

Claims

1. A hydrothermal reactor, comprising:
 - (31) an inlet for receiving an aqueous mixture, positioned at the top part of the reactor interior (32);
 - 5 (32) a tube-shaped reactor interior, which is inclined at an angle in the range of 1 – 45°;
 - (33) a first zone in the reactor interior (32) comprising means (5) for heating the aqueous mixture to a predetermined temperature;
 - (34) a second zone in the reactor interior (32) for keeping the aqueous mixture at the predetermined temperature;
 - 10 (35) a third zone in the reactor interior (32) for cooling the aqueous mixture;
 - (38) an outlet for discharging a hydrothermally treated aqueous mixture, positioned at the bottom part of the reactor interior (32); and
 - (43) an outlet for discharging gas, positioned at the top part of the reactor interior (32).
- 15 2. The reactor according to claim 1, wherein the inclination angle of the reactor interior is in the range of 2 – 15°.
3. The reactor according to claim 1 or 2, further comprising an expansion vessel (4) positioned at the top part of first zone (32), wherein the outlet (43) is integrated in the expansion vessel
20 (4).
4. The reactor according to claim 3, wherein the expansion vessel (4) comprises a sensor (44) for determining the liquid level within the expansion vessel (4),
- 25 5. The reactor according to any one of the preceding claims, wherein the outlet (38) comprises a valve which can be opened and closed during operation.
6. The reactor according to any one of the preceding claims, wherein the reactor comprises a heat exchanger (5) for heating the aqueous mixture in the first zone (33) and for cooling the
30 aqueous mixture in the third zone (35).
7. The reactor according to any one of the preceding claims, wherein the reactor is capable at operating at a predetermined temperature in the range of 160 – 320 °C, preferably in the range of 175 – 230 °C, and a pressure in the range of 10 – 50 bar, preferably in the range of 15 – 30
35 bar.
8. A hydrothermal treatment facility, comprising:
 - (1) a buffer tank for holding an aqueous mixture that is to be treated
 - (2) a pump for pumping an aqueous mixture from the buffer tank (1) to a reactor (3);
 - 40 (3) the reactor according to any one of claims 1 – 7; and

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- (4) an expansion vessel positioned at the top part of the reactor (3), wherein the outlet (43) is integrated in the expansion vessel (4).
9. The hydrothermal treatment facility according to claim 8, further comprising a dewatering device (7) for dewatering the liquid effluent discharged via outlet (38), and preferably a digester (6) for digesting the aqueous mixture before it is subjected to the reactor (3) or after it has been dewatered in the dewatering device (7).
10. A process for hydrothermally treating an aqueous mixture in a reactor according to any one of claims 1 – 7 or in a facility according to claim 8 or 9, comprising:
- (a) feeding the aqueous mixture into the reactor interior (32) via inlet (31),
 - (b) allowing a downward flow of the aqueous mixture through the reactor interior (32), while heating the aqueous mixture to a predetermined temperature in the first zone (33), keeping the aqueous mixture at the predetermined temperature in the second zone (34), and cooling the aqueous mixture in the third zone (35), as such hydrothermally treating the aqueous mixture;
 - (c) discharging a hydrothermally treated mixture via outlet (38),
 - (d) discharging gas via outlet (43).
11. The process according to claim 10, wherein the aqueous mixture is watery biomass, preferably selected from sludge, manure, dredging waste, food production waste and garden waste, most preferably wherein the sludge is obtained from a wastewater treatment process.
12. The process according to claim 10 or 11, wherein the gas that is discharged via a gas outlet (43) is further treated by a method for capture of H₂S and other sulfurous compounds.
13. The process according to any one of claims 10 – 12, wherein the reactor operates in cycles, each cycle comprising while continuously feeding the aqueous mixture during step (a):
- (1) a first stage wherein the outlet (48) is closed, no hydrothermally treated mixture is discharged, and the pressure within the reactor increases from an initial pressure to a final pressure,
 - (2) a second stage wherein the outlet (48) is open, hydrothermally treated mixture is discharged, and the pressure within the reactor decreases from the final pressure to the initial pressure.
14. The process according to claim 13, wherein the first stage lasts 70 – 99 % of the cycle duration and the second stage lasts the remaining cycle duration, preferably wherein the cycle duration is in the range of 5 minutes – 2 hours.

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15. The process according to claim 13 or 14, wherein the initial pressure is in the range of 10 – 30 bar and the final pressure is in the range of 20 – 50 bar, wherein the initial pressure is higher than the final pressure, preferably at least 5 bar higher.