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(71) Applicant: **Pisanello, Marco**
17100 Savona (SV) (IT)

(72) Inventor: **Pisanello, Marco**
17100 Savona (SV) (IT)

(74) Representative: **Bottino, Giovanni**
ARBO Srl
Via Colombo, 11/29
16121 Genova (IT)

(54) **SYSTEM FOR THE THERMAL TREATMENT OF MUNICIPAL SOLID WASTE**

(57) Plant for the heat treatment of municipal solid waste comprising a reactor (1) having a treatment chamber (10), an internal stirrer (2) included in said chamber (10), and heating means (5) of said chamber (10), which chamber (10) is provided with at least one inlet opening (11) for said waste and at least one outlet opening (12)

for the treated material, in which said chamber (10) is delimited by one or more metal walls and said heating means (5) are of the magnetic induction type, steam suction means from the treatment chamber (10) being included, which suction means are configured to create a negative pressure inside said chamber (10).

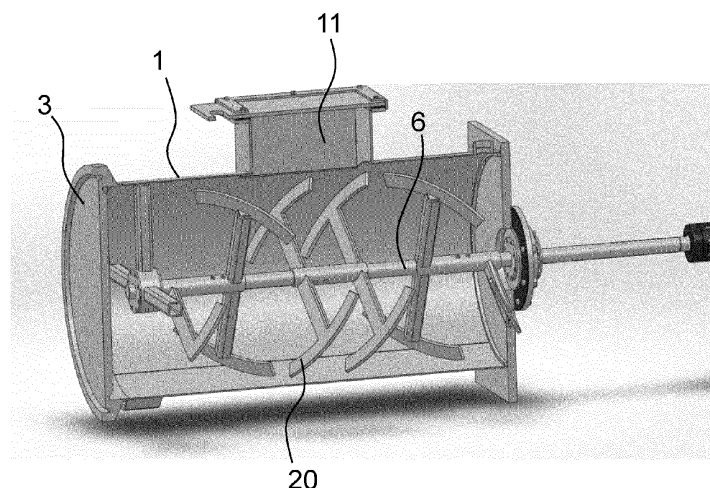


Fig. 3

EP 4 283 193 A1

Description

[0001] The present invention relates to a plant for the heat treatment of municipal solid waste comprising a reactor having a treatment chamber, an internal stirrer included in said chamber, and means for heating said chamber, which chamber is provided with at least one inlet opening for said waste and at least one outlet opening for the treated material.

[0002] The problem of municipal solid waste, and more in particular its disposal, is well known. This waste contains organic materials, wood, paper, textiles, metals, glass, aggregates, etc.

[0003] These components can advantageously be recovered and recycled.

[0004] Connected to this same situation is the need to sterilize any recovered treated material as well as the possible deodorization thereof.

[0005] The object of the present invention is to devise a simple and inexpensive process for the treatment of municipal solid waste by means of a plant that is simple to build and maintain.

[0006] Consequently, the main object is to devise a plant which allows the recovery of the useful and recyclable fractions of the same municipal waste. A further object of the invention is to allow a reduction in energy consumption and the time necessary for the effective heat treatment of the waste.

[0007] The present invention aims to achieve the aforesaid objects with a plant as described above, in which furthermore said chamber is delimited by one or more metal walls and said heating means are of the magnetic induction type, vapour suction means being included from the treatment chamber, which suction means are configured to create a negative pressure inside said chamber.

[0008] Induction heating is a fast, efficient, precise, repeatable, and contact-free method for heating metals or other electrically conductive materials. Induction heating is inherently safe, as it is free of open flames. Induction heating uses two different phenomena. The first phenomenon consists of the parasitic currents generated by the resistivity losses of the metal material. The second phenomenon consists of hysteresis heating, in which the energy inside the metal material is generated by the alternating magnetic field created by a coil, which changes the magnetic polarity of the metal material itself.

[0009] It has been calculated that, with the same geometric conditions of the reactor, induction heating reaches an efficiency close to 94% with respect to the 60-70% ensured by traditional heating systems, for example by heated diathermic oil. This results in lower energy consumption and a drastic reduction in treatment times. This is of primary importance especially in multi-line plants, where multiple reactors are operated in parallel, where it is desired to avoid machine shutdown for carrying out ordinary or extraordinary maintenance as much as possible.

[0010] The present invention includes creating a vacuum in the treatment chamber for extracting steam from the material contained therein. Thereby, the organic matrix material undergoes a reduction of about 50% in weight and volume with respect to the initial state in which it is fed into the reactor. A smaller percentage relates to plastic or industrial-derived materials.

[0011] In an embodiment, said heating means comprise magnetic coils covering at least part of the outer surface of said metal walls, the magnetic coils being suitably spaced from the metal walls themselves. Preferably, the coils cover up to 75% of the surface of the walls.

[0012] This avoids the need to convey heating fluids around the treatment chamber, for example by means of coils or watertight cavities. By virtue of this expedient, the need to provide for example a circulation circuit for diathermic heat treatment oil, as generally used in plants of the prior art, with a total saving in manufacturing, installation and maintenance costs, is overcome.

[0013] In an embodiment, said heating means comprise one or more electrical resistors.

[0014] Alternatively or in combination, said heating means comprise means for generating and introducing dry saturated steam into the chamber.

[0015] The dry saturated steam acts as an accelerant in the heating step, raising the temperature and favouring the evaporation of the water fraction contained in the material.

[0016] The heating means can then use magnetic induction heating and heating by dry saturated steam in combination, introduced directly in contact with the material to be treated. It is thus possible to set up heat treatment only with magnetic induction or combined with magnetic induction and the injection of dry saturated steam. In the event of only organic qualified waste from separate waste collection, it is possible to use only magnetic induction, while in the event of waste from undifferentiated waste collection, it is possible to evaluate a combined use of magnetic induction and dry saturated steam based on the type of waste. In the event of waste containing containers contaminated with oily residues, for example, the use of dry saturated steam can be decisive for an effective separation of the different components.

[0017] According to an embodiment, said walls identify a cylindrical body provided with a sealed door.

[0018] In a further embodiment, said coils only cover the lower part of said cylindrical body.

[0019] By virtue of the internal stirrer, the material is moved inside the treatment chamber, therefore the induction heating means allow the heat treatment of all the material without having to be arranged on the whole surface of the reactor body. In fact, the heat is irradiated homogeneously throughout the treatment chamber.

[0020] In an alternative embodiment suitable for reactors of more significant dimensions, the coils also cover the side walls of said cylindrical body.

[0021] According to an embodiment, said cylindrical body is arranged with its own horizontal longitudinal axis

and said outlet opening of the treated material is included below.

[0022] This is particularly advantageous in the expulsion step of the treated material in which the internal stirrer is aided by the force of gravity for conveying the treated material to the outlet opening and for expulsion there-through.

[0023] In an embodiment, the means for suctioning steam from the treatment chamber and the means for generating dry saturated steam can be connected to the same circuit, which circuit comprises means for sterilizing the steam extracted from the treatment chamber and a heat exchanger for condensing said steam. The means for generating dry saturated steam and the means for suctioning the steam and creating the vacuum advantageously have an alternating operation.

[0024] Thereby, a closed recirculation circuit of the treatment water is formed which allows the formation of dry saturated steam, the treatment of the steam extracted by means of the vacuum and the recovery of the water by condensation to start the cycle again. Preferably, the circuit is placed in communication with the treatment chamber with dedicated and distinct ducts respectively for the intake of dry saturated steam and for the suction of the steam and the creation of the vacuum. This is particularly advantageous in the presence of contaminants, such as oily residues, which can mix with the dry saturated steam introduced into the chamber if the same duct is used for both suction from the chamber and for entry therein.

[0025] An object of the present invention is also a process for the heat treatment of municipal solid waste comprising the following steps:

- a) introducing said waste into a reactor;
- b) heating said reactor by means of magnetic induction;
- c) unloading the treated material;

[0026] in which a vacuum is included inside the treatment chamber, for the extraction of the steam from the material in the chamber.

[0027] The vacuum can be created as a result of heating, i.e., when heating is complete, or during the heating step, in particular during the entire heating step or, advantageously, during a final part of the heating step. The vacuum forming step can thus be subsequent, contextual or semi-contextual with respect to the heating step.

[0028] The water content of the material must be reduced to a maximum of 5% by weight. By starting the formation of the vacuum during the heating step, it is advantageously possible to lower the boiling point of the water and then extract the same amount of water at a lower temperature, resulting in a heating energy saving.

[0029] In an embodiment, said heating includes the use of one or more electrical resistors.

[0030] In a further embodiment, said heating includes generating and introducing dry saturated steam into the

chamber.

[0031] In a preferred embodiment, the method includes introducing only organic-cellulosic fraction into the treatment chamber. Alternatively, generic urban waste can be introduced as such.

[0032] In an example embodiment, the material is stirred inside the treatment chamber.

[0033] In a further example embodiment, a vacuum formation is included inside the treatment chamber, for the extraction of the steam from the material in the chamber.

[0034] The vacuum can be created as a result of heating, i.e., when heating is complete, or during the heating step, in particular during the entire heating step or, advantageously, during a final part of the heating step. The vacuum forming step can thus be subsequent, contextual or semi-contextual with respect to the heating step.

[0035] The water content of the material must be reduced to a maximum of 5% by weight. By starting the formation of the vacuum during the heating step, it is advantageously possible to lower the boiling point of the water and then extract the same amount of water at a lower temperature, resulting in a heating energy saving.

[0036] In a further example embodiment, the treated material is remixed and pushed towards an outlet opening.

[0037] In an embodiment, the inlet opening is opened before the outlet opening, such that the air drawn by the vacuum into the treatment chamber through the inlet opening creates a thrust on the treated material towards the outlet opening. Preferably, the outlet opening is connected by a duct of appropriate size with a tank under negative pressure, i.e., where the vacuum has been previously created. When the inlet opening is opened, the connection with such a tank allows an effective thrust of the material towards the outlet by the inlet air.

[0038] In a further example embodiment, the injection of dry saturated steam into the treatment chamber, the formation of the vacuum inside the treatment chamber, the extraction of steam from the treatment chamber, the sterilization and condensation of the extracted steam is included.

[0039] These and other features and advantages of the present invention will become clearer from the following description of some embodiments illustrated, by way of example only, in the attached drawings, in which:

fig. 1 shows a sectional view of an example embodiment of the reactor;

fig. 2 shows a detailed view of the door;

fig. 3 shows a sectional view of a preferred example embodiment of the reactor;

fig. 4 shows a detailed view of the impeller.

[0040] The heat treatment plant of municipal solid waste according to the present invention comprises a cylindrical reactor 1 defining a treatment chamber 10.

[0041] A stirrer 2 is included inside the treatment chamber 10, consisting of an impeller provided with stirring

blades, placed rotatably around the longitudinal axis of the cylindrical reactor 1. The stirrer 2 is driven by a motor with gear motor not illustrated in the figures and continuously mixes the material inside the treatment chamber 10.

[0042] The cylindrical body of the reactor 1 is arranged with its own horizontal longitudinal axis and rests on the ground or on a special support structure by means of a plurality of bases, for example two bases 4 as shown in the figure.

[0043] The reactor 1 is provided with an inlet opening 11 which constitutes the access of the waste to the treatment chamber 10. The waste is delivered to the inlet opening 11 by means of a receiving hopper provided with a dispenser, not shown in the figures, for the introduction into the treatment chamber of a predetermined amount of material. Between the hopper and the inlet opening 11 a shredder device is included for the reduction into parts of bulky objects which hinder the movement of the stirrer 2 or prevent the entry of further material into the chamber 10.

[0044] The waste is inserted as such into the hopper and can be of any type, or limited to an organic-cellulosic fraction.

[0045] The reactor 1 comprises heating means of the treatment chamber 10. The cylindrical wall delimiting the treatment chamber 10 is metallic and the heating means are of the magnetic induction type, in particular consisting of one or more magnetic coils 5 which cover at least part of the outer surface of the metal wall, being appropriately spaced from the wall itself. In the example in the figure, the coils 5 cover only the lower part of the cylindrical body of the reactor 1. The coils 5 are electrically powered by an electrical circuit not shown in the figures. It is possible, for larger reactors, to include coils 5 which also cover the side walls of the cylindrical body or are located in other positions.

[0046] In combination, the heating means comprise one or more electrical resistors.

[0047] In combination, the heating means comprise means for generating and introducing dry saturated steam into the chamber.

[0048] By means of the electromagnetic induction coils 5, a temperature between 110° and 140° C is maintained inside the treatment chamber 10, preferably about 120° C, for a period between about 20 and 40 minutes.

[0049] In magnetic induction heating, the material of which the element to be heated is made determines the necessary heating rate and power. Steel and iron are easily heated due to their higher resistivity, while copper and aluminium require more power due to the lower resistivity. The metal walls of the reactor are preferably made of carbon steel, but can be made of any metal material suitable for magnetic induction heating.

[0050] The treatment chamber 10 is provided with an outlet opening 12 of the treated material, included below the cylindrical body.

[0051] The impeller of the stirrer 2 has a number of

remixing blades.

[0052] The plant includes suction means of the steam from the treatment chamber 10 configured to create a negative pressure inside the chamber 10. The suction means comprise a vacuum pump, not shown in the figure, which by means of a duct allows to create a vacuum inside the reactor. The formation of the vacuum is preferably carried out in the final drying step of the material. The suction means of the steam from the treatment chamber 10 comprise a filtration system, preferably comprising one or more quartz cartridges, to preserve the functionality of the entire suction system, in particular of the pump. The condensed steam downstream of these cartridges has similar features to sewage. Quartz cartridges are particularly effective in this filtering.

[0053] To ensure the operation of the suction means and allow the creation of the vacuum inside the treatment chamber, both the inlet opening 11 and the outlet opening 12 are provided with respective sealing valves adapted to create a hermetic closure such as to allow the creation of the vacuum inside the treatment chamber 10. At the end of the drying step, when the material is ready for expulsion from the reactor 1, the sealing valve of the inlet opening 10 is opened before the sealing valve of the outlet opening 12. Thereby, the air drawn by the vacuum in the treatment chamber 10 through the inlet opening 11 creates a thrust towards the outlet opening 12 on the treated material, which is expelled more easily. Advantageously, a conveyor belt, not shown in the figure, is included below the outlet opening 12 for the transfer of the treated material to further screening and treatment stages located downstream of the plant. The material is sterilized, dried, and possibly deodorized. The plant can be provided upstream or downstream with a metal separator, a sieve, a conveyor belt for the possible manual separation of some components and a glass separator.

[0054] The system also optionally includes a dry saturated steam generation circuit connected to the treatment chamber by a plurality of nozzles 6 for the introduction of dry saturated steam into the treatment chamber 10. Such a circuit includes a boiler, not illustrated in the figures, which allows the generation of dry saturated steam.

[0055] Means are provided for sterilizing the steam extracted from the treatment chamber 10 at the end of the drying step and a heat exchanger for the condensation of the steam, not illustrated in the figure. The fluids extracted from the treatment chamber thus pass into the exchanger, which allows their condensation for the subsequent treatment. The sterilizing means can for example comprise UV lamps for the total abatement of any residual bacterial loads.

[0056] The reactor 1 is also provided with a pressure-tight door 3, shown in figure 2. The door 3 is included on one of the two head areas of the cylindrical body of the reactor 1 and takes up its circular area. The door 3 is flat in shape. By opening the door 3, it is possible to access the interior of the treatment chamber 10 to carry out or-

dinary or extraordinary maintenance, in which it is also possible to include the extraction of the stirrer 2.

[0057] Figures 3 and 4 show a preferred embodiment of the reactor according to the present invention. The reactor includes a drive shaft 6 on which the remixing blades 20 of the impeller of the stirrer 2 are engaged, which consist of interrupted arms having a substantially T-shape. The remixing blades 20 are mounted on the shaft 6 so as to have predetermined angles with respect to each other.

[0058] Therefore, a process for the heat treatment of municipal solid waste is carried out using the plant shown in the figures, comprising the following steps:

- a) introducing waste into the reactor 1;
- b) heating the reactor 1 by means of the magnetic induction coils 5;
- c) unloading and screening the treated material.

[0059] The municipal waste as such is unloaded without any pre-selection in said hopper, which has the function of receiving and dosing.

[0060] The heating can include the use of one or more electrical resistors or the generation and introduction of dry saturated steam into the chamber.

[0061] Once the loading operation is completed and the inlet opening 11 sealing valve is closed, the sterilization operation begins at a temperature between 110° and 140° C, preferably about 120° C, for a period between about 20 and 40 minutes by means of magnetic induction heating. This operation is accelerated by the introduction of dry saturated steam. In combination, the chamber 10 can be heated by means of electrical resistors.

[0062] During the sterilization step, due to the effect of the moisture contained in the urban waste, which is about, if not more than, 50% by weight of the material itself and due to the effect of the blown steam, some of the existing components are transformed as follows:

- paper, cardboard, organic matter such as vegetables, fruit, leaves, etc., is considerably reduced in volume,
- plastic materials remain unchanged in their composition and the heat only causes their shrinkage;
- wood is also significantly reduced in volume.

[0063] Once the sterilization step is completed, the insufflation of dry saturated steam is interrupted and the heating by magnetic induction is kept constant.

[0064] The drying occurs by operating the vacuum in the reactor. The vacuum can be formed consecutively, contextually or semi-contextually to the heating step. Then a condensation step follows by means of an extracted steam exchanger.

[0065] The extracted condensation water having a COD of about 200-300 is subsequently purified.

[0066] Upon completion of this operation, the obtained treated material can pass to a discharge unit where after

cooling the final product passes to a component separation unit. Preferably, the discharge unit includes suction by connection to a tank in which the vacuum has been previously created. Alternatively, the material can be extracted from the outlet opening by falling.

[0067] From what is described and illustrated, it can be seen that the process is particularly simple and also the plant does not have critical parts in its construction and operation. With a plant of this type it is possible to treat municipal solid waste in large quantities in an economically advantageous manner, recovering reusable components thereof.

[0068] From the foregoing, it is therefore evident that the invention is not limited to the embodiments just described and illustrated by way of nonlimiting examples, but may be varied and modified, as a whole and in individual details, especially constructively, according to the specific needs and conveniences of production and use, within the scope of the technical and functional equivalents, without abandoning the guiding principle set forth above and subsequently claimed.

Claims

1. Plant for the heat treatment of municipal solid waste comprising a reactor (1) having a treatment chamber (10), an internal stirrer (2) provided in said chamber (10), and heating means (5) of said chamber (10), which chamber (10) is provided with at least one inlet opening (11) for said waste and at least one outlet opening (12) of the treated material,
characterized in that
said chamber (10) is delimited by one or more metal walls and said heating means (5) are of the magnetic induction type, steam suction means from the treatment chamber (10) being included, which suction means are configured to create a negative pressure inside said chamber (10).
2. Plant according to claim 1, wherein said heating means (5) comprise magnetic coils (5) which cover at least part of the outer surface of said metal walls, the magnetic coils (5) being suitably spaced from the metal walls themselves.
3. Plant according to claim 1 or 2, wherein said heating means (5) comprise one or more electrical resistors.
4. Plant according to one or more of the preceding claims, wherein said heating means (5) comprise means for generating and introducing dry saturated steam into the chamber (10).
5. Plant according to one or more of the preceding claims, wherein said walls identify a cylindrical body provided with a sealed door (3), said cylindrical body being arranged with its own horizontal longitudinal

axis and said outlet opening (12) of the treated material being included below.

6. Plant according to one or more of the preceding claims, wherein the means for suctioning the steam from the treatment chamber (10) and the means for generating dry saturated steam are connected to the same circuit, which circuit comprises means for sterilizing the steam extracted from the treatment chamber (10) and a heat exchanger for condensing said steam. 5 10
7. Process for the heat treatment of municipal solid waste
characterized in that 15
 it comprises the following steps:
 - a) introducing said waste into a reactor (1) having a treatment chamber (10);
 - b) heating said reactor (1) by means of magnetic induction; 20
 - c) unloading the treated material;
 wherein subsequently or at least in part at the heating step a step of forming the vacuum inside the treatment chamber (10) is included. 25
8. Process according to claim 7, wherein said heating includes the use of one or more electrical resistors.
9. Process according to claim 7 or 8, wherein said heating includes the generation and introduction of dry saturated steam into the chamber (10). 30

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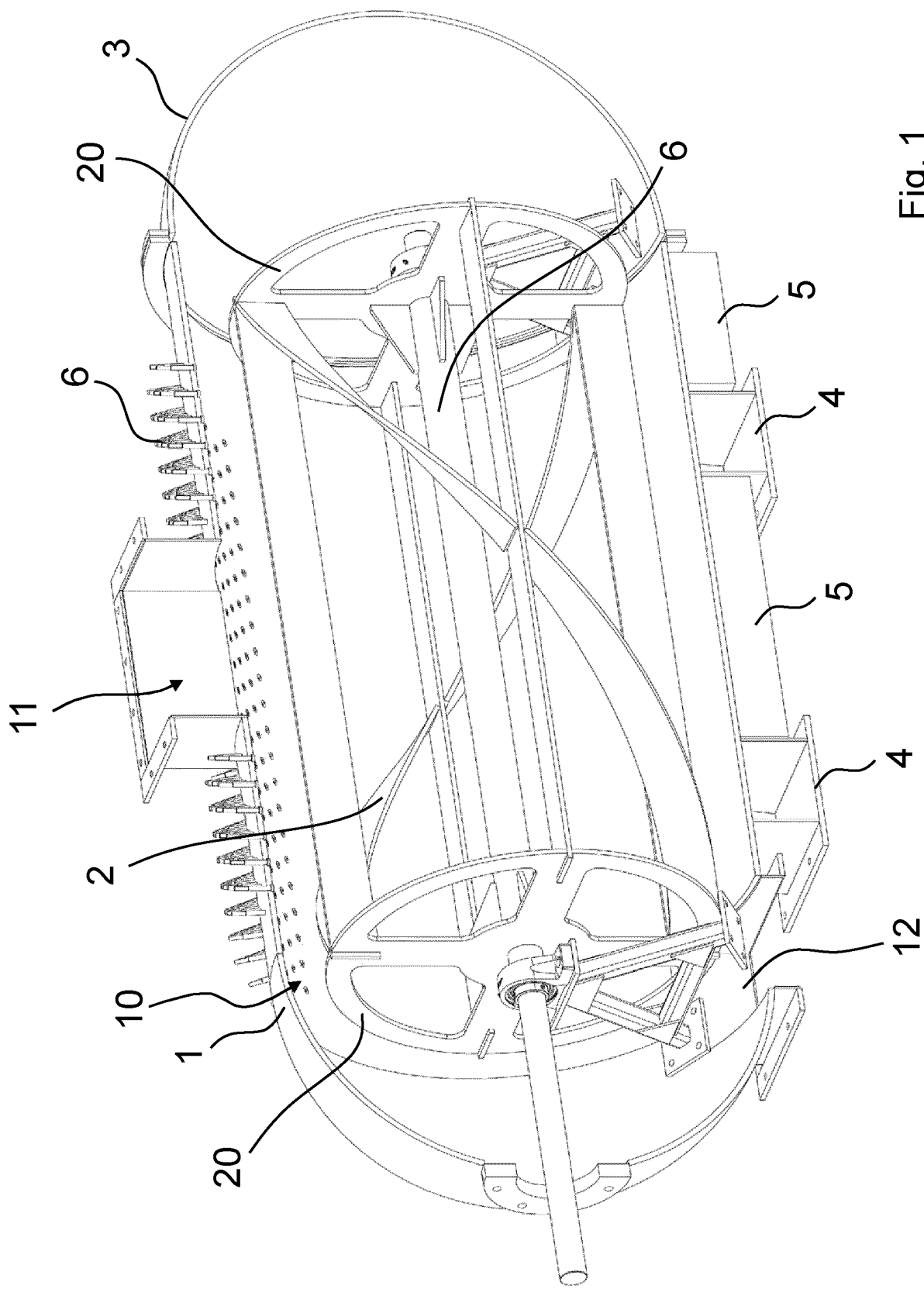


Fig. 1

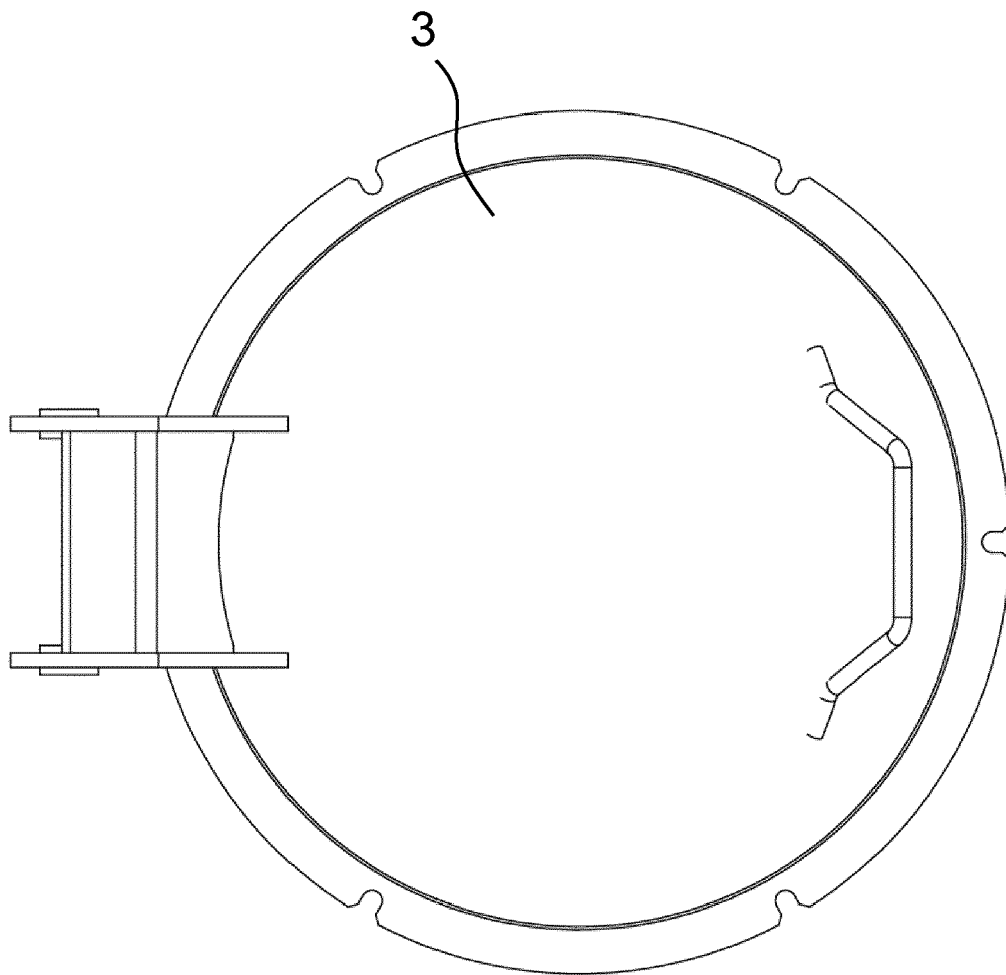


Fig. 2

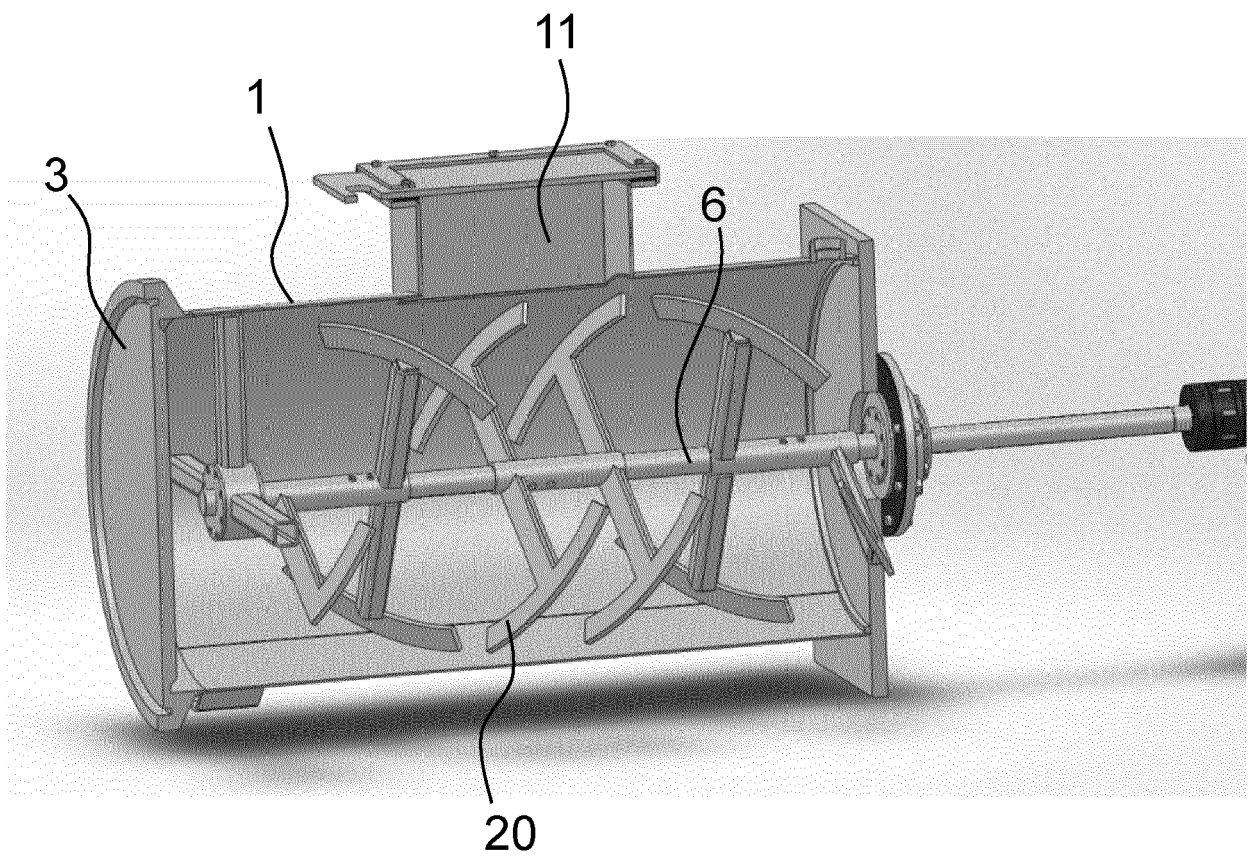


Fig. 3

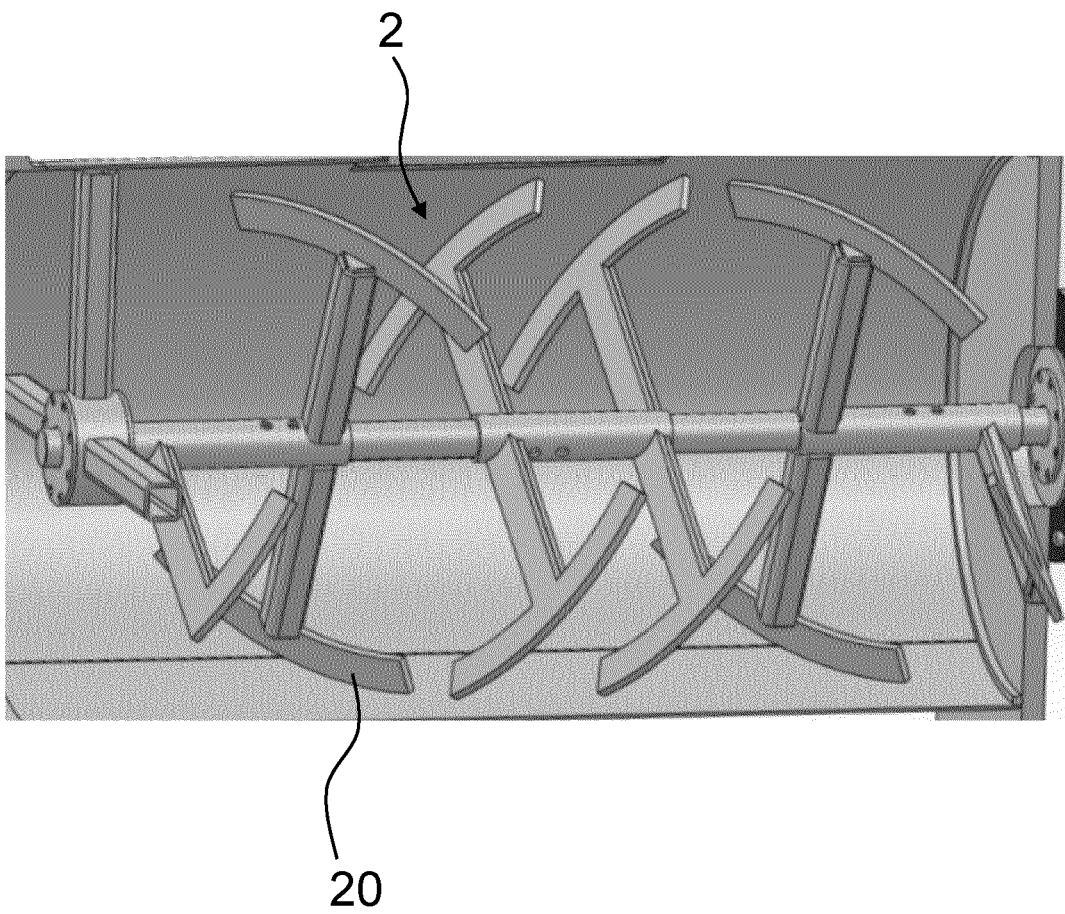


Fig. 4



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Place of search Munich		Date of completion of the search 14 November 2022	Examiner Theis, Gilbert
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EP 22 17 4936

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