A METHOD OF GASIFICATION OF SUBSTANCES BY ELECTRIC ARC AND AN APPARATUS

Abstract: Working chamber (20) of reactor (13) is filled with homogenized liquid waste under pressure followed by applying the alternating electric current to the reaction rods (11, 12) placed movably one against the other with the same longitudinal axis in chamber (20). The electric arc is then ignited and homogenized liquid waste is exposed to it at a temperature of 14,000 °C. The gas generated is treated and then supplied to appliances. The optimum distance between reaction rods (11, 12) is controlled by the laser beam L passing through the centre of working chamber (20), perpendicular to the longitudinal axis of reaction rods (10, 11), being adjusted automatically using the mechanical means (28, 29).
Working chamber (20) of reactor (13) is filled with homogenized liquid waste under pressure followed by applying the alternating electric current to the reaction rods (11, 12) placed movably one against the other with the same longitudinal axis in chamber (20). The electric arc is then ignited and homogenized liquid waste is exposed to it at a temperature of 14,000 °C. The gas generated is treated and then supplied to appliances. The optimum distance between reaction rods (11, 12) is controlled by the laser beam L passing through the centre of working chamber (20), perpendicular to the longitudinal axis of reaction rods (10, 11), being adjusted automatically using the mechanical means (28, 29).
Method of gasification of substances by an electric arc and apparatus

**Technical field**

The invention concerns a method and a device for gasification of biochemical and chemical substances for a gas production to be used to produce energy. The invention particularly concerns the processing of carbon-containing waste, e.g. the content of desludging tanks and gulley emptier, manure, liquid manure, and similar kinds of biochemical waste.

**Background of the invention**

There are many methods and devices currently used to eliminate the above-mentioned kinds of waste. For example, there are devices intended for the elimination of waste by pyrolysis where waste is exposed to very high temperatures which results in the conversion of waste into harmless compounds or gases. However, in a large number of cases these compounds and gases still pose a risk to the environment because all this depends on the efficacy of the method used. Other devices and methods are based on the principle of exposing waste either to a plasma arc, which is called resistive plasma, or to radiofrequency, which is called inductive plasma. Serious disadvantages such as non-symmetrical burning of electrodes were observed, leading to problematic maintenance and plasma kernel control in terms of its shape, temperature, and homogeneity.

The method and the device for gasification of liquid biomass solution described in GB 2290303 is the state-of-the-art technology which is closest to this invention. The method according to GB 2290303 consists of the following stages: the filling of the reaction chamber with liquid biomass solution, the generation of an electric arc inside the solution, the detection of the length of the first and the second electrode and polarity change of an electric arc which is dependent on the result of the detected electrode length. The device for performing the above-mentioned method according to GB 2290303 consists of
the reaction chamber filled at least partially with the biomass solution, the pair of spaced apart carbon electrodes which are immersed in the biomass solution, direct current supply of the electrodes, and the switch placed between the supply and electrodes allowing to switch the polarity of the current supplied to the electrodes.

A great disadvantage of this design is that the device uses direct current supply from the cell, which will always lead to a complicated and therefore expensive and defective electrical device. For example, electrodes supplied with the direct current undergo uneven wear. As a result, it is necessary to address the problem of the moving of worn-out electrodes. In this case, such movement is ensured by a servo-drive. Components of the electric circuit are also subjected to magnetization. Furthermore, because of the direct current the arc is also switched off significantly more slowly, as compared to the alternating current. As a result, it is necessary to equip the electric circuit with special fuses. Another disadvantage of the design described in GB 2290303 is that the temperature during waste processing according to the invention only rises to approximately 3,500°C, which is not sufficient to convert all waste substances into substances which will not represent a burden for the environment. The device is secured electronically which is disadvantageous in this case because fine electronics may be affected by arcing which may lead to failure and subsequently to the damage of the whole device.

**Summary of the invention**

The above-mentioned disadvantages are eliminated by the method of gasification of biochemical and chemical substances using an electric arc and a device for performing this method, as specified in this invention.

The principle of the method according to this invention is that the working chamber of the reactor is filled with homogenized liquid waste which is then exposed to an electric arc induced by alternating current and the respective waste is converted into gas at high temperatures reaching an
optimum temperature of 14,000°C. The optimum course of waste gasification can be checked by laser beam which monitors the distance between reaction rods or the distance between the reaction rods is kept by the even cooling pressure of the reaction rods. The gas formed is treated and then fed to appliances.

The principle of the device for performing the above-described method is that the reaction rods made of conductive material, pivoted for counter-rotating around the longitudinal axis, and operable to slide in order to adjust their optimum distance, extend to the working chamber from two opposite sites. On the opposite end, reaction rods are in contact with mechanical means allowing to slide reaction rods. Reaction rods are connected to the alternating current supply.

It is advantageous to place the laser at the reactor perpendicular to the longitudinal axis of reaction rods so that the laser beam L that monitors the distance runs through the centre of the working chamber perpendicular to the longitudinal axis of reaction rods.

It is advantageous when conductive material of rods consists of tungsten.

Another characteristic feature of the invention is that the cooling of the reaction rods is ensured by pressurized homogenized waste and that the surface of the reaction rods is grooved or otherwise treated to allow the cooling medium to flow between the surface of the rod and the internal wall of the casing where the movable rod is placed.

The main advantage of the design described in the invention is that it uses the alternating current and that the reaction rods counter-rotate around the longitudinal axis at the same rate which allows even wear without changes in the shape of end surfaces of the reaction rods. The temperature reached in the reaction chamber according to the invention is 14,000°C where plasma hydrogen is generated and waste undergoes almost complete gasification thanks to the electric arc, high temperature, and laser irradiating the process.
Advantageously, reaction rods are coated with copper and grooved which facilitates the flow of cooling liquid around electrodes to form the screen allowing undisturbed arcing. The filling of the reaction chamber with homogenized waste under pressure also contributes to the stability of the conditions in the working chamber and increases safety since it prevents the generation of free oxygen and hydrogen which would pose a risk of explosion if in contact with the arc. The device also works well in vacuum but this is more demanding with regard to tightness and safety. Another advantage is that reaction rods have their own independent cooling. The movement of both electrodes proceeds simultaneously using mechanical means so that interferences in electric circuits caused by possible current impulses or variation in voltage related to arcing is eliminated.

**Brief description of the drawings**

Fig. 1 depicts a scheme of the whole device for the gasification of biochemical and chemical substances. Fig. 2 shows an example of the design of the reactor (shown in the longitudinal section) according to the invention.

**Detailed description of the preferred embodiment**

Fig. 1 depicts the arrangement of the whole device indicating the route of waste material and the individual stages of waste treatment. Waste is first diluted and subsequently fed using slurry pump 1 to reservoir 2 which is equipped with stirrer 3, crusher of solid waste 4, and circulating pump 5. Homogenized waste flows from reservoir 2 to mixing chamber 7 using pressure pump 6. Mixing chamber 7 consists of the separator of coarse particles 8. Part of homogenized waste is pumped from mixing chamber 7 through cooler 9 using pump 10 to cool both reaction rods, i.e. right-hand reaction rod JLL and left-hand reaction rod \( \overline{2} \) of reactor 13 as it flows around reaction rods H and \( \overline{2} \) into working chamber 20 of reactor 13. Reaction rods H and \( \overline{2} \) are made of carbon, being longitudinally grooved which enables the
cooling liquid to flow freely around them. Mixing chamber 7 is under pressure and directly connected with working chamber 20 of reactor J3 so that the working chamber 20 is also under pressure, being continually filled with liquid homogenized waste. The waste in working chamber 20 of reactor 13 is exposed to the electric arc and high temperatures reaching 14,000°C. The gas generated is fed through output gas line 14 into gas separator 15 where it is cooled. Vapours are allowed to condensate here and the resulting condensate whose amount is controlled by a liquid level sensor is pumped using circulating pump 16 of reactor 13 back into mixing chamber 7. The resultant mixture of combustible gases can be fed from gas separator 15 directly to an appliance, or via cooler 18 and using compressor 21.

Fig. 2 shows reactor 13 inside of which there is working chamber 20. Right-hand reaction rod H is placed movably in right-hand casing 22 which is attached to the body of reactor 13 via insulant 24 while left-hand reaction rod 12 is placed movably in left-hand casing 23 attached to the body of the reactor 13 via insulator 25. On the opposite end, there are right-hand casing 22 and left-hand casing 23 equipped with respective insulators 26 and 27, with gas seals to prevent gas leakage from the device. The respective movable rods 28 and 29, which are connected to reaction rods H a 12 and can be disassembled, are inserted into casings 22 and 23 with one of their ends. The other ends of movable rods are placed in the respective isolated casings 34 and 35, being adapted for both fast manual control and connection to automatic control (not depicted). Lines 30 and 31 for pressure homogenized waste from mixing chamber 7 to cool reaction rods H and 12 are led through insulators 26 and 27 to the ends of casings 22 and 23 which are distant from reactor 13. Respective alternating power supply cables 32 and 33 are connected to casings 22 and 23 of reaction rods H and 12. Reactions rods H and 12 from the two opposite sides extend with one of their ends into working chamber 20 of reactor J3. Perpendicular to the longitudinal axis of reaction rods H and H laser 21 is placed at reactor J3, so that the laser beam L runs through the centre of
working chamber 20 to monitor the configuration of both reaction rods H and 12 continually.

After mixing chamber 7, working chamber 20 of reactor JJ3 and cooling loops of reaction rods 11 and 12 are filled with homogenized liquid waste under pressure, the electric arc is ignited through the instantaneous contact of both reaction rods H and 12 after which the distance of both rods is immediately set to the nominal distance. The reaction of gasification proceeds continually at a temperature around 14,000°C. The alternating current causes reaction rods H and JJ2 to wear off symmetrically, as they are continually moved by mechanical means using movable rods 28, 29 into working chamber 20 so that the required intensity of arcing remains the same. This movement is controlled automatically, e.g. according to the current or voltage of the arc. The electric arc is switched off and the whole process stops in the case of any non-standard configuration of reaction rods H and 12 inside working chamber 20, e.g. if one of the rods breaks off.

Movable rods 28 and 29 are adjusted to facilitate the exchange of reaction rods 11 and 12. This is possible thanks to their demountable connection with reaction rods H and 12. Movable rods 28 and 29 are moved from casings 22 and 23, followed by exchanging reaction rods H and 12. Movable rods 28 and 29 are then re-inserted into casings 22 and 23.

The body of reactor 13 is equipped with a window enabling one to check the placement of the arc and particularly the movement of reaction rods 11 and 12, their contact point during arc ignition. This window can be equipped with a TV camera for easier monitoring using a TV display. The window is placed perpendicular to both reaction rods H and 12 and laser beam L.

Putting the device into operation, the start of the reactor, the individual operation of the device and interruption when non-permissible states are detected is ensured by electric circuits as follows:

1. Putting the device into operation:
First it is necessary to switch on pressure pump 6. The required level in gas separator 5 must be achieved while circulating pump 16 of the reactor must be switched on, followed by connecting pump K to cool reaction rods, with the automatic pressure control of cooling liquid. The self-regulation of micromovement of reaction rods H and \( \nabla \) is disconnected.

The reactor can be started if the above-mentioned conditions are fulfilled and any non-permissible status has not been detected

2. Start of the reactor.

Prior to the start, the distance and the position of reaction rods \( J_{LL} \) and \( Y \) is manually adjusted according to the TV monitor followed by the adjustment of the main transformer according to the required output. The main transformer is then switched on. The arc is ignited and the distance of reaction rods \( \tilde{y} \) and \( \tilde{y}_2 \) and the output of the transformer are fine-tuned. Finally, the self-regulation of micromovement of reaction rods H and \( \nabla \) is connected manually.

3. During operation

The main gas valve for the exit of the generated gas is automatically opened when the required value of pressure is reached. If the gas supply is higher than gas consumption, pumping is automatically switched on.

4. Shutdown of the device if any non-permissible status is detected.

The whole device is automatically shut down, if any of the following non-permissible states is found:

- Gas leakage
- Failure of the driving system of reaction rods (including the end switch of the driving system)
- Incorrect temperature of the reactor
- Incorrect temperature of the cooling of rods
- Incorrect temperature of the cooling of the reaction liquid
- Incorrect temperature of the gas exit
- The main discharge valve is opened
- The level in the gas separator is incorrect
- Failure in the circulation of the liquid from the gas separator to the mixing chamber
- The overpressure of output gas is not permissible (the opening of the overpressure discharge valve is also ensured)
- Incorrect manual intervention in the adjustment of switches of individual devices has been made.

Another example of the design according to the invention which is not illustrated is based on Fig. 1. However, it does not employ laser 21 to check the nominal distance between reaction rods K and Ü, but rods are kept at an optimum distance by the even cooling pressure of the cooling medium of reaction rods. Reaction rods J and H are placed in casings 22 and 23 and can be moved and counter-rotated around their longitudinal axes evenly. The counter-rotating of the reaction rods around the longitudinal axis at the same rate results in even wear without any changes in shape at opposite end surfaces of reaction rods. Reaction rods can be made of any conductive material, but tungsten appears to be advantageous since it shows minimum losses during arcing, as compared to carbon and other materials used for this purpose.
Claims

5. A method of gasification of biochemical and chemical substances which uses an electric arc and high temperatures, characterized in that working chamber (20) of reactor (13) is filled with homogenized liquid waste under pressure followed by the application of alternating electric current into reaction rods (10, 11), which are made of conductive material and extend into working chamber (20), being placed against each other in the same longitudinal axis, with a nominal distance between them being kept by even pressure of the cooling medium of reaction rods and automatically adjusted by a mechanical means, where the homogenized liquid waste is exposed to the electric arc and temperature of 14,000 °C upon ignition of the electric arc between the rods (10, 11).

2. The method of Claim 1, characterized in that working chamber (20) of reactor (13) is filled with homogenized liquid waste in vacuum.

3. Method of Claims 1 or 2, characterized in that the reaction rods (10, 11) counter-rotate around their axis at the same rate.

4. The method of any of Claims 1 to 3, characterized in that the gas generated is fed to the gas separator (15), where it is cooled and the vapours contained in it are allowed to condensate and then taken back into mixing chamber (7) to yield a mixture of combustible gases that is fed to appliances.

5. The method of any of Claims 1 to 4, characterized in that the nominal distance between reaction rods (10, 11) is controlled by the laser beam L.
6. The device for performing the method of Claims 1 to 4 comprising reactor (13) inside of which there is working chamber (20) with two reaction rods (11, 12) made of conductive material, characterized in that reaction rods (11, 12) from two opposite sides extend with one of their ends into working chamber (20); reaction rods (11, 12), which are placed in casings (22, 23) and can be moved and rotated, are attached to one side to the reactor (13) through insulator (24, 25) while on their opposite sides there are insulators which are adjusted (26, 27) with gas sealers through which the supply (30, 31) for the cooling of reaction rods (11, 12) and the mechanical means (28, 29) allowing to slide reaction rods (11, 12) is led whereas reaction rods (11, 12) are connected to respective alternating electric current input (32, 33).

7. The device for performing the method of Claim 5, comprising reactor (13) inside of which there is working chamber (20) with two reaction rods (11, 12) made of conductive material, characterized in that two reaction rods (11, 12) from two opposite sides extend into working chamber (20) with one of their ends, and laser (21) is placed at the reactor (13) perpendicular to their longitudinal axis so that the laser beam L runs through the centre of working chamber (20) perpendicular to the axis of reaction rods (11, 12) in order to check their distance while the reaction rods (11, 12) are movable being placed in casings (22, 23) attached to the reactor (13) on one side through insulator (24, 25), while on their opposite side there are insulators (26, 27) with gas sealers through which the supply (30, 31) for the cooling of reaction rods (11, 12) and the mechanical means (28, 29) allowing to slide reaction rods (11, 12) is led whereas reaction rods (11, 12) are connected to respective alternating electric current input (32, 33).
8. The device of Claims 6 or 7, characterized in that the cooling of reaction rods (11, 12) is performed by pressurized cooling homogenized waste led by a pipeline from mixing chamber (7) through cooler (9) and pump (10) separately either to right-hand casing (22), or left-hand casing (23) where the surface of reaction rods (11, 12) is grooved or otherwise treated to allow the passage of the cooling medium between the surface of the rod and the inner wall of the casing.

9. The device of any of Claims 6 to 8, characterized in that mechanical means (28, 29) to slide reaction rods (11, 12) consists of movable rods (28, 29) which are inserted into casings (22, 23) with one side, where they are connected with reaction rods (11, 12) in a demountable manner, and in insulated casings (34, 35) with the other side, thus being connected to both automatic control unit and manual control of movable rods (28, 29).

10. The device of any of previous Claims 1 to 9, characterized in that reaction rods (10, 11) are made of tungsten.