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(54) PYROLYSIS METHOD WITH RAPID DECOMPRESSION

(57) The present invention relates to a method for obtaining liquid and gas hydrocarbons from solid organic compounds, to an apparatus, and to auxiliary devices necessary for carrying out the method. In particular, the invention relates to a method for producing liquid and gas hydrocarbons, which comprises a step of homogenising the particle size, moisture, and chemical composition of the processed materials. During the method, the processed materials and waste undergo three changes of state and are subjected to pressures of up to 250 atmospheres.

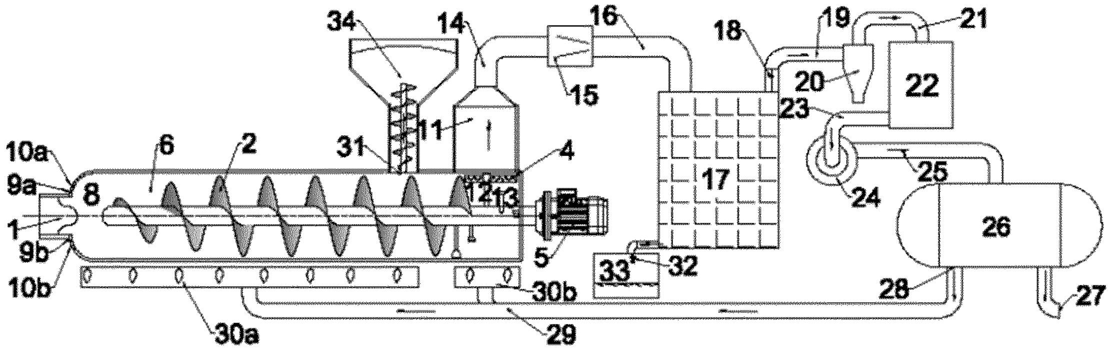

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a method for obtaining liquid and gas hydrocarbons from solid organic compounds, to an apparatus, and to the auxiliary devices necessary for carrying out said method.

BACKGROUNDS

[0002] Many pyrolysis methods for obtaining liquid and gas hydrocarbons from specific materials are known today. Normally, the materials intended for the pyrolysis methods are usually plastic materials. Various pyrolysis methods, intended mainly for the treatment of biomass, tyres, and reject fractions of solid urban waste, are also known in the state of the art. All these methods require reducing the particle size and moisture of the materials processed therein, with a high energy cost. Methods which do not reduce the particle size of the materials processed therein require a much longer process time in order to achieve the thermal decomposition of said materials.

BRIEF DESCRIPTION OF THE INVENTION

[0003] The present invention relates to a new pyrolysis method by means of heating, compression, and decompression of solid organic compounds, which allows shortening the time used by current pyrolysis methods for obtaining liquid and gas hydrocarbons significantly.

[0004] In the scope of the present invention, organic compound is understood to mean a chemical compound containing carbon, forming carbon-carbon and carbon-hydrogen bonds.

[0005] The proposed new method allows the pressure and temperature of the process to be permanently controlled, indicating when the optimal pressure values (between 20 and 250 Atm) and temperature values (between 250 and 650ºC) for causing thermal decomposition of the processed materials are reached.

[0006] The drastic decompression of pressure (from between 20 and 200 Atm to 1 Atm) to which the partially homogenised materials which are pyrolysed (at a temperature of between 250 and 650ºC) are subjected and the increase in the heat exchange surface cause a very rapid generation of gases, significantly shortening (between 30 and 50%) the vaporisation time in pyrolysis processes.

[0007] During the pyrolysis process with rapid decompression, three changes of state occur in the processed material. The solid materials processed by means of the extruder screw are mixed and ground at a high pressure and temperature until the partial homogenisation of the moisture, particle size, and chemical composition of said materials is achieved. Once homogenised and due to the heating process to which they are subjected, the processed solid materials change to a liquid-viscous state.

[0008] Partially homogenising the moisture, particle size, and chemical composition of the processed materials allows calculating the time the injected compound remains in the vaporisation chamber, as well as the temperature of said chamber. The optimal physical conditions in which the vaporisation reaction must be carried out during pyrolysis are thereby established.

[0009] In the scope of the present invention, the expression "partially homogenous" means that the intensive properties are maintained in all the compounds of the processed materials, where only one phase is observed. Intensive properties are properties that do not depend on the amount of substance or on the size of a system, so their value remains unchanged when the initial system is sub-divided into several subsystems. Non-limiting examples of intensive properties which can be observed in the solid of the present invention are: specific heat capacity, density, hardness, concentration, melting point, ductility, or malleability.

[0010] The second change of state, from liquid-viscous state to gas state, occurs due to the thermal decomposition of the processed materials; pyrolysis gases are generated in this step. Said materials are in liquid viscous state and decompose into pyrolysis gas.

[0011] The third change of state, from gas state to liquid state, occurs by means of the condensation of part of the pyrolytic gases obtained in the condensed hydrocarbons.

[0012] The new method reduces the prior treatment of the different processed materials and waste, such as particle size reduction and moisture reduction, to the minimum levels. The process is performed in an uninterrupted manner with a range of practically zero emissions and does not require the addition of any substance of chemical or of any other nature. The only waste resulting from the process are inert (inorganic) materials that could not be thermally decomposed.

[0013] Part of the fuel obtained during the method is used in the process to provide the required power, by means of the numerous existing and proven technologies, so, once initiated, the new method that has been described is an energy self-sufficient method.

[0014] The starting materials used in the present invention are non-hazardous materials and waste of an organic nature. In a particular embodiment, these waste flows preferably originate from urban and industrial solid waste treatment plants. They can also originate directly from industrial, agricultural, forestry, or maritime production activity.

[0015] "Waste" is understood to mean any substance or object disposed of, or which is to be or must be disposed of, by its owner. In any case, the waste mentioned in the European Waste Catalogue (EWC), approved by the Community Institutions contemplated in Decision 2000/532/EC, will be understood in this sense. Furthermore, "urban or municipal waste" is understood to mean the waste generated in private homes, shops, offices, and facilities, as well as all the waste which is not classified as hazardous waste and which, due to its nature or composition, can be assimilated into the waste produced in the preceding locations or activities. The following will also be considered urban waste: waste originating from the cleaning of public roads, green areas, recreational areas and beaches; dead domestic animals, as well as furniture, mattresses, and belongings; waste and debris originating from minor home repair and construction works.

BRIEF DESCRIPTION OF THE FIGURES

[0016]

Figure 1 shows a vertical section of the pyrolytic reactor with the shut-off valve of the recirculation system open.

Figure 2 shows a horizontal section of the pyrolytic reactor with the shut-off valve of the recirculation system open and the auxiliary devices necessary for carrying out the process.

[0017] In view of Figures 1 and 2 and according to the numbering used therein, a preferred non-limiting embodiment of the invention which comprises the parts and elements indicated and described in detail below can be seen, where the following reference numbers have been assigned to each of said parts and elements:

1. Main shut-off valve
2. Extruder screw
3. Recirculation circuits

    3a Recirculation circuit 1

    3b Recirculation circuit 2

4. Shut-off and injection valves.

    4a Shut-off and injection valve of recirculation circuit 3a
    4b Shut-off and injection valve of recirculation circuit 3b

5. Actuating device
6. Pyrolysis reactor
7. Inlets to the recirculation circuit

    7a Inlet to recirculation circuit 3a
    7b Inlet to recirculation circuit 3b

8. High-pressure area
9. Pressure-measuring sensors

    9a Pressure-measuring sensor 1 in high-pressure area 8
    9b Pressure-measuring sensor 2 in high-pressure area 8
    9c Pressure-measuring sensor 3 in recirculation circuit 3a
    9d Pressure-measuring sensor 4 in recirculation circuit 3b

10. Temperature-measuring sensors

    10a Temperature-measuring sensor 1 in high-pressure area 8
    10b Temperature-measuring sensor 2 in high-pressure area 8
    10c Temperature-measuring sensor 3 in recirculation circuit 3a
    10d Temperature-measuring sensor 4 in recirculation circuit 3b

11. Pyrolysis gas outlet
12. Main vaporisation area
13. Area of the extruder screw with shafts
14. Pyrolysis gas outlet conduit
15. Pyrolysis gas extraction turbine
16. Pyrolysis gas outlet conduit
17. Pyrolysis gas condensation system
18. Non-condensable pyrolytic gas outlet
19. Non-condensable pyrolytic gas outlet conduit
20. Non-condensable pyrolytic gas purification cyclone
21. Non-condensable pyrolytic gas transport conduit
22. Non-condensable pyrolytic gas filtration system
23. Non-condensable pyrolytic gas transport conduit
24. Non-condensable pyrolytic gas compressor
25. Compressed pyrolytic gas conduit
26. Compressed pyrolytic gas tank
27. Compressed gas outlet
28. Compressed gas outlet into the pyrolytic reactor heating system
29. Transport conduit for transporting compressed gases to the pyrolytic reactor heating system
30. Pyrolytic reactor heating system

    30a Pyrolytic reactor heating system

    30b Vaporisation area heating system

31. Inlet for materials into the pyrolytic reactor
32. Condensed hydrocarbon outlet
33. Condensed hydrocarbon tank
34. Forced feeding system
35. Safety valves

    35a Safety valve 1 of recirculation circuit 3a

    35b Safety valve 2 of recirculation circuit 3b

DETAILED DESCRIPTION OF THE INVENTION

STARTING MATERIALS

[0018] The starting materials used in the present invention are non-hazardous materials and waste of an organic nature. In a particular embodiment, these waste flows preferably originate from urban and industrial solid waste treatment plants. The processed materials can also originate directly from industrial, agricultural, forestry, or maritime production activity.

PYROLYSIS METHOD

[0019] The materials that will be processed are introduced by means of the extrusion-based forced feeding system (34) into the feed opening (31) located after the gas outlet area (11) of the pyrolytic reactor (6). The extrusion-based forced feeding system (34) ensures the absence of incoming oxygen during the continuous pressurised loading operation. The extruder screw (2) operated by the motor (5) pushes, brushes against, mixes, and grinds the materials as they advance towards the high-pressure area (8), where the shut-off and decompression valve (1) is closed, forcing the processed waste to move back again and resume the mixing and grinding processes time and again at a high pressure and temperature until the partial homogenisation of the moisture, particle size, and chemical composition of the processed materials is achieved.

[0020] When the pressure probes (9a and 9b) and temperature probes (10a and 10b) installed in the high-pressure area (8) indicate that the pressure (between 20 and 250 Atm) and temperature (between 250 and 650ºC) required for the decompression pyrolysis process have been achieved, the valve (1) is opened and the processed waste moves in through holes (7a and 7b), advancing along the recirculation conduits (3a and 3b) towards the outlets which lead to the main vaporisation area.

[0021] While the homogenised waste advances along the recirculation conduits (3a and 3b), it is subjected to a temperature of between 250ºC and 650ºC by the installed heating system (30a), favouring the thermal decomposition of the processed waste.

[0022] The outlets into the main vaporisation area (12) are controlled by shut-off and injection valves (4a and 4b). When the pressure probes (9c and 9d) and temperature probes (10c and 10d) installed in the recirculation circuits (3a and 3b) along with the shut-off and injection valves (4a and 4b) indicate that the pressure (between 20 and 250 Atm) and temperature (between 250 and 650ºC) required for the decompression pyrolysis process have been achieved, the shut-off and injection valves (4a and 4b) open and the processed materials are injected into the vaporisation area. The processed materials injected into the main vaporisation area are instantaneously subjected to a drastic reduction of pressure (from between 20 and 250 Atm to 1 Atm), causing the generation of gases from fast pyrolysis, significantly increasing the vaporisation speed in organic compound thermal decomposition processes, in the absence of oxygen.

[0023] To ensure process safety, at the end of the recirculation circuits (3a and 3b), safety valves (35a and 35b) are located which allow reducing the internal pressure of the recirculation circuits, where necessary.

[0024] In order to maximise performance, the heat exchange surface in the method is increased during the vaporisation phase by injecting into the main vaporisation area (12) the processed materials and compounds in the form of sheets of between 3 and 10 millimetres thick, by means of the shut-off and injection valves (4a and 4b).

[0025] The partial homogenisation of the moisture, particle size, and chemical composition of the processed materials and compounds allows calculating the time the injected compound remains in the main vaporisation chamber and the temperature of said chamber. The optimal physical conditions in which the vaporisation reaction must be carried out during pyrolysis are thereby established.

[0026] The injected material that has not vaporised is collected through the extruder screw section (13) and is introduced back into the main vaporisation area, while it is transported back to the high-pressure area (8) to repeat the process. Said materials mix with the new materials introduced through the feed inlet (11), causing a much more efficient enthalpy exchange between the hot material returning to the process and the new cold material starting the process.

[0027] The extruder screw section (13) in the main vaporisation area replaces the metal coils with cylindrical blades collecting the material injected into the pyrolysis chamber which has not vaporised and subjects it to the vaporisation process again, while it is transported to the high-pressure area to resume the pyrolysis process.

[0028] The hydrocarbons in gas state resulting from the thermal decomposition of the processed waste in different areas of the pyrolytic reactor are extracted through gas outlet conduits (11) by means of a gas extraction turbine (15) interposed between the reactor and the condensation system.

[0029] The extracted gases run through the leak-tight condensation system (17) where a drastic change in temperature occurs, allowing the extracted gases to condense into condensed hydrocarbons. The condensed hydrocarbons that are obtained exit the condenser (17) through outlet (32) and are delivered to the tank (33).

[0030] The non-condensable gas hydrocarbons exit the condensation system (17) through outlet (18) and are directed through conduit (19) to a cyclone (20) for a first non-condensed gas purification in which part of the suspended impurities are removed by gravity. Once treated, the gases are directed through conduit (21) to a second filter system (22) for purification by filtering out the suspended impurities. Once purified, the impurity-free non-condensable gases are directed by means of conduit (23) to the gas compressor (24) which compresses them and delivers them through conduit (25) to the compressed gas storage tank (26).

[0031] Part of the compressed gas hydrocarbons stored in tank (26) is delivered by means of conduit (29) to the heating systems (30a and 30b) implemented in the pyrolytic reactor (30a) and in the vaporisation chamber (30b).

[0032] Another part of the compressed gas hydrocarbons stored in tank (26) can be used to generate electric power, by any of the means known by one skilled in the art for powering the actuating system (5) of the extruder screw (2).

[0033] The remaining part of the compressed gas hydrocarbons stored in tank (26) can be directly sold or intended for generating power to be sold.

Claims

1. A method for obtaining liquid and gas hydrocarbons from organic compounds, wherein said compounds are processed and injected into the main vaporisation area, subjecting them to a drastic reduction of pressure comprised between 20 and 250 Atm to 1 Atm and at a temperature between 250 and 650ºC, causing the generation of gases from fast pyrolysis.

2. The method according to claim 1, wherein the starting materials do not receive any type of prior treatment before the processing thereof.

3. The method according to any of claims 1 or 2, wherein the moisture, particle size, and chemical composition of the processed materials are partially homogenised before being injected into the main vaporisation area.

4. The method according to any of claims 1 to 3, wherein the processed materials are subjected to three changes of state.

5. The method according to any of claims 1 to 4, wherein the pressure and the temperature of the process are controlled at all times.

6. The method according to any of claims 1 to 5, wherein the processed materials are injected into the main vaporisation area in the form of sheets of between 3 and 10 millimetres thick, increasing the vaporisation surface of the processed material.

7. The method according to any of claims 1 to 6, wherein the injected materials that have not thermally decomposed in the main vaporisation area are collected through the extruder screw section (13) which subjects them to the vaporisation process again while they are transported to the high-pressure area to resume the pyrolysis process.

8. The method according to any of claims 1 to 7, wherein the materials that have not vaporised in the main vaporisation area are collected through the extruder screw and mixed with the new waste entering to be processed, improving the enthalpy exchange of the method.

9. The method according to any of claims 1 to 8, wherein the process is an energy self-sufficient process.

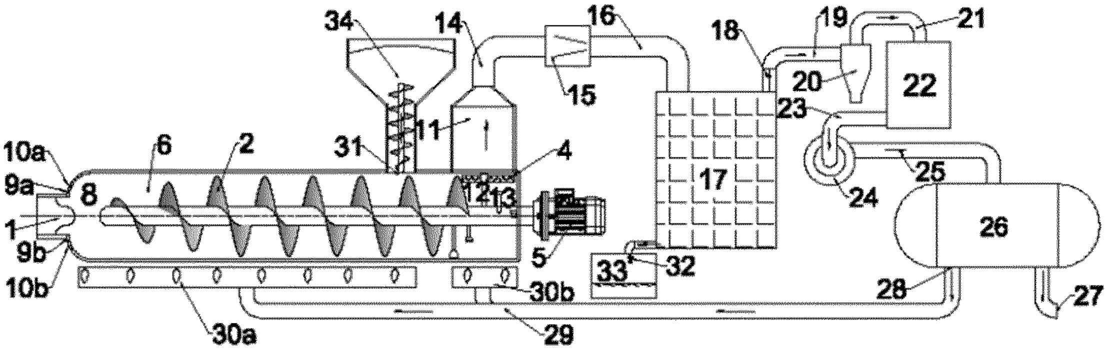
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Fig. 1

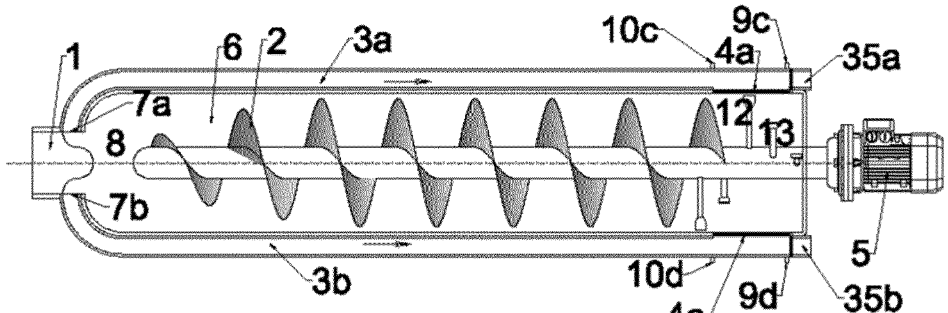

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2018/000072

A. CLASSIFICATION OF SUBJECT MATTER

C10B51/00 (2006.01)
C08J11/12 (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10B, C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, INVENES, WPI, XPESP

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance.		
"E"	earlier document but published on or after the international filing date		
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"O"	document referring to an oral disclosure use, exhibition, or other means.	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents , such combination being obvious to a person skilled in the art
"P"	document published prior to the international filing date but later than the priority date claimed		
		"&"	document member of the same patent family

Date of the actual completion of the international search 29/04/2019	Date of mailing of the international search report **(07/05/2019)**
Name and mailing address of the ISA/ OFICINA ESPAÑOLA DE PATENTES Y MARCAS Paseo de la Castellana, 75 - 28071 Madrid (España) Facsimile No.: 91 349 53 04	Authorized officer B. Aragón Urueña Telephone No. 91 3493277

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2018/000072

C (continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category *	Citation of documents, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

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