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(54) **DRYING PLANT FOR IMPLEMENTING A PROCESS OF SEWAGE SLUDGE**

(57) A plant for the implementation of a process of sewage sludge is disclosed, of the type which performs the drying using superheated steam and wherein the sludge is placed to dry as extruded products on sliding shelves is disclosed.

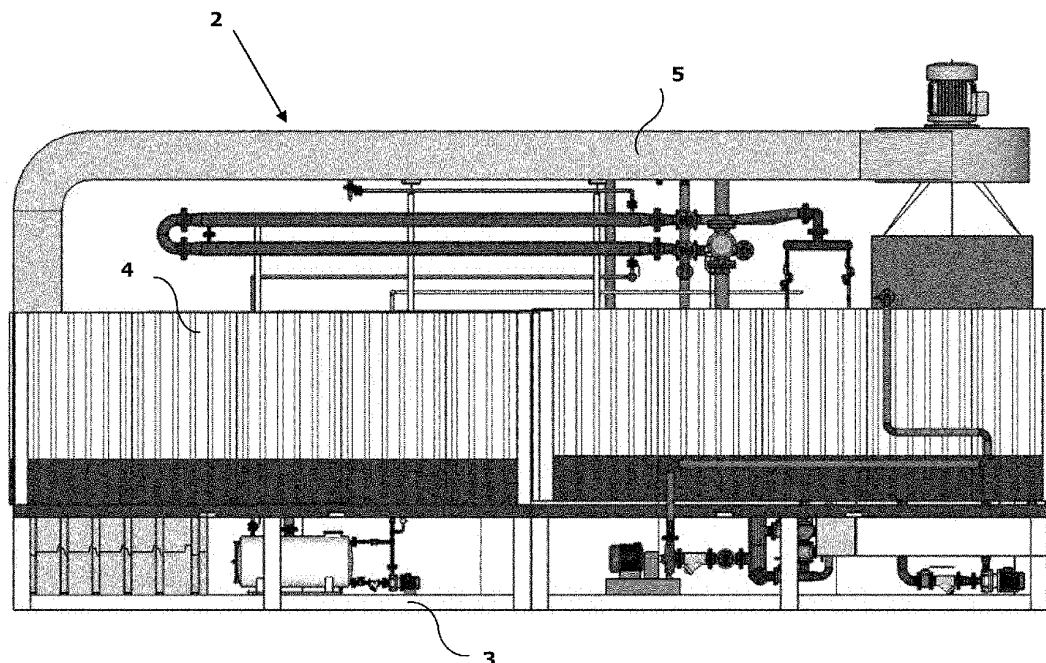


Fig. 1

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Description

[0001] The present invention is within the framework of the wastewater treatment sector and refers to a plant for drying sewage sludge.

[0002] Once used, water is polluted and can no longer be used as drinking water or as domestic hot water. In particular, there is domestic wastewater which makes up sewage water, which contains excrements, food residues and soap. And industrial discharges exist, which contain the most diverse chemical agents, deriving from chemical processes and manufacturing or from use of water as coolant, in lines which, however, are not clean or which nevertheless leak therein part of the metal they consist of, charging it with ions.

[0003] Since these discharges have become more and more important, both qualitatively and quantitatively, it is no longer possible to do as it occurred in the past and release them into the environment with no further treatment, since that would have mainly two negative consequences. Firstly, the water-bearing strata would be polluted in heavier and heavier manner and would be injurious or even harmful to health. Secondly, the amount of water available for domestic use would reduce continuously over time and the water supply would become a big problem, which may lead to serious consequences, among which famine and wars for water control (please consider that one of the main reasons why China today maintains Tibet occupation is to have control over a vast amount of drinking water, necessary for the survival of all the rest of the country).

[0004] It is then necessary that wastewater be treated, so as to make it as little polluted as possible, removing the majority of the dangerous agents therein contained, before the final disposal and before putting it back into the water cycle. This purification is performed in many different ways, especially taking into account the specific pollutants contained in wastewater, both from the point of view of the composition and from that of concentrations. Thus, treatments exist aimed at removing metals and inorganic agents, there are those for the removal of organic agents and those for the removal of pathogenic bacteria.

[0005] A good deal of the domestic water purifiers uses suitable bacteria, which use polluting agents, transforming them into harmless agents (which can sometimes also be recovered and enhanced), such as carbon dioxide, fuel gas and others. The purification occurs inputting wastewater into suitable tanks, where the bacteria are added in a known manner, selected for the purpose and where the air necessary for the aerobic part of the purification is adjusted and dosed. Preferably, the water in the tanks is kept under stirring, so as to increase the efficiency of the contact between the bacteria and the agents to be removed and to circulate better in the liquid, so as to purify the water necessary for bacterial life and for oxidation reactions which take place in the wastewater. In some cases, to the air blown into the water being

purified ozone is added, which - as known - is a strong oxidising agent, to accelerate and push the reactions.

[0006] During purification, the so-called sewage sludge is formed, consisting of dead bacteria and of reaction products. The sludge tends to increase in volume over time and, if they were not removed, they would end up clogging up the plants. For this reason and to prevent overflowing thereof, undesired for the reasons illustrated above, they are removed from purification tanks, continuously or discontinuously. Discontinuously, there is a purification treatment for a certain time, then the purifier is stopped, the sludge is removed, and purification is resumed. Continuously, when the plant gets up to speed, part of the solids is sent to the exit from the tanks, like a sort of purge.

[0007] The destiny of sludge depends on the type of wastewater and on the type of treatment. The most frequent destinations are the agricultural one, combustion or landfill placement.

[0008] Agricultural use consists in the use of sludge as soil improvers, since they contain organic nitrogen matter, excellent elements for agriculture. This is possible if the concentration of heavy metals is below legal thresholds, otherwise it is resorted to combustion or to other actions to make the sludge harmless to health and to the environment and often to landfill placement which has, however, critical points (potential forming of percolates).

[0009] Whether sludge is used in agriculture or is burnt, or must undergo other treatments, it is suitable for it to be previously dried. As a matter of fact, non-dried sludge contains remarkable amounts of water which enormously increase the volume and weight thereof, so that even temporary storing thereof and displacing it become a non-negligible problem. After drying, sludge volume is by far smaller and storing is no longer a problem. If the sludge must then undergo a combustion treatment, water presence, unless one resorts to co-combustion, for example with solid waste, prevents also ignition and combustion becomes impossible or extremely complicated and could nevertheless be incomplete, with the undesired development of harmful emissions.

[0010] The techniques for sludge drying are numerous: ventilation with dry air, hot air and other processes can be provided. Sludge is generally introduced into the dryer in forms and arrangements apt to expose the largest possible surface to the action of the drying agent. It is possible, for example, to extrude the sludge so as to create a sort of spaghetti, which are then arranged tied up in a small coil on a surface and which thus undergo the drying action of the air. A wide variety of drying methods in general is reported in Industrial Superheated Steam Drying, Heft L 202, 2004, TNO Environment Energy and Process Innovation.

[0011] A special type of process is superheated steam drying, wherein steam is used to increase the temperature of the material to be dried, up until bringing the water therein contained to faster evaporation, drying it.

[0012] US 5 228 211 discloses a method and an ap-

paratus for efficiently drying humid material, in this case laundry clothes, using superheated steam. Drying occurs in a humid environment, wherein the air present is heated inducing steam formation which gradually removes all the other gases present in said environment. The continuous steam recirculation turns it into superheated steam, which is partly flushed into a condensation system which thus allows to recover energy.

[0013] US 5 711 086 discloses an apparatus for the continuous drying of humid material with superheated steam. The material is transported in the lines where the superheated steam circulates from a suitable conveyor belt.

[0014] In all the dryers of the prior art, the surfaces necessary to obtain a valid drying are very large, with space and cost problems which are related to such size. For this reason, drying with superheated steam today is not used for wastewater sludge (since the volumes are already very large), but is used only for materials of smaller size having a lower water content.

[0015] US2013/014 678 discloses a method for drying wastewater treatment sludge which provides a first drying step with a heat transfer fluid, which leads to the formation of pre-dried sludge and water steam, a sludge-forming step at the exit from the first step and a second drying step, by means of a heated gas, for example air, to produce dried sludge, at least part of which goes to combustion to produce thermal energy, part of which supplies the heat transfer fluid. The proposed plant and method are rather complicated and hence expensive. The use of a rotary drum is provided, internally heated by a fluid heated in a suitable boiler. There is a rather bulky production of gaseous mixtures, both air and steam remaining inside the drum, with the development of odours and, sometimes, even of agents harmful to breathing, which must nevertheless be disposed of, with the problems linked thereto.

[0016] KR 101 565 315 discloses a sludge drying apparatus which uses newly heated steam, comprising a conveyor belt for the discharge of moisture from dehydration, contained in the sludge, while the sludge is moved. Means for discharging a fixed amount of dried sludge are provided. Also in this case, air-steam mixtures are used when fully operational for the drying of the supplied sludge. The residual moisture level remains very high (in an often unsatisfactory way). The sludge is placed on belt surfaces, circulating due to a series of tiny holes with which toothed gears mesh; such tiny holes also serve for steam passage.

[0017] DE 196 44 465 concerns a process for the drying of sludge, transported through hot air or reduced-pressure steam or even under vacuum. It comprises two cocleas, which rotate at different speeds. The sludge is introduced discontinuously into the ring formed by the two cocleas which have heated core. The sludge moves from one coclea to the other and it cannot be understood why the cocleas rotate at different speeds, apart from possible reasons of better mixing.

[0018] KR 2012 0020709 discloses a sludge drying system with superheated steam, comprising a sludge supply, a steam supply, a hot air supply and an output of the dried sludge. The steam is used to destroy the cellular membrane of the organisms contained in the sludge, while the actual drying occurs by means of hot air, which must then be vented. A drawing of this document shows the alignment of the extruded products in parallel rows, but there are no conveyor belts on top of each other and in sequence.

[0019] The problem at the basis of the invention is to suggest a plant for a drying process of sewage sludges which overcomes the mentioned drawbacks, and which allow to obtain dried extruded products of sewage sludge of wastewater, with high efficiency, in a reduced space and in an economically sustainable manner. This object is achieved through a drying plant of sewage sludge, which is caused to flow through some parallel conveyor belts, characterised in that it provides upstream a deposition unit of extruded products of moist sludge, apt to place such extruded products in rectilinear and orderly parallel rows. The dependent claims describe preferential features of the invention.

[0020] Further features and advantages of the invention are in any case more apparent from the following detailed description of a preferred embodiment, given purely as a non-limiting example and illustrated in the attached drawings, wherein:

fig. 1 represents a perspective view of a dryer to be used in the process and in the plant according to the present invention; and
fig. 2 is a block diagram which represents the process implemented by the plant according to the present invention.

[0021] Following the purification operations of liquid wastewater, the obtained sludge is taken from the corresponding tank, preheated and sent to an extruder which transforms it into a sort of noodles. Said noodles may be continuous or of a preset length; such preset length may be obtained, for example, resorting to blades in the proximity of the extruders cutting the noodles at preset time intervals. The preset length just mentioned may vary a lot and be so reduced to cause the extruded products to appear as pellets. Forms of this type allow to obtain advantages in transport. The noodles thus obtained by extrusion, with a very high water contents, are supplied in 1 to the plant according to the present invention. As an example, it can be envisaged to supply 1 ton an hour in 1, but the initial flow rate is not limiting.

[0022] It has been ascertained that the process according to the present invention is much more efficient if the noodles section is not circular, as occurs for example in KR2012 0 020 709, but if grooves or cavities are provided on the external side surface of the same. This can be obtained acting on the shape of the extruder. The gain in surface area implies a significant increase of the drying

speed.

[0023] Supply 1 leads to a first shelf of a dryer 2. Dryer 2 comprises a casing 3, closed and having meshed walls and a series of sliding shelves 4 one on top of the other, such as conveyor belts, said shelves carrying in sequence, from the uppermost to the lowermost, the noodles of extruded sludge being dried, so as to exploit as much as possible the available space. Thereby, subsequent drying steps are obtained with a low energy consumption per weight unit of the dried material, thus achieving energy savings. Moreover, a circuit 5 supplying superheated steam is provided. Said belts 4 can, according to a preferred embodiment, carry on the resting surface thereof for the noodles spacing devices of the extruded products (not shown in the drawings), which can be nails or pins arranged at regular intervals or grooves within which the noodles would insert and lock in position, so as to maintain a regular layout for the entire path on belts 4.

[0024] Two exits are provided on dryer 2: the first exit, 6, discharges the dried sludge; starting from the previously cited example, such exit has a flow rate of 0.2 tons/hour; the second exit, 7, removes the discharge steam, at a lower temperature, at the end of the drying operations. Exit 7 supplies a separator 8, preferably a cyclone separator, to remove any solids from the steam, so as to avoid damaging the inner walls of the pipes, hence extending the service life thereof. Exit 9 leads out the steam purified by separator 8 and supplies it, after partialisation, partly to a condenser 10 and partly to a heat exchanger 11.

[0025] Condenser 10 operates in cooperation with a cooling tower 12 or with potential users of thermal energy and, still in the example already described, leads to the removal of about 0.8 tons/hour of water.

[0026] Heat exchanger 11, preferably a shell and tube exchanger, gives to the steam inside itself heat coming from a heating fluid, contained in a suitable circuit 13, such fluid potentially being oil or process steam, generated by a dedicated boiler.

[0027] As regards the amounts of heat involved, condenser 10 provides a removal of about 0.9 MW, while exchanger 11 provides an absorption of about 1 MW, but these figures are purely indicative and do not limit the scope of protection of the invention.

[0028] Heat exchanger 11 has an exit 14 which supplies a fan 15 which, in turn, supplies the circuit 5 supplying superheated steam. On its part, condenser 10 has an exit 16, which leads to the final disposal of the condensed water, subject to the possible recovery of condensation heat for production purposes.

[0029] As already stated, the extruded sludge noodles to be dried, with a high water content, are supplied in 1 and arranged on the first one of the belts 4 of dryer 2. According to a preferred embodiment of the present invention, the extruded noodles, instead of being arranged in coils and in bulk on shelves 4, as normally occurs for the plants of the prior art, are arranged in an orderly man-

ner, in parallel rows; in practice, the extruded products are placed substantially in a straight line onto said belts 4, in orderly parallel rows. It has been surprisingly ascertained that, unlike what was believed in the past, that is that an arrangement in coils would lead to a more rapid drying, the orderly rows are in actual fact much more efficient in the removal of moisture by evaporation. Of course, an orderly arrangement of this type has the additional advantage of taking up less space. Shelf 4 is a conveyor belt, which causes the noodles to move forward as far as the opposite end. While the noodles move forward, they are continuously exposed throughout the surface thereof to a jet of superheated steam, coming from steam supply circuit 5. In actual fact, initially dryer 2 is full of air which heats up against exchanger 11. Heating up, it removes water from the noodles and produces steam. Circuit 5 may be of any known type and may belong to any type of dryer. For the circulation of the steam within dryer 2 a fan or other similar device can be provided. The superheated steam, being at high temperature (above 100°C, preferably at a temperature ranging between 130 and 300°C), causes the water contained in the noodles to heat up, gradually increasing its vapour pressure. That causes the water to evaporate, at increasing speed; the steam originating from such evaporation replaces the air present in dryer 2: air is heavier, so it tends to fully exit (at operating speed, the maximum content of oxygen within dryer 2 is of 5%) from exit 7, while the steam, as long as air is present, remains trapped in dryer 2. This replacement, which makes the process and the plant according to the present invention distinctly different from those described in US2013/014 678 is advantageous, since, owed to the lower density that steam has over air, there is a smaller energy absorption for the moving thereof, the drying level being equal, in addition to having a low energy consumption, there is also the minimisation of gaseous emissions, with evident advantages from the point of view of occupation hygiene and environmental protection. Moreover, steam transmits better than air its heat to sludge, so that there is a much faster evaporation. The plant diagram is furthermore much simpler than in US2013/014 678, which implies remarkable energy savings.

[0030] The evaporation process slows down as steam temperature decreases. Once the noodle has arrived at travel end, it moves to the lower level and moves into the opposite direction to the previous one on the new conveyor belt, returning towards the former end of dryer 2, thereby shedding further water. At travel end, it moves to the subsequent lower belt and returns into the direction of former belt 4, and so on. At the end of the process of the last belt, the sludge, by now dried up, leave from exit 6. The parallel and consecutive arrangement of belts 4 allows to obtain a good drying of the noodles, ordered in longitudinal, parallel rows, which thus allow to save space.

[0031] In the drying path, shedding water, the noodles become thinner and tend to contract. For this reason,

based on a preferred embodiment, in order to compensate the volume reduction of the sludge, optimise drying, belts 4 have a decreasing speed from the first one to the last one; thereby, the noodles maintain the texture thereof constant until the end of the process; moreover, the efficiency of the heat exchange is improved, thereby obtaining higher yields. Although a different speed between two sections of the plant is provided also by DE 196 44 465, in that document the only reason for having differentiated speeds was to have a better mixing of the material. In this case instead it is useful to vary the speed, since the sludge being dried passes once only through every area of the plant (where it will always have the same, set moisture).

[0032] As regards steam, after having gone through all belts 4, it leaves dryer 2 through exit 7, in a distinctly greater amount with respect to the one supplied in 5. As a matter of fact, in addition to the supplied steam the steam which forms in sludge drying is added, as already stated; of course, the outgoing steam temperatures will be lower than that of the steam incoming to dryer 2, but will nevertheless have to be above 100°C, in order to avoid condensations which would be undesirable in this area of the plant, since they would bring moisture back into the sludge, lowering the yield of the process. An optimal management of the drying process, also due to the use of a fan, hence provides that steam exit from exit 7 occurs at a temperature above 100°C, for example at 110°C or at even distinctly higher values. Thereby, the steam does not condensate and the subsequent steps require less energy. In any case, at operating speed, only steam comes out of exit 7, which contains at most some volatile agent vapour. It must be taken into account that drying occurs, at operating speeds, in the absence of or with very low values of oxygen.

[0033] The steam come out of exit 7 is sent to separator 8, preferably a cyclone separator, which separates from the steam any solids which it has possibly dragged during the process (for example, sludge particles or metal impurities coming from the plant). The removed solids are periodically discharged by separator 8, to avoid clogging up thereof, and are then disposed of in a known manner.

[0034] The steam, freed from solid waste, comes out of exit 9. Part of the steam, with a flow rate corresponding to that of circuit 5, is supplied to heat exchanger 11. Therein, the steam is brought again to the original operating temperature, preferably by means of a heat exchange with a heating fluid contained in circuit 13. Once it is brought up to the temperature, the steam is sent, due to compressor 15, again to circuit 5 and resumes the drying operations.

[0035] The steam excess contained in exit 9 with respect to the flow rate of circuit 5 is sent to condenser 10, where it is cooled, condensed by means of a dedicated circuit connected to a cooling tower 12 or to thermal users. The condensate is discharged from exit 16; the outgoing water in 16 makes up the only wastewater of the process and is a liquid, easily disposable waste, normally

with no particular pollution problem. More usefully, excess steam can be used to pre-heat the sludge before the input thereof into dryer 2, so as to accelerate and push the process further or to supply thermal utilities of different types, for example, staying on topic, conventional-type air drying plants. Coupling a plant of the type described here with a conventional air dryer an assembly is obtained characterised by very high energy efficiency.

[0036] The plant according to the present invention hence allow to dry in a clean, fast and effective manner the standard sewage sludge, with no appreciable amounts of solid waste - limited to the wastes of separator 8 - with an easily disposable liquid waste and with a very reduced energy expense. Moreover, there is no leak of smelly gases from the plant, as occurs instead with the processes and plants of the prior art. Unlike the prior art, the present invention, instead of using the steam only as indirect heating means - for example as vector fluid to be supplied to an exchanger - uses it also directly, investing therewith the sludge to be dried; the two steam flows never mix and always remain separate. The extruded sludge noodles to be dried in straight and parallel rows, unlike what may be assumed based on a common technical prejudice, allows fast drying of sewage sludge; moreover, it allows a simpler moving compared to coils of noodles, since the noodles can be brought forward from a belt 4 to the subsequent one with no problems, obtaining in fact a continuous process, without the need for interruptions. Any provision of different speeds for each of belts 4 allows to exploit even more the advantages of this arrangement, maintaining the integrity of the noodles throughout the processing, so as to discharge a solid product, not in powdery form, better suited to the subsequent turning into a product to be disposed of or to be sold as fertiliser and with no dispersion of the dried material.

[0037] The extruder used for supplying the sludge to the plant according to the present invention can also be easily cleaned, using a pressurised water jet.

[0038] At steady state, the drying process and the dryer 2 according to the present invention provide the entry into dryer 2 of moist sludge and the exit therethrough only of dried sludge and condensation. Another great advantage of the present invention is that there is a high heat recovery and a high efficiency of drying.

[0039] However, it is understood that the invention must not be considered limited to the particular embodiment illustrated above, which makes up only an exemplifying embodiment thereof, but that different variants are possible, all within the reach of a person skilled in the field, without departing from the scope of protection of the invention, as defined by the following claims.

LIST OF REFERENCE CHARACTERS

[0040]

1 Supply (of 2)

2	Dryer	
3	Casing (of 2)	
4	Sliding shelves (of 2)	
5	Supply circuit of superheated steam	
6	Exit (of 2)	5
7	Exit (of 2)	
8	Separator	
9	Exit (of 8)	
10	Condenser	
11	Heat exchanger	10
12	Cooling tower	
13	Heating fluid circuit (of 11)	
14	Exit (of 11)	
15	Compressor	
16	Exit (of 12)	15

Claims

1. Drying plant of sewage sludge, comprising a supply unit (5) of superheated steam, which is caused to flow through some parallel conveyor belts (4), wherein it provides upstream a placing unit of extruded products of moist sludge, apt to place such extruded products in rectilinear and orderly parallel rows, **characterised in that** said conveyor belts (4) carry on the resting surface thereof for the extruded products spacing devices of the extruded products. 20 25
2. Drying plant of sewage sludge as in 2), **characterised in that** said spacing devices are chosen among nails or pins arranged at regular intervals or grooves into which the extruded products insert and lock, so as to maintain a regular layout throughout the entire path on the belts (4). 30 35
3. Drying plant of sewage sludge as in any one of claims 1) or 2), **characterised in that** a fan is provided for steam circulation within the dryer (2). 40

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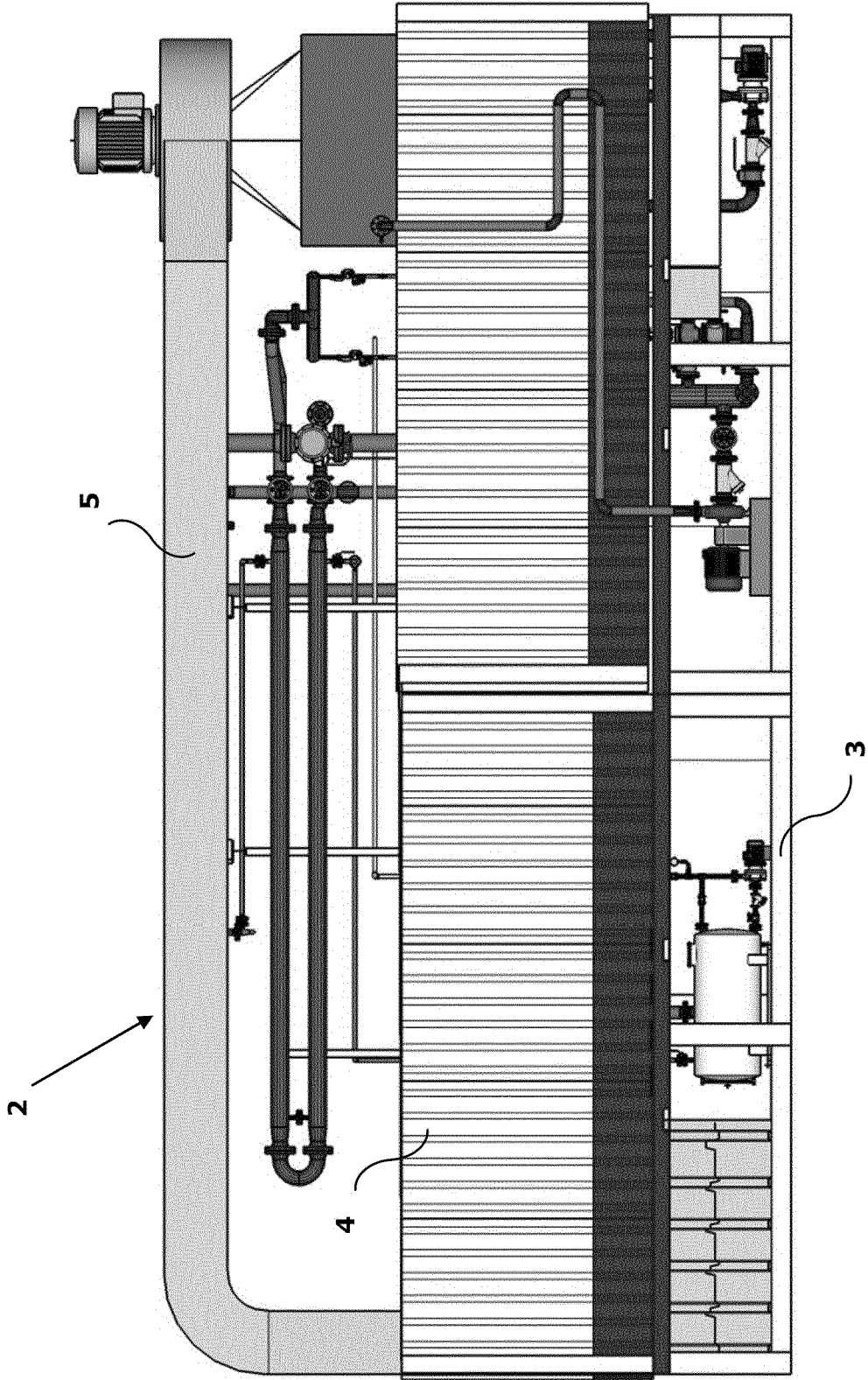


Fig. 1

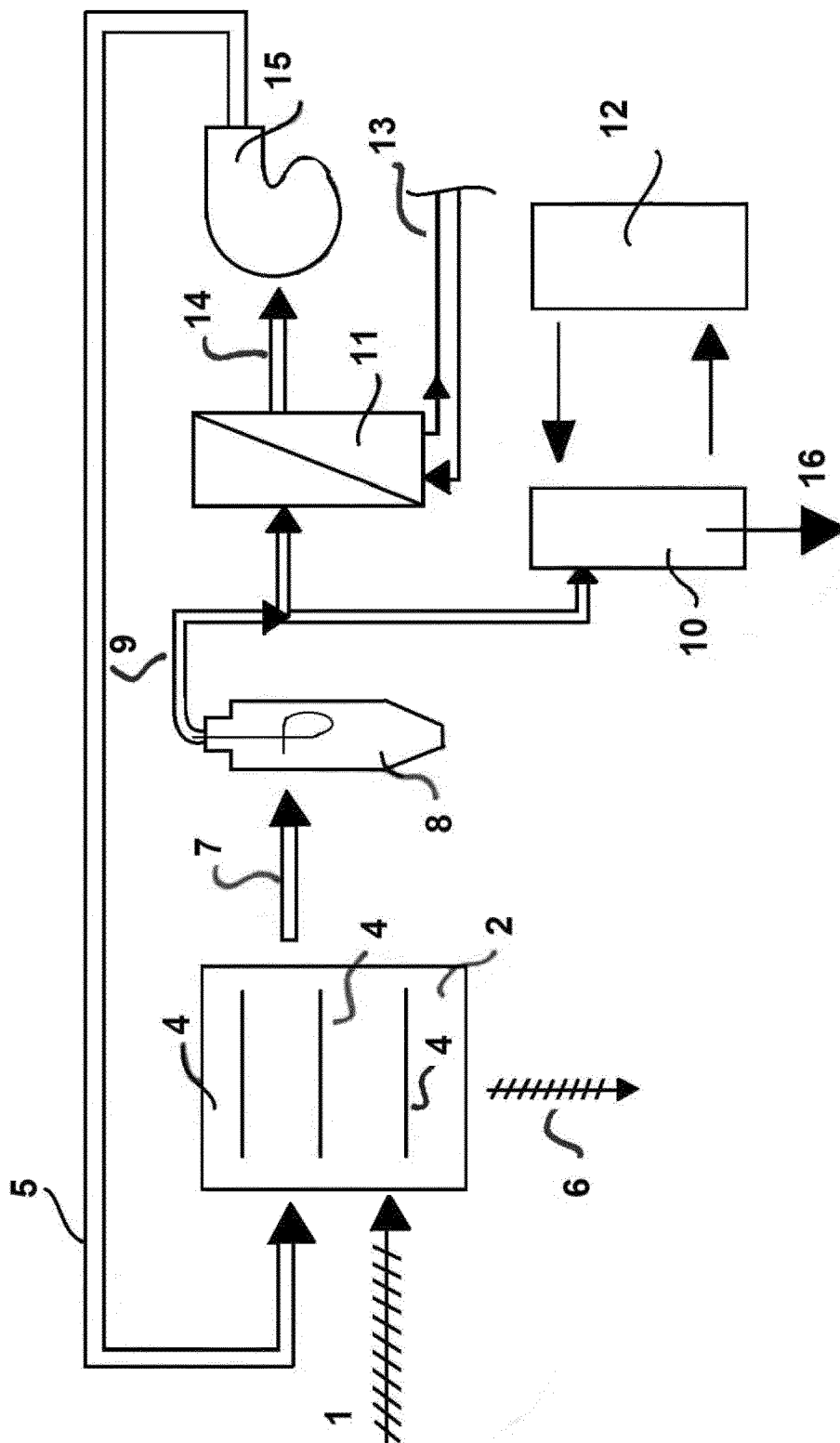


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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