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(54) PROCESS AND PLANT FOR THE DISPOSAL OF OLIVE POMACE

(57) A process is disclosed therein for the disposal of olive pomace. Said process provides a first processing step, during which the pomace undergoes pyrolysis and a second step, during which the product obtained from the previous step undergoes a treatment with steam at a temperature above 500°C. Preferably, the disposing material undergoes a preliminary heating step.

First step normally occurs at a temperature of 500°C, while the second step occurs at a temperature ranging between 700 and 1,000°C.

The present invention also relates to a plant for accomplishing the disposal of olive pomace, comprising a pyrolysis reactor (4) and a steam treatment reactor (26), said reactors (4; 26) being coaxial pipe reactors.

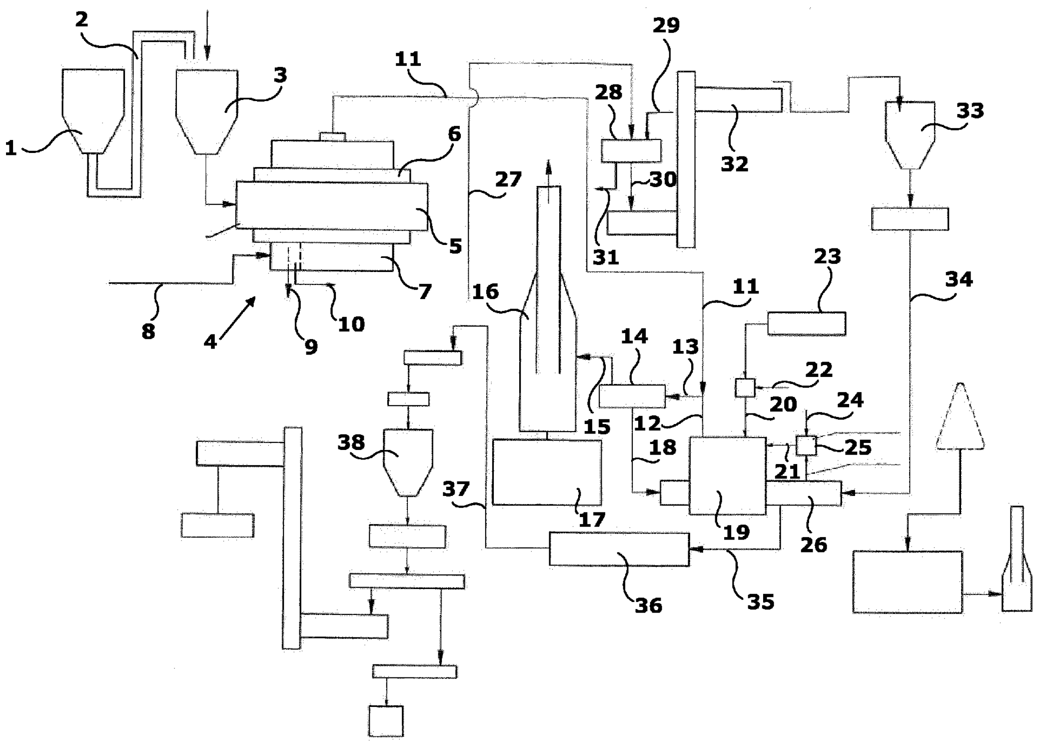

Fig. 1

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Description

[0001] The present invention relates to a process for the disposal of olive pomace, a process that allows the enhancement of waste, thus fitting fully into the so-called circular economy.

[0002] In the Mediterranean area and in climatically similar areas, the olive tree is widely spread. The use of its fruits -olives- to produce edible oils has been known since the earliest antiquity. Olive oil can be obtained by pressing or extraction of olives. Generally, an oil is classified as extra virgin oil, if obtained by pressing, with an acidity not higher than 0,8%, virgin oil, if obtained by pressing with an acidity lower than 2%, lampante virgin olive oil, if obtained by pressing with an acidity of more than 2%. Lampante virgin olive oil cannot be used for food purposes and its name derives from the fact that it can be used for lighting lamps (mainly used as a fuel).

[0003] An olive oil that is refined and mixed with a virgin oil is called olive oil.

[0004] The pressing residue, composed of kernel fragments, peel and pulp residues, is called pomace. It represents a quantitatively important fraction of the production since, in a traditional olive mill, one can obtain between 30 and 35% by weight of pomace, while in a continuous one, one can obtain between 40 and 45% by weight. From these numbers, considering that the annual production of olive oil, in Italy, is about 464,000 tons, it is easy to understand how the use of pomace obtained during this processing has a certain importance. One can consider the enhancement of pomace, by producing pomace oil, which is obtained from pomace by extraction with hydrocarbon solvents; of course, the hydrocarbon solvent -generally hexane- must then be removed completely, for example by fractioned distillation, since it is inedible. Pomace oil is particularly suitable, for example, for frying, since it is qualitatively better than seed oils used more commonly today.

[0005] The chemical composition of pomace oil is different from that of virgin and extra-virgin oils and sometimes, to make it edible, it must be treated in a similar way to the one used for seed oils, by modifying the degree of saturation, acidity and isomeric composition, thus making its composition more similar to that of edible olive oils.

[0006] Once, there was a greater use of pomace. Today, the properties of extra-virgin oil are better known to everyone and the attention on food products has become very high. For this reason, oils of slightly lower quality than the extra-virgin oils are now less appealing to the public, which is why extra virgin oil as dressing, olive oil for cooking and seed oils for frying are the ones almost exclusively sold. Even though pomace oil is more suitable for cooking than seed oils, common perception is not in accordance with that and pomace oil is sold with greater difficulty. There are also suspicions -which are per se baseless- on the fact that the removal of the solvent from the oil may not be complete, therefore purchase is avoided and there are also rumours around the harmfulness of pomace oil for the human health, rumours which have never been confirmed up to date.

[0007] All this has led to a decreased price at which this oil can be sold. This has resulted in that the costs associated to the extraction, distillation and transportation of pomace make it often cheaper to destroy it as biomass (possibly after a second pressing, called repass) which undergoes energy enhancement in comparison to its processing to obtain a vendible product. Therefore, today pomace is mainly used as a fuel, having a non negligible calorific power. It should, however, be borne in mind that pomace contains some of the so-called vegetation water, so it often must be dried before its combustion, which raises the cost and sometimes makes the destruction only a disposal cost for what now turns out to be essentially a waste rather than a product.

[0008] A product that has a remarkable use in the industry today, especially chemical, but not only, is the activated carbon, an amorphous, very porous carbon-based substance with very high surface areas, in the order of a thousand square metres per gram. Activated carbon is used as a catalyst, a carrier for catalysts, a filtering, adsorbent material, a purifier and the like. The production cost of activated carbon is relatively high, and its selling price is therefore largely profitable.

[0009] CN 214 370 214 discloses a plant for the treatment of agricultural waste. A pyrolysis furnace, a rotary kiln, a combustion furnace, a tank for condensation, a gas containing tank, a device for separating water/oil, a tank for oil and another one for water are included in the plant. The heat produced by the pyrolysis is used for the other steps of the process. The material that undergoes the pyrolysis must be dried until it reaches a water content of less than 10% by weight. The pyrolysis reaction occurs at a temperature ranging between 100 and 350°C.

[0010] EP 2 236 588 discloses a process for the use of pyrolysis water, which is injected into a combustion chamber. The claimed process can be used in a plant integrated with a combined cycle gasification, which can lead to the co-production of liquid fuel. This patent relates to a reaction complex and the reuse of effluents from the pyrolysis (water, oil and gas) and does not give precise indications on how the pyrolysis occurs.

[0011] The problem underlying the invention is to propose a process for the disposal of pomace oil, which overcomes the disadvantages cited and allows a wide enhancement of the product, without creating polluting waste. This aim is reached through a process for the disposal of olive pomace, characterised in that it provides a first processing step, during which the pomace undergoes pyrolysis and a second step, during which the product obtained from the previous step undergoes a treatment with steam at a temperature above 500°C. The present invention also relates to a plant for accomplishing the disposal of olive pomace, comprising a pyrolysis reactor and a steam treatment reactor, characterised in that said reactors are coaxial pipe reactors. The dependent claims disclose preferable characteristics of the invention.

[0012] Additional features and advantages of the invention become more evident, however, from the following detailed description of a preferred embodiment, given purely for illustrative and non limiting purposes, and illustrated in the attached drawing which represents a plant for the implementation of the process according to the present invention.

[0013] In the illustrated plant, the pomace is fed in a hopper 1, connected via a conduit 2 to another hopper 3 that feeds a reactor 4, which can exhibit internally content stirring devices. The reactor 4 comprises advantageously the following sections: a section 5 of pre-heating, a section 6 of pyrolysis and a section 7 of combustion, fed with gas and air from a conduit 8. In this way, the thermal efficiency of the reactor 4 is maximised. There is a discharge 9 of the pyrolysis carbon and a discharge 10 of gas.

[0014] From the top of the reactor 4 a fume discharge pipe 11 comes out, which converges, along with a discharge 12, into a feed 13 towards a steam generator 14 (heat recuperator) with an outlet 15 feeding a stack 16 and a turbine 17, so as to make full use of the produced heat, and an outlet 18, which is inserted into a combustion chamber 19, from which the previously mentioned discharge 12 begins.

[0015] In addition to feed 18, the combustion chamber 19 is fed by an inlet 20 and by an inlet 21.

[0016] Inlet 20 receives in turn air from an inlet 22 and fuel from a tank 23.

[0017] Inlet 21, on the other hand, receives air from an inlet 24 and gas coming from an inlet 25. The inlet 25 comes from a reactor 26.

[0018] The carbon flowing out of the discharge 9 is fed into 27 to a cooler 28, which receives water from an inlet 29, and is discharged in 30. The cooler 28 (another heat recuperator) also includes an outlet 31. With an elevator 32, the carbon is transferred in a hopper 33, from which a pipe 34 leads to the reactor 26.

[0019] The reactor 26, in addition to the reaction gas outlet 25, also features a pipe 35, feeding a cooler 36 of activated carbon, from which a discharge 37 comes out and brings material to a tank 38 (a silo for activated carbon).

[0020] The process for the disposal of pomace oil will be now illustrated.

[0021] As mentioned earlier, the olive pomace comprises residues from pressing, which are fragments of kernels, peel and pulp and contains considerable amounts of water, basically vegetation water, but sometimes also water that was added in the processes which brought to the production of pomace. The amount of water contained in pomace is what discourages its use today as fuel, since it would require a deep drying in order to obtain an acceptable and uninterrupted combustion. In general, pyrolysis is also deterred by the amount of water.

[0022] The pomace to be disposed of presents a composition (percentages by weight) of the following type: water 13.70%, carbon 22.40%, volatile substances 74.20%, ash 3.40%: there is an appreciable amount of carbon, as shown. The amount of water contained in the pomace is higher than that considered maximum (10%) from CN 214 370 214.

[0023] Pomace is fed, in a known way, to the hopper 1, possibly after undergoing some preliminary treatment, of a known type. From hopper 1, when appropriate, pomace is fed, passing through conduit 2, to hopper 3, from which, preferably in a continuous way for reasons of operational uniformity, for example with a water screw, pomace is fed to reactor 4. The reactor 4 is designed as a coaxial tube reactor, preferably made of AISI 321 steel, possibly rotating. Tube 5, where the pomace mass enters, has a pre-heating function: upstream of the first step of pyrolysis, the material undergoes a preliminary heating step. For example, the pomace temperature is raised, due to thermal exchange with gas combustion fumes, to a suitable temperature for a preliminary heating (or pre-heating), which allows to prepare the material for the following step and dry it, overcoming the drawback of its high humidity. It should be noted that the step from the external tube alone is sufficient to prevent a preliminary drying step, contemplated by the previous technique, as CN 214 370 214, while still managing to obtain carbon, in a way that is far from predictable. Exiting from tube 5, for example, through suitably reinforced holes on its side walls, the material intended for the reaction enters tube 6, preferably moving in the opposite direction in comparison to the one followed in tube 5, so as to take advantage of the heat provided, where the temperature is raised above 400°C, preferably at about 500°C, bearing in mind that the pyrolytic removal of substances contained in the biomass occurs, in an exothermic way, from 260-280°C. The material is held in absence of air and thus a pyrolysis or distillation reaction occurs, resulting in the production of solid carbon, which is discharged in 9, tar and other liquid substances and a gas, which are discharged in 10. The gas discharged in 10, is added to other gas and air in 8 and feeds the combustion section 7 of the reactor 6, making an energy recovery and appreciably reducing the consumption of gas which is necessary for the pyrolysis. Preferably, the heat is provided from section 7 to tubes 5, 6 -made preferably in Incoloy DS, to withstand the corrosive condition encountered-via indirect thermal exchange, through the casing of tube 6, with the fumes coming from the same chamber 7. The fumes are, then, preferably conveyed towards the heat recuperator 14, for the production of steam.

[0024] Based on an example, by feeding 7000 kg/h of pomace to reactor 4, 2250 kg/h of vegetable carbon can be obtained, consuming 6819 kcal/h in total.

[0025] Contrarily to expectations based on its composition and on the knowledge of the prior art, pomace can be used advantageously as a material intended for pyrolysis and activation, by using a combination between a tubular reactor and a pyrolysis temperature above 400°C, preferably 500°C.

[0026] The carbon exiting from discharge 9 is fed at 27 into a cooler 28, where thermal exchange occurs via a water source heat exchanger, fed from pipe 29. The carbon is brought to a temperature below 200°C, preferably at a temperature ranging between room temperature and 100°C, most preferably at a temperature of about 50°C, for safety reasons. The carbon now cooled down comes out from pipe 30, while steam comes out from pipe 31. Discharge 30 feeds an elevator 32 which, in turn, feeds a hopper 33 that sends the cooled carbon, for example via a water screw, to reactor 26, heated by the combustion chamber 19. Also, in this case, the reactor can be composed of two axial tubes, one, internal, for preliminary heating and one, internal, for the actual reaction. In the reactor 26, carbon is mixed with water and left to react at a temperature above 500°C. Preferably, during the second step the temperature ranges from a minimum of 500 to a maximum of 1,200°C, more preferably, the temperature is within a range of 700 to 1,000°C, 900°C being the most preferred temperature, a temperature at which optimum yield is obtained. In the reactor the water gas endothermic reaction occurs:

$$C + H_2O \dashrightarrow CO + H_2$$

[0027] In this way, carbon is activated for the final use, greatly increasing its porosity and, thus, the specific surface area. Activated carbon comes out from pipe 35, is sent to cooler 36, where it is cooled again with a water heat exchanger; exiting the cooler 36 through pipe 37, it is delivered in the appropriate tank 38, from which it can then be sent to use, in the most appropriate ways, possibly after selection of the product via micron screening (so as to collect the most suitable particle size), qualitative packaging and quantitative packaging, so as to be ready for shipment to markets of interest.

[0028] Carbon monoxide and hydrogen, formed in the activation reaction, flow out from pipe 25, from where they are sent to burn in the combustion chamber 19. Exhaust fumes in 12 come out from the combustion chamber 19, which merge with those coming from 11 and fed together to the steam generator 14. From the generator 14, exhaust fumes are sent through the pipe 15 to the furnace 16, which feeds also a turbine 17. On the other hand, steam comes out from pipe 18 which feeds the reactor 26. The combustion in chamber 19, in addition to gas produced during the activation in reactor 26, is also sustained by top-up gas, coming from tank 23 through pipe 20, while pipe 22 feeds the necessary air. The fumes from this step are also then directed to a heat recuperator, to produce steam, which also brings an additional value for all the further processing it allows. In essence, the gas produced in the pyrolysis reaction and/or in the reaction with steam is used in the combustion used for maintaining the reaction temperature, thus substantially reducing the need to add fresh fuel, such as illuminating gas, diesel oil or other.

[0029] The process of disposal according to the present invention transforms a waste product, even very abundant, such as pomace oil, into a valuable product, of massive industrial use, such as activated carbon, at an overall relatively modest energy consumption, partially sustained by the waste itself and with a surprisingly favourable yield, not adversely affected by the water contained within the waste itself. There are negligible gaseous emissions from the processing according to the present invention, what makes this process even more appealing.

[0030] Based on the exemplary embodiment already previously seen for the production of vegetable carbon, for a feed of 2250 kg/h of vegetable carbon and 4500 kg/h of demineralised water, 800 kg/h of activated carbon can be obtained, with high added value, with a methane consumption of 50 Nm^3/h.

[0031] It is understood, however, that the invention should not be considered limited to the particular arrangement illustrated above, which is only an exemplary embodiment, but that several variations are possible, all of them available to a person skilled in the art, without departing from the scope of protection of the invention, as defined by the following claims.

LIST OF REFERENCE CHARACTERS

[0032]

1 Loading hopper of pomace
2 Conduit
3 Reactor feed hopper
4 Pyrolysis reactor
5 Pre-heating section (of 4)
6 Pyrolysis section (of 4)
7 Combustion section (of 4)
8 Conduit
9 Vegetable carbon discharge
10 Gas discharge from the pyrolysis reaction
11 Fume discharge pipe
12 Fume discharge
13 Feed (of 14)

14 Steam generator
15 Fume outlet
16 Furnace
17 Turbine
18 Steam outlet
19 Combustion chamber
20 Inlet
21 Inlet
22 Inlet
23 Fuel tank
24 Inlet
25 Inlet
26 Activation reactor
27 Feeding point
28 Carbon cooler
29 Inlet
30 Discharge point
31 Outlet
32 Elevator
33 Hopper
34 Pipe
35 Pipe
36 Activated carbon cooler
37 Activated carbon discharge
38 Tank of the product

Claims

1. Process for the disposal of olive pomace, **characterised in that** it provides a first processing step, during which the pomace undergoes pyrolysis and a second step, during which the product obtained from the previous step undergoes a treatment with steam at a temperature above 500°C.

2. Process as in 1), **characterised in that** upstream of the first pyrolysis step, the material undergoes a preliminary heating step.

3. Process as in 1) or in 2), **characterised in that** the first step occurs in the absence of air, at a temperature above 400°C.

4. Process as in 3), **characterised in that** the first step occurs at a temperature of 500°C.

5. Process as in any one of the preceding claims, **characterised in that** the second step occurs at a temperature ranging between 500 and 1,200°C.

6. Process as in 5), **characterised in that** said second step occurs at a temperature ranging between 700 and 1,000°C.

7. Process as in any one of the preceding claims, **characterised in that** the gas produced in the pyrolysis reaction and/or in the reaction with steam is used in the combustion used for maintaining the reaction temperature.

8. Process as in any one of the preceding claims, **characterised in that** it occurs in a tubular coaxial pipe reactor (4).

9. Plant for accomplishing the disposal of olive pomace, comprising a pyrolysis reactor (4) and a steam treatment reactor (26), **characterised in that** said reactors (4; 26) are coaxial pipe reactors.

10. Plant as in 9), **characterised in that** at least part of the pipes of the pyrolysis reactor (4) is made of AISI 321.

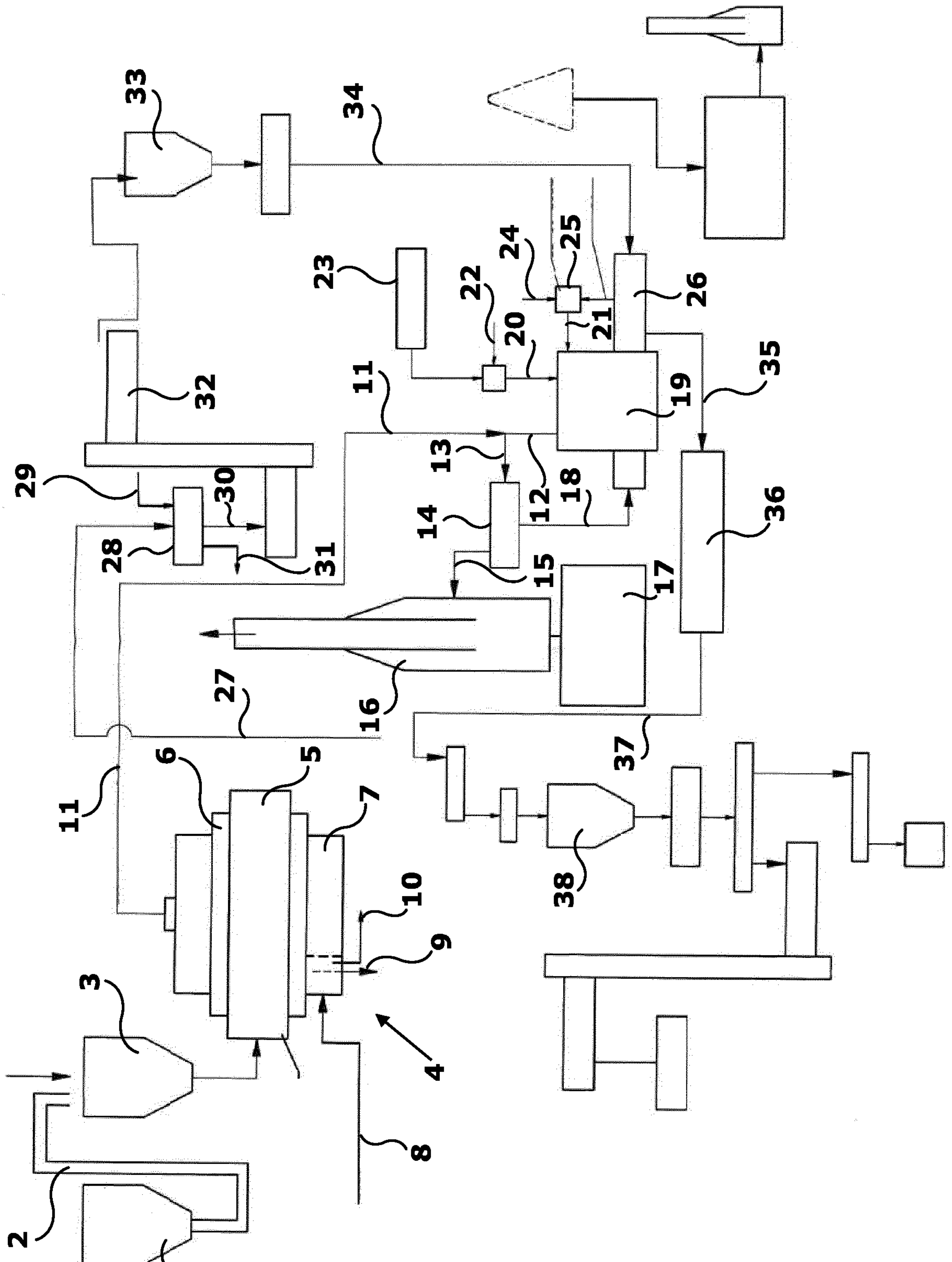
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Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 5741

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	CN 214 370 214 U (TIANJIN LYUZHAN ENVIRONMENTAL PROTECTION TECH CO LTD) 8 October 2021 (2021-10-08) * the whole document * -----	1-10	INV. F23G5/027 F23G5/12 F23G7/10
Y	EP 2 236 588 A1 (GEN ELECTRIC [US]) 6 October 2010 (2010-10-06) * column 3, paragraph 17 - column 12, paragraph 65 * * figure 1 * -----	1-10	
A	WO 2014/012556 A1 (PYRONEER AS [DK]) 23 January 2014 (2014-01-23) * page 7, paragraph 3 - page 14, paragraph 2 * * figure 1 * -----	1-10	
A	US 2020/200383 A1 (BORYS SERGE [CA] ET AL) 25 June 2020 (2020-06-25) * page 2, paragraph 32 - page 12, paragraph 194 * * figures 1-13 * -----	1-10	TECHNICAL FIELDS SEARCHED (IPC) F23G

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 October 2023	Rudolf, Andreas

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

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04-10-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- CN 214370214 **[0009] [0022] [0023]**
- EP 2236588 A **[0010]**