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Amended claims in accordance with Rule 137(2) EPC.

(54) Steam dryer device and method

(57) An improved steam dryer device for paper, board or pulp webs is disclosed. The steam dryer device comprises a low pressure steam source (1) for generating low pressure steam, a mechanical compressor (2) for increasing the pressure of the low pressure steam, and a dryer (3) for drying the paper, board or pulp web using the steam from the mechanical compressor (2). The invention also regards to a respective method.

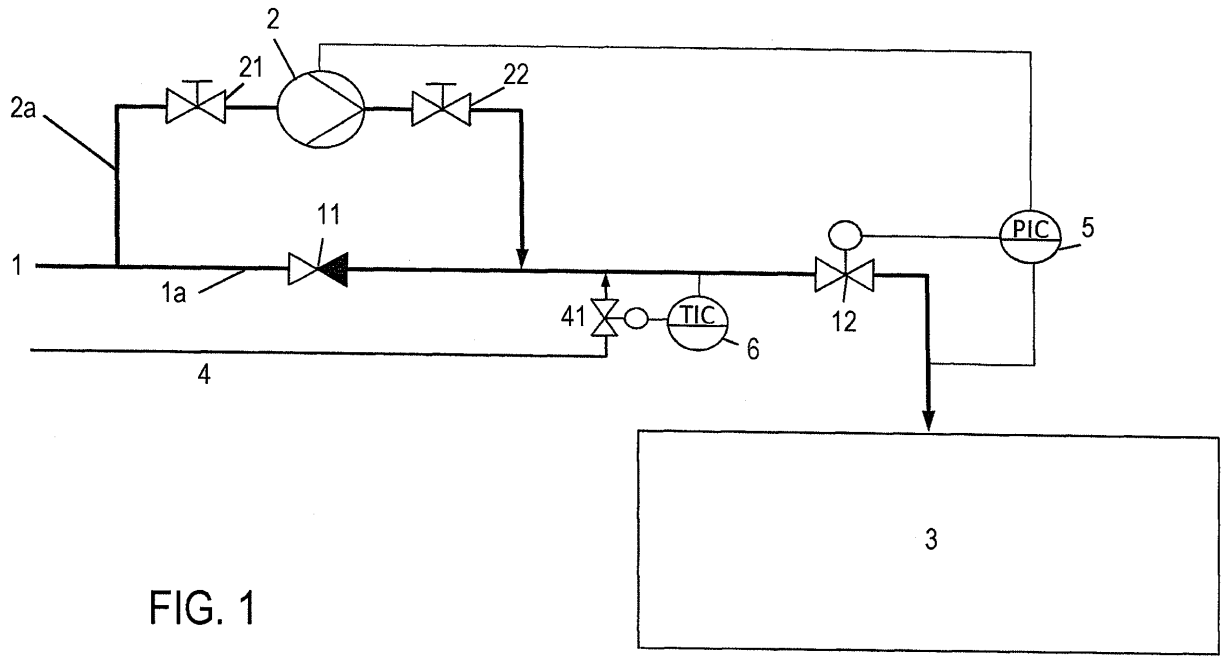

FIG. 1

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Description

[0001] The present inventions regards to a steam dryer device for paper, board or pulp webs. Such a steam dryer device comprises a pressure steam source for generating pressurized steam, and a dryer for drying the paper, board or pulp web using the steam. Further, the present inventions also regards to a respective method.

[0002] In the paper or pulp production, paper and pulp webs are dried. The drying of paper and pulp webs is performed in several different ways. One possibility of drying paper and pulp webs is a drying process by steam-heated air. In steamheated air dryers for paper and pulp webs, however, the available steam pressure sets an upper limit for blowing air temperature in the dryer.

[0003] Thus, there is room for improvement in steam dryer devices for paper, board or pulp webs.

[0004] Therefore, it is the object of the present invention to provide an improved steam dryer device and an improved drying method. Regarding the steam dryer device, the above object is solved by a steam dryer device having the features of claim 1. Regarding the drying method, the above object is solved by a drying method having the features of claim 7. Further developments are stated in the dependent claims.

[0005] In the present invention, a steam dryer device for paper, board or pulp webs comprises a low pressure steam source for generating low pressure steam, a mechanical compressor for increasing the pressure of the low pressure steam, and a dryer for drying the paper, board or pulp web using the steam from the mechanical compressor.

[0006] For example comparing to a steam ejector, using a mechanical compressor in order to raise the pressure of the low pressure steam is very advantageous. Mechanical vapor recompression (MVR) is used in certain industrial sectors, and equipments are available in the market. However, in pulp and paper dryers this technology has not been used.

[0007] A mechanical compressor enables a higher pressure rise than a steam ejector. In economical calculations, the power consumption in the compressor can be compared to lost generator power in case of a steam ejector. When comparing these two technologies, this comparison goes in favor of a mechanical compressor, because the lost generator power due to a steam ejector is larger than the power consumed by a mechanical compressor.

[0008] Further, a bypass can bypass the mechanical compressor to allow drying the paper, board or pulp web using the steam from the low pressure steam source. Thereby, the dryer device is made able to switch between low pressure steam supply and high pressure steam supply to the dryer.

[0009] Further, a valve can be used for bypassing the mechanical compressor.

[0010] Further, an electric motor can be used for driving the mechanical compressor. Mechanical compressors use mainly electric motor as source of power, however also other methods to drive the compressor are possible.

[0011] Further, a desuperheater can be used for cooling the steam. The desuperheater can be arranged between the mechanical compressor and the dryer.

[0012] Further, the dryer can be an air dryer or a cylinder dryer.

[0013] In such a steam dryer device, the mechanical compressor can run all the time if a higher steam pressure is needed continuously. On the other hand, the mechanical compressor can run only a part of the time if higher steam pressure is needed only occasionally. Thereby, the flexibility of steam supply is raised, and whether high steam pressure is used for drying can be adapted to the particular existing temporary demand.

[0014] The compressor suits well for boosting of old airborne pulp dryers. The installation work can be done mainly during normal machine operation, and only a short shutdown period is needed to connect the compressor to the steam line. A short shutdown time is a very important aspect in the dryer rebuilds. Thus, in a rebuild, by using the mechanical compressor, installation time can be saved and the restart of the plant can be advanced.

[0015] Further, the mechanical compressor is useful for example in following cases:

- motive steam for a steam ejector is not available or it is troublesome to arrange
- a steam ejector is not able to produce the required steam pressure rise
- the mill is not willing to reduce the back-pressure generator power.

[0016] The only drawing FIG. 1 shows one steam dryer device according to one embodiment of the present invention.

[0017] In the following, the present invention is explained in more detail under reference of several embodiments.

Embodiment

[0018] The only FIG. 1 shows a steam dryer device according to one embodiment. In this steam dryer device, steam having a low pressure is generated in a low pressure steam source 1 shown on the left side in FIG. 1. From the low pressure steam source 1, a main line 1a extends to a dryer 3 for drying a paper web, board web or pulp web. Regarding the main line 1a, between the low pressure steam source 1 and the dryer 3, there is provided a branch by a compressor line 2a extending from and returning to the main line 1a. In this compressor line 2a, there is provided a compressor 2. After the compressor 2, the compressor line 2a returns to the main line 1a, so that the compressor 2 is situated between the starting point of the compressor line 2a and the end point of the compressor line 2a. Between the starting point of the

compressor line 2a and the compressor 2, a first valve 21 is arranged in the compressor line 2a. Between the compressor 2 and the end point of the compressor line 2a there is arranged a second valve 22 in the compressor line 2a. In other words, in the compressor line 2a there is provided the first valve 21 upstream of the compressor 2 and the second valve 22 downstream the compressor 2.

[0019] In the main line 1a, there is provided a first main line valve 21 in the portion of the main line 1a, which is bypassed by the compressor line 2a. In other words, the first main line valve 11 is provided in the main line 1a between the starting point of the compressor line 2a and the end point thereof.

[0020] By the first main line valve 11, the main line 1a can be blocked so that the steam from the low pressure steam source 1 is delivered through the compressor line 2a and via the compressor 2 further on to the portion of the main line 1a provided downstream of the end point of the compressor line 2a and further to the dryer 3.

[0021] The compressor 2 is a mechanical compressor and increases the pressure of the low pressure steam.

[0022] Regarding the compressor 2, the part of the main line 1a having the first main line valve 11, can be regarded as a bypass as defined in the claims. Thus, when the first main line valve 11 is opened, the compressor 2 is bypassed and low pressure steam from the low pressure steam source 1 is delivered to the dryer 3. The first main line valve 11 can be an on/off valve which is closed when the compressor 2 is in operation. In an alternative, the first main line valve 11 can be a back-pressure valve which prevents a steam backflow when the compressor 2 is in operation.

[0023] The first valve 21 and the second valve 22 are on/off valves. Both the first valve 21 and the second valve 22 are open when the compressor 2 is in operation. When the first valve 21 and the second valve are closed, the compressor 2 can be isolated from the steam system for example in case of a maintenance etc.

[0024] The first main line valve 11, the first valve 21 and the second valve 22 serve for bypassing the mechanical compressor.

[0025] Further, the mechanical compressor 2 can be operated permanently if higher steam pressure is needed continuously, and the mechanical compressor 2 can be operated only a determined part of time if higher steam pressure is needed only occasionally. When the mechanical compressor 2 is operated permanently or occasionally, this operation can be performed with full open the first valve 21 and second valve 22 to reach a rather high steam pressure. On the other hand, the mechanical compressor 2 can be operated permanently or occasionally by having the first valve 21 and second valve 22 open. Thereby, a flexible steam supply can be established which can be adapted to the particular need of steam supply.

[0026] Further, to increase the flexibility of the steam supply, the mechanical compressor 2 can be operated by adapting the compressor speed to the particular need. In case more steam is needed, the compressor speed is increased; and in case less steam is needed, the compressor speed is decreased.

[0027] Downstream of the end point of the compressor line 2a there is provided a second main line valve 12 in the main line 1a. The second valve 12 is provided in the main line 1a before the dryer 3. The second valve 12 serves to control the dryer steam pressure. There are several options to do this, either the operator can give pressure setpoint, or the operator can give a dryer temperature setpoint, or the second valve 12 can be controlled according to sheet moisture after the dryer, or the operator can give a fixed opening setpoint for the second valve 12. Further, the second valve 12 can be connected to a control device 5 which can be a PIC controller. The control device 5 gathers information for example about the pressure, temperature, etc of the steam supplied in the main line 1a at a location downstream of the second valve 12, and controls the second valve 12 and the compressor 2 considering the gathered data. Thereby, the compressor 2 can be controlled considering the actual pressure of steam in the main line 1a at the entrance of the dryer 3.

[0028] Further, a desuperheater 4 can be used in the steam dryer device of the embodiment. In case the desuperheater 4 is used in the steam dryer device, a desuperheater line extending from the desuperheater 4 is connected to the main line 1a at a location downstream of the compressor 2.

[0029] In Figure 1, the desuperheater line extending from the desuperheater 4 is connected to the main line 1a between the endpoint of the compressor line 2a and the second valve 12 provided in the main line 1a before the dryer 3.

[0030] Thus, regarding the effect thereof, the desuperheater 4 is located after the compressor 2. The purpose of the desuperheater 4 is to let drop the temperature of the steam close to the saturation temperature before the steam is delivered to the dryer. The steam temperature should be close to the saturation temperature in order to keep the heat transfer efficient in the heat exchangers. A compressor always increases steam superheat. If the steam is largely superheated after the compressor 2, it is beneficial to cool it close to saturation temperature with the desuperheater 4.

[0031] By the desuperheater 4 steam conditioning is performed, that is reduction of steam temperature. In one application, the desuperheater 4 can reduce the temperature in the main line 1a through the direct contact and evaporation of water. The type of the desuperheater 4 is not particular limited and can be for example a desuperheater having a venturi design which uses the velocity of the steam to atomize the cooling water. Alternatively, the desuperheater 4 can be an ejector atomizing desuperheater, an attemperator desuperheater, a surface absorption desuperheater or a mechanical atomizing desuperheater.

[0032] In the desuperheater line extending from the

desuperheater 4 to the main line 1a, there is arranged a desuperheater valve 41. The desuperheater valve 41 is connected to a control device 6 which can be a TIC controller. The control device 6 gathers information for example about the pressure, temperature, etc of the steam supplied in the main line 1a at a location downstream of the desuperheater 4, and controls the desuperheater valve 41 considering the gathered data. Thereby, the desuperheater valve 41 can be controlled considering the actual pressure of steam in the main line 1a.

Further embodiments

[0033] In another embodiment, the steam dryer device can be equipped with an intercooler. The intercooler can be located between the compressing stages that is between the low pressure steam source 1 and the compressor 2. The compressor 2 increases the steam temperature unless it is equipped with intercooling. The purpose of the intercooler is to improve the performance of the compressor 2.

[0034] In case the compressor is of multi-stage type, it may be equipped with an intercooler between the compressing stages. The presence of the intercooling is beneficial for the compressor performance especially in a case of higher compressing ratios.

[0035] Thus, in a further embodiment, the steam dryer device can be equipped with the intercooler and the desuperheater 4. In an alternative the steam dryer device can be equipped with the intercooler instead of the desuperheater 4. In a very simple form, the intercooler and the desuperheater can be omitted.

[0036] In addition to air dryers, the present invention can be used also for cylinder dryers for pulp and paper drying.

Effects and advantages of the present invention

[0037] The applying of the mechanical compressor in the steam dryer device serves to provide a high pressure steam supply for the dryer. Thereby, the high pressure steam is provided in an efficient and cost saving manner.

[0038] In case downstream of a low pressure steam source, there is used a steam ejector (thermocompressor) instead of the mechanical compressor of the present invention to raise the steam pressure, one disadvantage of thermocompressor is that it needs also high pressure steam (motive steam). Another disadvantage is that available pressure increment is rather low. The motive steam is often taken as tapping from a back-pressure turbine, thereby the power production in the generator reduces. In other words, the motive steam is more expensive than the low pressure steam.

[0039] Further, in case a steam ejector instead of the mechanical compressor is used, a relative low pressure increase is made available by the steam ejector. Further, the lost generator power due to a steam ejector is larger than the power consumed by a mechanical compressor.

[0040] Thus, the mechanical compressor brings about a very efficient and cost saving high pressure steam supply for a dryer.

Particular examples of applying the present invention

[0041] In the following, particular technical examples of applying the present invention are stated.

Example 1

[0042] The present invention is applied to a pulp dryer having a production capacity of 800 ADt/d, a steam consumption of 8.5 kg/s, a steam pressure of 3.5 bar(g) and a temperature before the dryer control valves of 150 °C. The objective is to raise the steam pressure from 3.5 to 4.5 bar(g). As a result, the capacity of the dryer will improve by 9 % (that is from 800 to 872 ADt/d) and the steam consumption changes from 8.5 to 9.3 kg/s.

[0043] When the steam entering the compressor has a pressure of 3.5 bar(g) and a temperature of 150 °C, it will heat up to about 180 °C in the compressor. The electrical power required to drive the compressor is calculated as follows:

steam flow m_h = 9.3 kg/s
pressure rise 3.5 → 4.5 bar(g), Δp = 100 kPa
steam temperature 150 → 180 °C
steam volume flow 3.98 → 3.50 m^3/s , $\overline{V}_h$ = 3.74 m^3/s
compressor efficiency η_{comp} = 0.80
motor efficiency η_m = 0.95

[0044] The following formula is used to calculate the power needed

$$P = \frac{\overline{V}_h \Delta p}{\eta_{comp}\, \eta_m}$$

[0045] The result is a power P = 492 kW.

Example 2

[0046] In the previous example dryer steam pressure was elevated from 3.5 to 4.5 bar(g), leading to a capacity increase of 9 % in the dryer. As a comparison, similar capacity improvement is possible to do also by adding dryer circulation air flow by 18 %, for example by changing circulation fan motors to larger ones, and by adding speed of the fans with inverters. The power used in the circulation fans would increase by 64 % because the required power goes in by exponent 3 of the fan speed. The increase in power consumption of the circulation fans would be about the same as the one needed to drive the steam compressor in the previous example. Thus, when considering the operating costs these two examples are

about equal.

Example 3

[0047] The present invention is applied to a board coating machine having seven steamheated air dryers, using steam of 8 bar(g) and having a blowing air temperature of 161 °C. Each dryer uses a heating power of 700 kW, that is 4900 kW in total, and the total steam consumption is = 4900 / 2033 = 2.41 kg/s.

[0048] A compressor is used to raise the steam pressure from 8 to 14 bar(g). The blowing air temperature is increased from 161 to 182 °C, giving 18 % more drying capacity. Now the heating power is 1.18 x 4900 = 5780 kW and the steam consumption is 5780 / 1951 = 2.96 kg/s. the power needed to drive the compressor is calculated as follows:

steam flow m_h = 2.96 kg/s
pressure rise 8 → 14 bar(g), Δp = 600 kPa
steam temperature 180 → 250 °C
steam volume flow $\overline{V}_h$ = 0.55 m^3/s
compressor efficiency η_{comp} =0.80
motor efficiency η_m = 0.95

[0049] The power consumption is = 430 kW. Due to higher air temperature, the power consumption in the circulation fans of the dryers will drop by about 5 %, that means 6 kW/dryer = 42 kW total. The net increase in the power consumption is then about 390 kW.

List of reference signs

[0050]

1	low pressure steam source
1a	main line
11	first main line valve
12	second main line valve
2	compressor
2a	compressor line
21	first valve
22	second valve
3	dryer
4	desuperheater
41	desuperheater valve
5	control device
6	control device

Claims

1. A steam dryer device for paper, board or pulp webs comprising
a low pressure steam source (1) for generating low pressure steam,
a mechanical compressor (2) for increasing the pressure of the low pressure steam, and
a dryer (3) for drying the paper, board or pulp web using the steam from the mechanical compressor (2).

2. The dryer device according to claim 1, further comprising
a bypass bypassing the mechanical compressor (2) to allow drying the paper, board or pulp web using the steam from the low pressure steam source (1).

3. The dryer device according to claim 2, further comprising
a valve (11, 21, 22) for bypassing the mechanical compressor.

4. The dryer device according to one of the claims 1-3, further comprising
an electric motor for driving the mechanical compressor (2).

5. The dryer device according to one of the claims 1-4, further comprising
a desuperheater (4) for cooling the steam, wherein the desuperheater (4) is arranged between the mechanical compressor (2) and the dryer (3).

6. The dryer device according to one of the claims 1-5, wherein
the dryer (3) is an air dryer or a cylinder dryer.

7. A method for drying paper, board or pulp webs comprising the steps of
providing low pressure steam by a low pressure steam source (1),
increasing the pressure of the low pressure steam by a mechanical compressor (2), and
using the steam from the mechanical compressor (2) in a dryer (3) for drying the paper, board or pulp web.

8. The method according to claim 7, further comprising the step of
bypassing the mechanical compressor (2) to allow drying the paper, board or pulp web using the steam from the low pressure steam source (1).

9. The method according to one of the claims 7 or 8, further comprising the step of
cooling the steam by a desuperheater (4) between the mechanical compressor (2) and the dryer (3).

10. The method according to one of the claims 7-9, wherein
the mechanical compressor (2) is operated permanently if higher steam pressure is needed continuously, and
the mechanical compressor (2) is operated only a determined part of time if higher steam pressure is

needed only occasionally.

Amended claims in accordance with Rule 137(2) EPC.

1. A steam dryer device for paper, board or pulp webs comprising

a low pressure steam source (1) for generating low pressure steam,
a mechanical compressor (2) for increasing the pressure of the low pressure steam,
a dryer (3) for drying the paper, board or pulp web using the steam from the mechanical compressor (2),
a main line (1a) extending from the low pressure steam source (1) to the dryer (3),
a bypass bypassing the mechanical compressor (2) to allow drying the paper, board or pulp web using the steam from the low pressure steam source (1), and
a desuperheater (4) for cooling the steam, wherein the desuperheater (4) is arranged between the mechanical compressor (2) and the dryer (3), **characterized in that**
the desuperheater (4) is connected to the main line (1a) at a location downstream of the bypass.

2. The dryer device according to claim 1, further comprising a valve (11, 21, 22) for bypassing the mechanical compressor.

3. The dryer device according to one of the claims 1 or 2, further comprising an electric motor for driving the mechanical compressor (2).

4. The dryer device according to one of the claims 1-3, wherein
the dryer (3) is an air dryer or a cylinder dryer.

5. The dryer device according to one of the claims 1-4, wherein
in a desuperheater line extending from the desuperheater (4) to the main line (1a), there is arranged a desuperheater valve (41).

6. A method for drying paper, board or pulp webs comprising the steps of

providing low pressure steam by a low pressure steam source (1),
increasing the pressure of the low pressure steam by a mechanical compressor (2), and
using the steam from the mechanical compressor (2) in a dryer (3) for drying the paper, board or pulp web,
further comprising the step of

bypassing the mechanical compressor (2) to allow drying the paper, board or pulp web using the steam from the low pressure steam source (1), and further comprising the step of
cooling the steam by a desuperheater (4) between the mechanical compressor (2) and the dryer (3),

characterized in that

cooling the steam by the desuperheater (4) downstream of the bypass.

7. The method according to claim 6, wherein

the mechanical compressor (2) is operated permanently if higher steam pressure is needed continuously, and
the mechanical compressor (2) is operated only a determined part of time if higher steam pressure is needed only occasionally.

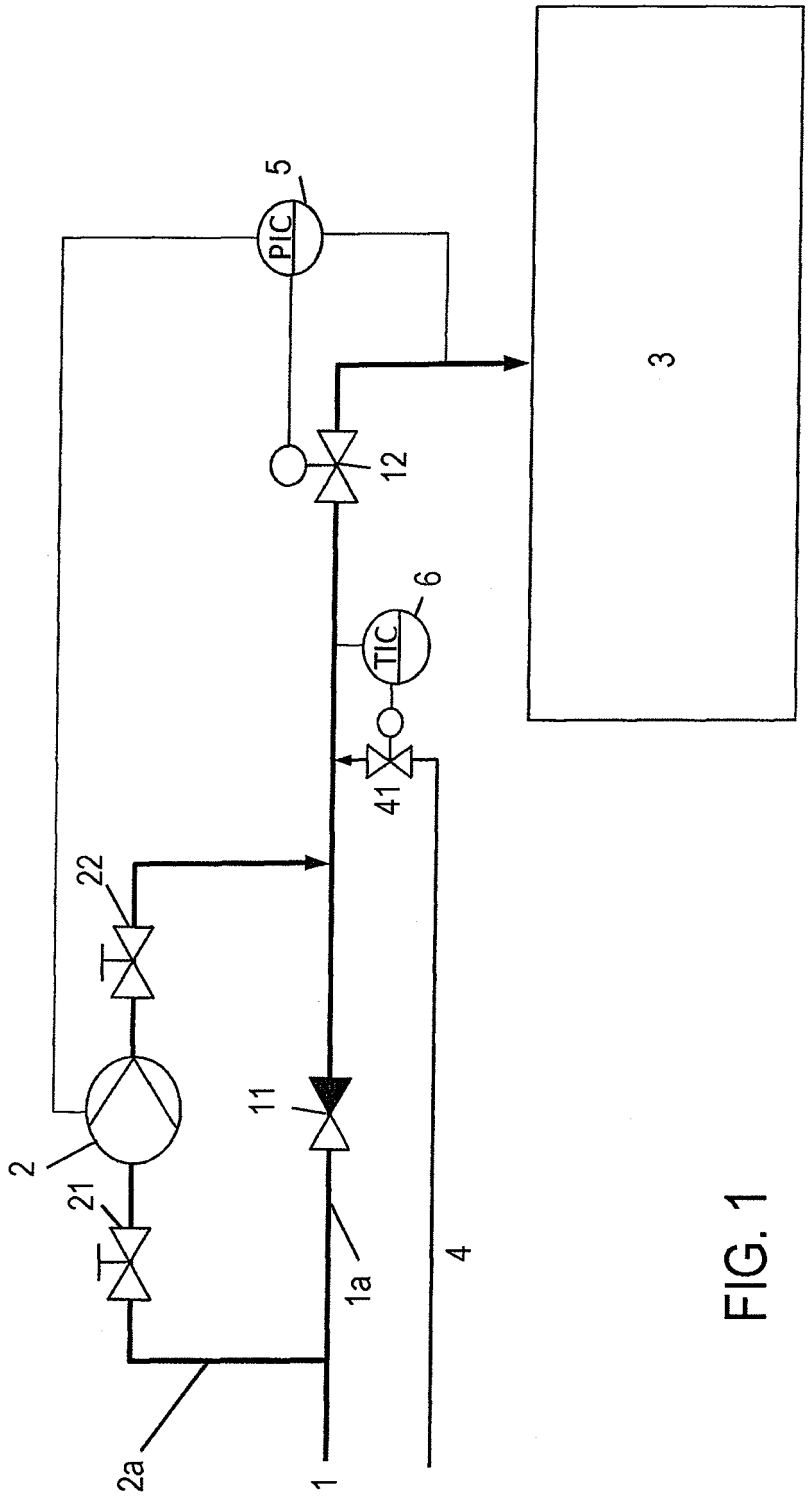

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 1761

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2010/096012 A1 (STORA ENSO AB [SE]; SVENLAND TORSTEN [SE]) 26 August 2010 (2010-08-26) * page 1, line 9 - page 9, line 17; figure 1 * -----	1-10	INV. D21F5/00 D21F5/02 D21F5/18
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			TECHNICAL FIELDS SEARCHED (IPC) D21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 May 2012	Maisonnier, Claire

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 16 1761

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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