam 46 is set in an indirect heat exchange contact with "clean" liquid free of volatile compounds for heating the liquid to a temperature exceeding the boiling point for producing clean steam. The flash steam is condensed inside the tubes as described in the above, while clean liquid boils on the outer surface of the tubes for producing clean steam. The clean liquid is led to the upper part of the tubes onto

their outer surface to flow via line 30. At least a portion, e.g. 50–80%, of the clean feed liquid is formed of the clean condensate of the reboiler from line 32. Additionally, if needed, mill water, e.g. boiler water, can be introduced

- 5 The steam is discharged from the reboiler 41 via line 38, which according to a preferred embodiment of the invention can be provided with a pressure increasing device 11, which is an ejector as described in connection with Figure 1. Steam is introduced into the ejector from the reboiler, the pressure of which steam is increased so that the pressure and the temperature are more adequate for heating the chips in the
- 10 bin (not shown). By means of the ejector the amount of steam produced in the flash tank can be increased.

Example 1:

- 15 The starting point without an ejector is that the temperature of black liquor entering the flash tank is 143 °C. Then the temperature of liquor exiting the tank is 114 °C and the pressure of the flash steam is 52 kPa (g). Steam at a temperature of 108 °C is generated in the vapor reboiler. In addition, low pressure steam from the mill network is to be introduced into the chip bin when the temperature of the chips is -15 °C.

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- When the steam discharge line of the vapor reboiler is provided with an ejector according to present invention, the pressure in the flash tank can be decreased, and the amount of flash steam can be increased. The temperature of the flash steam is 105.6°C and the pressure 20 kPa (g). The temperature of the black liquor exiting the
- 25 flash tank is 107.9 °C., i.e. more than 6 °C cooler than without an ejector. Steam at a temperature of 102 °C is generated in the reboiler. The pressure of the process steam of the ejector is 260 kPa and the temperature 140 °C. The ejector generates steam at a temperature of 108 °C. The ejector allows decreasing the need for low pressure steam, but what is most important is that the temperature of the black liquor
- 30 discharged from the flash tank is clearly lower than without an ejector. Therefore, the cooling requirement for black liquor to be led to the evaporation plant is substantially decreased, and thus the amount of hot water produced in liquor cooling is decreased. Hot water has been generated in excess amounts, which naturally is not sensible in view of the energy economy of the mill.

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By installing an ejector downstream of the reboiler, the pressure in the flash tank can be decreased. The temperature of the exiting black liquor is then 106°C and the

solids content 15.2%. The reboiler generates an adequate amount of steam for the chip bin and there is no need for low pressure steam.

Example 2:

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The use of clean condensate from the vapor reboiler as feed liquid, when the steam discharge line of the reboiler is not coupled to an ejector.

10 The temperature of the black liquor being discharged from the reboiler is 143°C. It is flashed so that the temperature is decreased to 114°C, and the temperature of the flash steam is 112°C and the pressure 52 kPa. The temperature of the reboiler feed water containing mainly clean condensate is 103°C. The temperature of the reboiler discharge steam is 108°C and the amount greater than when using conventional mill water as feed water, so that the use of low pressure steam can be decreased. The
15 energy economy can be further improved by coupling an ejector to the steam discharge line of the reboiler.

At least the following advantages can be achieved by means of the present invention:

20

- The use of fresh water of the mill is decreased, since the source of clean liquid for the reboiler is its own clean condensate. Thereby, expensive so-called boiler water can be saved.
- Reduced need for live steam for chip heating. Additionally, the amount of
25 steam is easy to adjust by means of the ejector in accordance with the amount of steam required.
- The overall heat economy of the mill is improved, since the solids content of discharged liquor being led to the evaporation plant is increased. The steam consumption and capacity requirement of the evaporation plant are decreased. The investment costs of the evaporation plant are decreased due to
30 decreased capacity requirement.
- Reduced detrimental odors (compared to the use of flash steam).
- Reduced explosion risks (compared to the use of flash steam).

Claims:

1. A method of generating steam at a digester plant of a chemical pulp mill, in which method
- 5 a) black liquor is discharged from the digester at a first temperature and a first pressure;
- b) the black liquor is treated in at least one flash tank for producing flashed black liquor and flash steam at a second temperature and a second pressure, which are lower than the first temperature and first pressure;
- 10 c) the flashed black liquor is led from the flash tank into further treatment;
- d) the flash steam from step b) is led into indirect heat exchange contact with clean liquid in a vapor reboiler for boiling the liquid and producing steam having a third temperature and third pressure, which are lower than the second temperature and second pressure, whereby the flash steam is condensed;
- 15 e) the steam flow from step d) generated in the reboiler is led to further use, **characterized** in that
- f) foul condensate and clean condensate are formed from the flash steam, and at least a portion of the clean condensate is led into the clean liquid flow to be used in stage d).
- 20
2. The method according to claim 1, **characterized** in that the clean condensate forms at least 20%, typically approximately 50–80% of the clean liquid feed flow into the reboiler.
- 25
3. The method according to claim 1 or 2, **characterized** in that the steam formed in step d) is led from the reboiler into an ejector, wherein also a second steam flow is led having a fourth pressure and a fourth temperature, which are higher than said third pressure and third temperature, whereby a third steam flow is formed that is used in step e) and that has a fifth pressure and a fifth temperature, which are higher
- 30 than said third pressure and third temperature.
4. The method according to claim 1, 2 or 3, **characterized** in that as clean liquid also some other clean mill water is used, such as boiler water.
- 35
5. The method according to claim 3, **characterized** in that the third steam flow is used for pretreating comminuted fibrous material prior to digester treatment.

6. A method of generating steam at a digester plant of a chemical pulp mill, in which method
- a) black liquor is discharged from the digester at a first temperature and a first pressure;
 - 5 b) the black liquor is treated in at least one flash tank for producing flashed black liquor and flash steam at a second temperature and a second pressure, which are lower than the first temperature and first pressure,
 - c) the flashed black liquor is led from the flash tank into further treatment;
 - d) the flash steam from step b) is led into indirect heat exchange contact with clean
 - 10 liquid in a vapor reboiler for boiling the liquid and producing steam having a third temperature and third pressure, which are lower than the second temperature and second pressure, **characterized** in that
 - e) the steam formed in stage d) is led from the reboiler into an ejector, wherein also a second steam flow is led having a fourth pressure and a fourth temperature, which
 - 15 are higher than said third pressure and third temperature, whereby a third steam flow is formed having a fifth pressure and a fifth temperature, which are higher than said third pressure and third temperature, and
 - f) the third steam flow formed in stage e) is led to further use, such as pretreatment of comminuted cellulosic fiber material prior to digester treatment.
 - 20
7. The method according to claim 6, **characterized** in that in step d) the flash steam is condensed, and the method further comprises a step g), wherein at least a portion of the clean condensate generated in step d) is led to be used as clean liquid in step d), and a step h) wherein the foul condensate generated in step d) is led to further
- 25 use.
8. The method according to claim 6 or 7, **characterized** in that the temperature of the black liquor that is treated in step b) is below 145 °C.
- 30 9. The method according to claim 6, 7 or 8, **characterized** in that the black liquor is flashed in two steps.
10. The method according to any one of claims 6–9, **characterized** in that the pressure of the steam being discharged from the ejector and the pressure of the steam in
- 35 the flash tank are adjusted according to the steam required in the pretreatment of the fibrous material, such as chips.

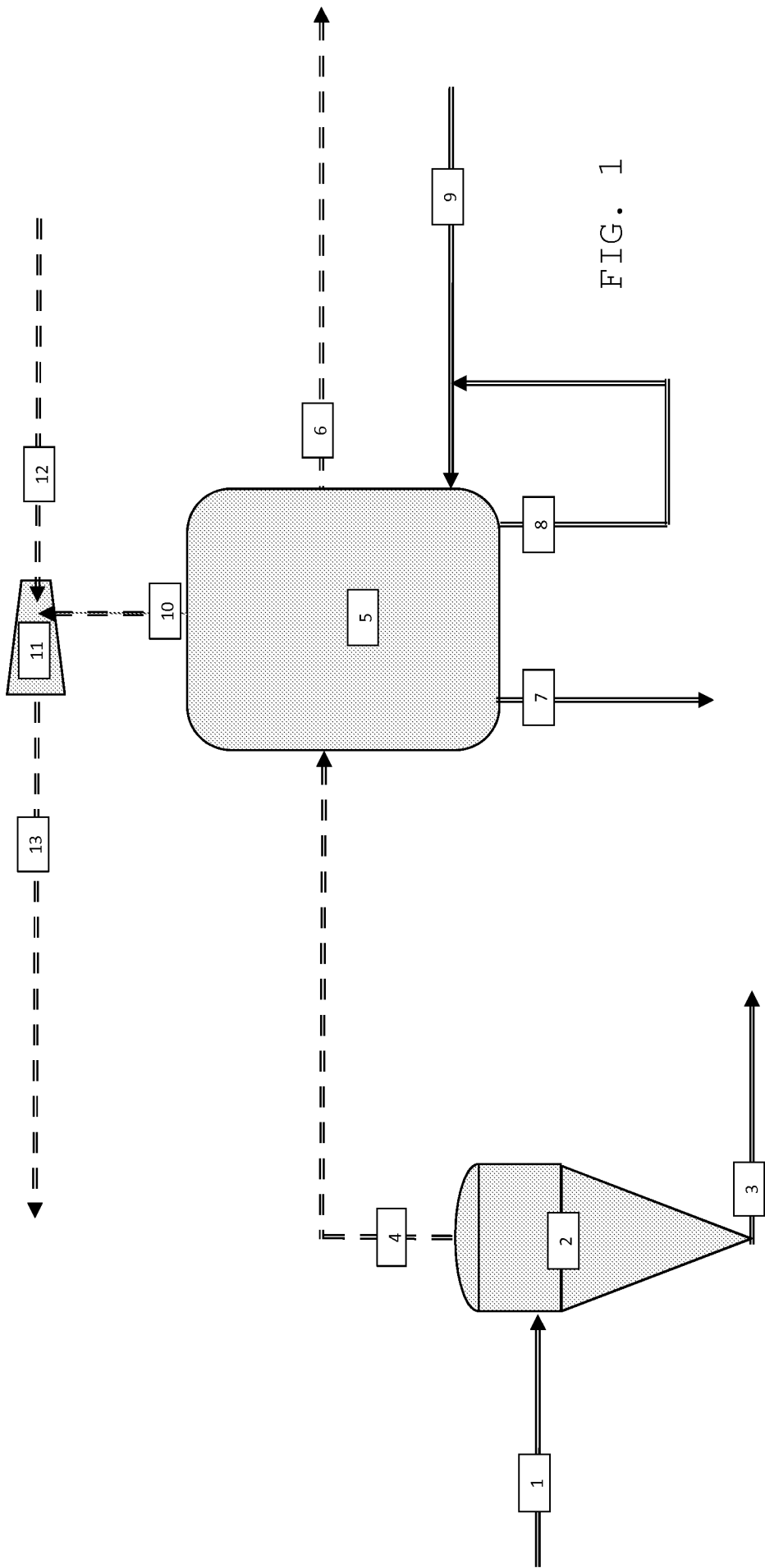


FIG. 1

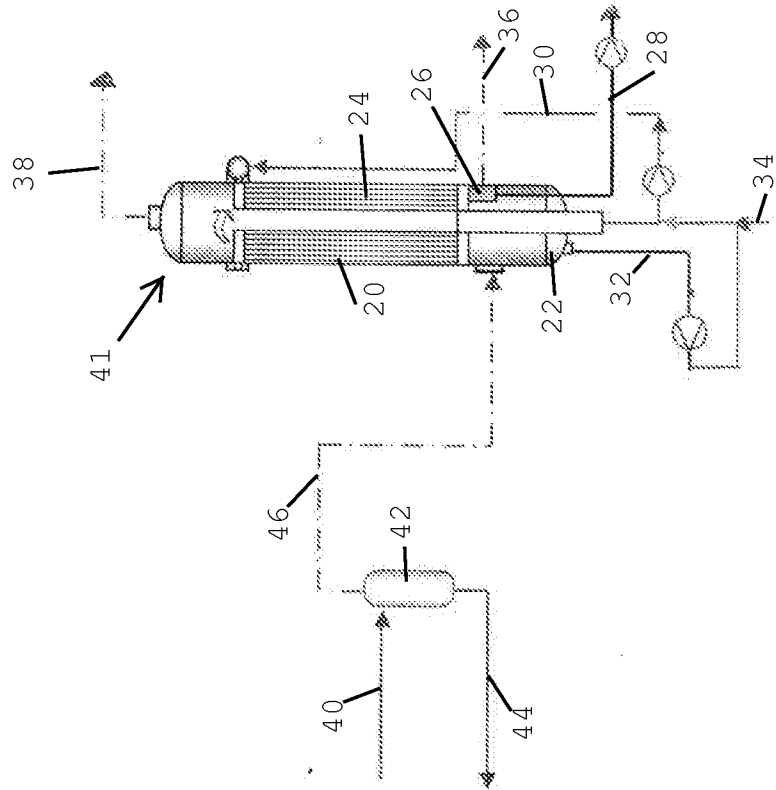


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2015/050581

A. CLASSIFICATION OF SUBJECT MATTER
INV. D21C7/10 D21C7/14
ADD.

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)
D21C

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 practicable, search terms used)

EPO-Internal, WPI Data

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/236733 A1 (TIKKA PETRI [FI] ET AL) 23 September 2010 (2010-09-23) paragraph [0032] - paragraph [0036]; claims 1-16; figure 1 -----	1
X	WO 00/28136 A1 (KVAERNER PULPING TECH [SE]; NYSTROEM PER [SE]; SNEKKENES VIDAR [SE]; G) 18 May 2000 (2000-05-18) cited in the application the whole document -----	6
A	US 6 346 166 B1 (KETTUNEN AUVO K [FI] ET AL) 12 February 2002 (2002-02-12) cited in the application the whole document ----- -/-	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

8 December 2015

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INTERNATIONAL SEARCH REPORT

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A	US 2007/131363 A1 (KETTUNEN AUVO [FI] ET AL) 14 June 2007 (2007-06-14) the whole document -----	1-10
A	US 6 261 412 B1 (RYHAM ROLF C [US]) 17 July 2001 (2001-07-17) the whole document -----	1-10
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A	US 6 176 971 B1 (SUN YU ELLA [SG] ET AL) 23 January 2001 (2001-01-23) the whole document -----	1-10

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Information on patent family members

International application No

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