



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.10.2006 Bulletin 2006/40

(51) Int Cl.:
C10G 1/10 (2006.01) C10G 9/00 (2006.01)
C10G 11/00 (2006.01) C10B 53/07 (2006.01)

(21) Application number: **05460034.1**

(22) Date of filing: **06.12.2005**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI
SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **06.12.2004 PL 37156404**

(71) Applicant: **Osrodek Badawczo-Rozwojowy**
Przemysłu Rafineryjnego
09-411 Plock (PL)

(72) Inventors:
• **Konopka, Mirosław**
09-400 Plock (PL)

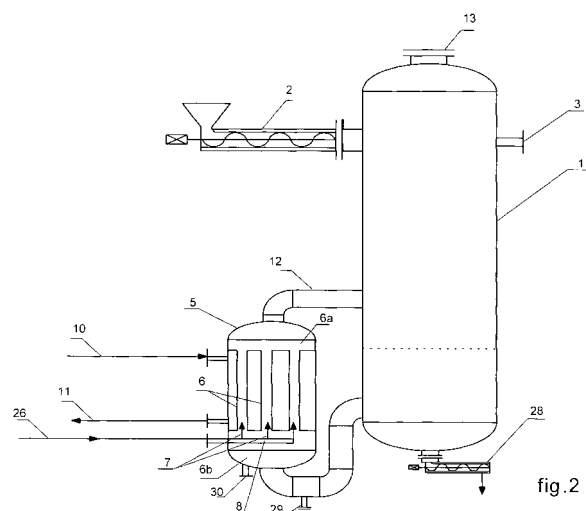
- **Maciukiewicz-Sosnowska, Lilia**
09-403 Plock (PL)
- **Chrapek, Tadeusz**
09-400 Plock (PL)
- **Packowski, Zbigniew**
09-403 Plock (PL)
- **Kempinski, Roman**
09-400 Plock (PL)
- **Fila, Wiesława**
09-400 Plock (PL)
- **Szumacher, Sławomir**
09-403 Plock (PL)

(74) Representative: **Rumpel, Alicja**
Al. Smiglego-Rydza 29/11
93-281 Lodz (PL)

(54) **Thermal or catalytic cracking process for hydrocarbon feedstocks and corresponding system**

(57) The process of cracking is conducted within the reaction system embracing the first reaction zone and the second reaction zone; hydrocarbons feedstock in a liquid state is introduced into the first reaction zone where such a temperature is maintained which enables running of cracking reaction. The liquid reaction mixture from the lower part of the first zone flows into the lower part of the mentioned second zone, where the reaction mixture flowing in from below is divided in numerous streams flowing upwards. Into every of such liquid streams, a stream of gas is introduced from below which, along with the reaction mixture, forms a liquid-gas mixture which is heated when flowing upwards by indirect exchange of heat with the heating medium and then the heated mixture flowing out up above from the mentioned second zone is turned back into the first reaction zone. Cracking products are carried away from the upper part of the first zone.

The system for hydrocarbons feedstock processing contains the tank-type reactor (1) and the tubular reactor (5). The tubular reactor is provided with the parallel tubes (6) mounted in the casing and directed from below to the top. The tank-type reactor is connected with the tubular space of the tubular reactor by the means of bottom pipe (4) and upper pipe (12). Each tube (6) has a small tube (7) installed on its lower end, with an inlet directed in principal coaxially to the tube's (6)



Description

[0001] The subject-matter of the invention is the technology of hydrocarbons feedstock processing using the method of thermal or catalytic cracking and the installation of hydrocarbons feedstock processing based on the method of thermal or catalytic cracking designed for hydrocarbons with lower molecular weights. Both the technology and the installation are useful especially in processing of waste raw-materials - used ones, impure or being the residues received in various technological processes. Such raw-materials contain waste plastics, including polyethylene, polypropylene, polystyrene and polyvinyl chloride (PVC), used lubricating oils and lubricants, distillation residues, impure heavy hydrocarbon fractions of various origin or used and fresh vegetable and animal fats as applicable in production of fuels.

[0002] Along with a continuous growth in production and consumption of oil products, also problems referring to volumes of waste received in processes of their application and usage are becoming much more important. Irrespectively of the fact whether these are liquid, semi-solid or solid wastes, their storage is very problematic, and their deposition on waste dumps is harmful and dangerous to the environment. Noxiousness of plastics waste storage on waste dumps is additionally connected with the fact, that they have a large volume in relation to their mass and that they are impervious to degradation and thus they can be deposited on waste dumps in a generally unchanged form (especially when in the dark) for over tens or even hundreds of years.

[0003] Taking into consideration the fact that permissions to storage waste as well as conditions of such storage are submitted to still much more severe administrative regulations dictated by the necessity to protect the environment and stipulating substantial financial burdens connected with wastes, various methods of waste utilization and waste management are most commonly introduced into the industrial practices. These methods differ in economic effectiveness as well as technological advancement and they embrace the most simple, uneconomic, non-ecological methods consisting in combustion of waste, utilization of waste as an energy carrier and its usage as a fuel in production processes (e.g. in cement plants), used products regeneration enabling to restore their original features, re-processing (in case of plastics) in order to obtain finished products; at last but not least - the above methods contain also methods consisting in conversion of waste into high-value hydrocarbon products received in such processes as hydro cracking, thermal and catalytic cracking. During the processes of hydro cracking, thermal or catalytic cracking bond cleavage occurs to raw-materials molecules and the mixture of hydrocarbons with lower molecular weights is received. The most required products in the process are hydrocarbons fractions corresponding to petrol fractions and diesel oil fractions.

[0004] Technologies of processing of hydrocarbons

feedstock such as the above mentioned waste and used oil products, using the methods of thermal and/or catalytic cracking as well as installations based on such methods, are known from numerous patent descriptions. The inventions presented in respective descriptions refer to different aspects of the above process and differ one from each other in a kind of the applicable catalysts, methods of preparation and raw-material feed, the way of heat supply to the process, systems of equipment and construction of the basic equipment designed for the installation.

[0005] Technologies of processing of hydrocarbon feedstock such as the above mentioned waste of polyolefin's plastics using the methods of thermal and/or catalytic cracking as well as installations based on such methods are known from numerous patent descriptions. The inventions presented in respective descriptions refer to different aspects of the above process and differ one from each other in a kind of the applicable catalysts, methods of preparation and raw-material feed, the way of heat supply to the process, systems of equipment and construction of the basic equipment designed for the installation.

[0006] In the description of the German patent No 100 49 377 the technology as well as the installation for production of diesel oil and petrol (but mainly diesel oil) by cracking of mixtures composed of various kinds of used oils and lubricants, mineral and biological oils, heavy oils being distillation residues with the addition of plastics waste has been presented. The oil products submitted to processing have the boiling point within the range of 350-550°C. The sodium aluminosilicate is being used as a catalyst. The process itself is conducted under such conditions, in which a part of the reaction mixture from the reactor equipped with a mechanical mixer passes through a tubing into the inter-tubular space of the jacket - tubular vaporizer; then - the reaction mixture is heated by combustion gas having a very high temperature equal to 1100-1200°C at the inlet to vaporizer tubes and through the tubing is turned back to the reactor enabling to maintain the temperature in the reactor at the level of 410-460° C. In order to stabilize reaction and operation of the vaporizer, a low pressure of 30-150 millibars generated in a vacuum pump is employed. The combustion gas is produced during combustion of solid, liquid or gas fuels; at the same time impurities collected at the bottom of the reactor are introduced into the combustion chamber situated in the lower part of the vaporizer. Directly on the reactor, the fractionating column for products is situated centrically.

[0007] In the description of the Polish patent application No 345291, the method has been presented consisting in running of the process in the reactor equipped with the mechanical mixer situated in the lower part of it and with the tubular heat exchanger built in the upper part of the said reactor. Additionally, the reactor is equipped with the heating jacket provided with burners producing combustion gas, which are installed in the upper part of the

jacket. Disintegrated plastics waste is introduced into the lower part of the reactor whereas the products of cracking are received at the top, above the exchanger. Hot combustion gas constituting source of heat supplied to the reactor is flowing first through the inter-tubular space of the vaporizer and then - through the jacket space of the outer heating jacket. The reaction mixture fills the lower part of the reactor containing the mixer as well as the upper part containing the heat exchanger.

[0008] The subject-matter of the invention as referred to in the Polish patent application No 332762 is conversion of polyolefin's waste at the temperature not exceeding 600°C and in the presence of the specified catalysts. The reactor (similarly to the other discussed solutions) is heated by means of indirect exchange of heat with hot combustion gas. At the bottom, the reactor is surrounded by the combustion chamber provided with burners, in which the fuel obtained as the product of reaction is being burnt; from the combustion chamber passage heating tubes are led out passing through the reactor inside and through which combustion gas from the combustion chamber is flowing out. The reactor is provided with the mixer.

[0009] The subject-matter of the invention as referred to in the Polish patent application No 337413 is the processing of liquid fuels with waste of polyolefin's plastics; the essence of the invention is application of the mixture composed of wastes and technological oil (most frequently - the used one) as a raw-material, mixed according to the weight ratio of oil to plastics waste as 100: 1 to 1: 1, as well as the equipment for melting of wastes before their mixing with oil.

[0010] In the Polish patent application No 354272 also referring to the cracking of waste plastics into liquid fuels the reactor has been presented, in the inside of which at least one heating element is mounted having a form of a heating tube of a curvilinear shape and the appropriate length and diameter. At the inlet to the heating tube, the burner to produce combustion gas is mounted; the received combustion gas, when passing through the tube, heats the reaction mixture in the reactor. The construction of the heating element limits (as it has been referred to in the description) the effect of coke settling and - in the event of coking - the element itself can be easily cleaned or replaced.

[0011] The goal to be attained in numerous technical solutions with respect to the processes of thermal or catalytic cracking of plastics waste and heavy hydrocarbons feedstock not suitable for processing in other known technological processes is to design the process characterized by effectiveness sufficient to guarantee an economic profitability of the process after its implementation on the industrial scale. The effectiveness of the process depends on efficiency of the main products i.e. petrol fraction and diesel oil fraction as well as on costs incurred for their production. The essential factor reflecting on the level of costs is consumption of energy during the process as well as duration of time, over which the installation is

under continuous operation.

[0012] The serious problem disturbing the continuous operation of the installation and causing the increased consumption of energy and decrease in selectivity of reaction aimed at obtaining of the most required products is that connected with the phenomenon of obtaining the coke as one of the cracking products. The coke is created and deposited mainly on surfaces of the heat exchange between the heating medium and the reaction mixture.

5 The term "reaction mixture" determines the mixture of melted plastics and/or other processed hydrocarbons feedstock as well as products with a different degree of cracking, which is contained within the process system.
10 This mixture, especially when processing of plastics or other raw-materials with plastics, is characterized by high viscosity and low heat conduction. These features require the special technical solutions with respect to supplying the heat into the mixture (in its entire mass) in such a volume, which is indispensable to conduct endothermic reactions of cracking as well as to force the mixture
15 through heat exchangers of various types in order to heat it. A gravitation flow of the mixture through the exchangers is often applicable, which can be possibly supported by employment of the additional pressure. In order to
20 achieve the quicker heat transfer between the heating medium and the reaction mixture it is also necessary to maintain a high temperature of the heating medium in relation to the temperature of the reaction mixture. The larger is the difference in temperatures, the more intensive is creation and deposition of coke on the heat exchange surface. The settling of coke causes reduction in heat exchange rates and thus, in order to compensate it and ensure an inflow of the sufficient volume of heat into the reaction mixture, the heating medium temperature
25 should be increased. This, on the other hand, will result in an accelerated settling of coke and, at last, will lead to switching off the installation in order to remove the gathered deposits of coke. The well-known solutions target is to design installation and equipment of such structure and construction so that works connected with cleaning
30 of the installation will be much more easy and simple to complete during a short time. Nevertheless, it does not change the fact, that the necessity to switch off the installation and its repeated switching on causes much inconvenience.
35

[0013] New technological solutions are being sought for all the time, application of which could result in lowering of consumption of process energy, increase in productivity of petrol fractions and diesel oil fractions as well as in facilitating and simplifying of exploitation services referring to the process in question, running of which is not easy in the industrial practice.

[0014] The method according to the invention consists in that the cracking process is conducted under the reaction system containing the first reaction zone and the second reaction zone. Into the first zone hydrocarbons feedstock in a liquid state is introduced and - in the case of catalytic process - also a catalyst. In this zone the
40
45
50
55

temperature specific for running of a cracking reaction is maintained, and obtained products in a form of vapours are carried away from the upper part of the first reaction zone. On the other hand, the liquid reaction mixture from the lower part of the first zone flows into the mentioned second reaction zone situated near by; the formed liquid-gas mixture is heated when flowing upwards by indirect exchange of heat with the heating medium and then the heated mixture flowing out up above from the mentioned second zone is turned back into the first reaction zone, preferably above the level of the liquid reaction mixture where the reaction mixture flowing in from below is divided in numerous streams flowing upwards. Into every of such liquid streams, a stream of gas is introduced from below which, along with the reaction mixture, forms a liquid-gas mixture closed in this zone. The products carried away up above from the first zone are submitted to fraction separation. Preferably, the products of reaction are at first separated into hydrocarbons fraction with the boiling point of up to 350°C and hydrocarbons fraction with the boiling point of over 350°C. The boiling fraction of over 350°C is turned back into the reaction system, preferably to the first reaction zone. The boiling fraction of up to 350°C contains petrol fractions and diesel oil fractions.

[0015] The system according to the invention designed for processing of hydrocarbons feedstock consists of the tank-type reactor and tubular reactor provided with an inlet for feeding raw-material and catalyst, an outlet for receiving products from the upper part of the reactor and an outlet for receiving impurities from the lower part of the reactor. The tubular reactor situated next to the tank-type reactor is provided with parallel tubes mounted in the casing and directed from below to the top. These tubes along with the lower chamber combining the lower open ends of the above tubes and with the upper chamber combining the upper open ends of the tubes form a separate tubular space, which is connected with the tank-type reactor by means of pipes. One pipe connects the lower part of the tank-type reactor with the lower chamber of the tubular space, whereas the second pipe connects the upper chamber of the tubular space with the tank-type reactor, where the inlet of the mentioned second pipe leading to the tank-type reactor is situated above the mentioned lower part of the said reactor. Each tube of the tubular reactor has a small tube installed on its lower end, with an inlet directed into the tube's inside and in principal - coaxially to the tube's surface; the diameter of the small tube is significantly less than the diameter of the tube. Small tubes are led out from the common collector. The casing of the tubular reactor has accordingly an inlet and an outlet to feed and carry away the heating medium. The tubular reactor in its lowest point of the tubular space may be additionally provided with an outlet for removal of impurities.

[0016] Combustion gas used as the heating medium may be produced by combustion of fuels in a separate furnace or by combustion in appropriate burners mount-

ed in the casing of the tubular reactor.

[0017] The application of the method according to the invention makes it possible to unexpectedly efficiently eliminate problems and noxiousness connected with the said process. Thanks to the introduction of gas into the streams of the reaction mixture at the inlet to the tubes of the tubular reactor constituting the second reaction zone and the following formation of the mentioned liquid-gas mixture characterized by the lower mean specific gravity than the weight of reaction mixture flowing in from the first reaction zone, in the second zone the flow rate of the mixture moving upwards is increased and a specific circulation of the reaction mixture is arranged within both zones; respectively also effectiveness of heat reception from the heating medium as well as the effectiveness of heat transfer to the first reaction zone is increased. Next, in order to feed the reaction system with the necessary heat volume it is enough to apply the heating medium with moderately high temperatures. This enables to avoid occurrence of large differences in temperatures on a surface of the heat exchange what causes undesirable phenomenon of coking. The reaction mixture in the second reaction zone is usually heated up to the temperature by 2 up to 50°C higher than the temperature maintained within the first reaction zone. It turned out also that a favourable change of the character of flow and heat exchange in the second reaction zone can be reached with a relatively smaller volume of gas introduced into the reaction mixture flowing in from the first reaction zone.

[0018] The gas applied to form a liquid-gas mixture in the second reaction zone may be the gas being a product of the cracking process or the gas originating from any other source e.g. natural gas, liquefied petroleum gas, vaporized light hydrocarbons including hydrocarbons received in the cracking process or inert gases not containing oxygen. The gas introduced into the reaction mixture does not require any preheating; for example, it can have a temperature equal to the ambient temperature or, in the case of gas received by means of hydrocarbons vaporization, equal to the vaporization temperature.

[0019] The heating medium in the second reaction zone is combustion gas obtained as a result of combustion in burners using the gas being the product of cracking or combustion of any other fuel originating from outer sources, including also solid fuels. The hot combustion gas in the second reaction zone is passed co currently or counter-currently (preferably counter-currently) in relation to the direction of flow of the liquid-gas mixture. The source of heat fed in the second zone may be also electric energy.

[0020] The positive results obtained following the process conducted with the application both of the method and the system according to the invention are due to: high productivity of the most valuable target products, low consumption of energy and long periods of continuous operation of the installation free from any disturbances caused by settling of coke on the surface of any equipment.

[0021] The method according to the invention, which can be completed with the application of the system according to the invention, is suitable for processing of a wide range of hydrocarbons feedstock: used lubricating oils and lubricants, residues obtained in various technological processes, distillation residues, vegetable fats and animal fats both used and fresh applicable in production of fuels as well as plastics waste, the most difficult mixtures to process. The process according to the invention is suitable for processing mixtures of polymer wastes such as: polyethylene, polypropylene, polybutene, polystyrene. The mixture of wastes submitted to processing may contain some quantity of other plastics such as e.g. ethylene polyterephthalate as well as multi-layer products containing, despite the above mentioned, also other kinds of polymers such as: polyamides or polyesters and these containing layers of glue, paper or layers of thin foil or sprinkled with powder e.g. aluminium. Of course, the way of waste preparation (e.g. disintegration, washing and drying) should correspond to the kind of waste and degree of its impurity. All materials which will be not cracked, will fall down to the bottom of the cracking installation and will be removed by means of the appropriate equipment.

[0022] The process according to the invention envisaging the system for removal of chloride and chloroorganic compounds out of cracking products, may be applied in processing of raw-materials containing chloride such as polyvinyl or any other waste hydrocarbons feedstock containing this element. In order to remove chloride and chloroorganic compounds any well-known method can be applied.

[0023] The method and the system according to the invention is also applied in hydrocarbons feedstock processing using the method of the catalytic cracking conducted in the presence of hydrogen.

[0024] The method and the system according to the invention is presented more particularly in the example referring to the drawings where Fig.1 presents schematic technological installation containing the system of hydrocarbons feedstock processing based on the cracking method whereas Fig.2 presents the system of hydrocarbons feedstock processing based on the cracking method.

Example:

[0025] The installation presented in the Fig.1 is applied to conduct processing of plastics waste or other hydrocarbons feedstock of any consistence, both liquid and solid ones, or mixtures of both above mentioned kinds of raw-materials. Raw-materials in a liquid state are introduced into the tank-type reactor 1. Raw-materials, which have been disintegrated and dried and then melted in the electrically heated extruder (shown in the Fig.2) are introduced into the reactor 1 through the inlet 2. Other raw-materials after their melting (where it is required taking into consideration the kind of raw-material submitted

to processing) are introduced into the reactor 1 by the inlet 3. The catalyst is introduced into the reactor together with the raw-material. In the reactor 1, the temperature of 350-450°C is maintained. The reaction mixture flows in from the lower part of the reactor 1 through the pipe 4 into the tubular reactor 5. The reaction mixture flows in into the reactor 5 from below, into the lower chamber 6a and then flows at the top through the vertical tubes 6 to the reactor. The stream of gas being the product of the process, is introduced into the reaction mixture through each tube 6 at its lower end. The gas is introduced by means of small tubes 7 mounted in such a way that their outlets are directed towards the tubes 6 inside and gas is flowing out from them vertically upwards. The inlet ends of the small tubes 7 are connected with the collector 8. The gas and the reaction mixture form the liquid-gas mixture which, when flowing upwards through the tubes 6, is heated thanks to indirect exchange of heat with combustion gas. The hot combustion gas is obtained by combustion of gas being the product of the process in the furnace 9. The combustion gas is introduced into the inter-tubular space of the reactor 5 through the pipe 10 and is carried away from the reactor through the pipe 11.

The combustion gas is flowing counter-currently in relation to the direction of flow of the liquid-gas mixture. The heated mixture is received through the pipe 12 from the upper chamber 6b of the tubular reactor 5 and is turned back to the tank-type reactor 1. The products of cracking are received at the top, from the tank-type reactor, and through the pipe 13 are introduced into the column 14, where they are separated into the first portion containing hydrocarbons boiling at the temperature of up to 350°C and into the second portion - containing hydrocarbons boiling at the temperature of over 350°C. The second portion as mentioned above is turned back into the tank-type reactor (as a whole or a part of it) using the pump 15 and the pipe 16. The first portion as mentioned above is cooled in the air cooler 17 and through the pipe 18 is introduced into the separator 19, where liquid products are separated from gas products. The liquid products constituting the main product of the process are the hydrocarbons mixture with the boiling point range corresponding to that of petrol fractions and diesel oil fractions. They are passed to the storage tank 22 through the pump 20 and the pipe 21. These products are next submitted to further processing consisting mainly in separation and hydrogenation (on spot or at the consignee). A part of the liquid product from the separator 19 is passed as a reflux to the column 14 through the pipe 23. The gas products from the separator 19 are suck in and slightly compressed by means of the blower 24 and then, through the pipe 25, they are introduced into the furnace 9 in order to produce combustion gas whereas through the pipe 26 they are introduced into the tubular reactor 5 in order to produce liquid-gas mixture; through the pipe 27 they are introduced into the column 14 as the stripping gas. Impurities collected at the bottom of the tank-type reactor 1 are removed by means of the equipment 28.

Impurities, which may possibly be collected also at the lowest point of the pipe 4 and/or at the bottom of the chamber 6a, may be removed through the outlets 29 and 30.

Claims

1. The technology of hydrocarbons feedstock processing using the method of thermal or catalytic cracking of such raw-material in order to receive hydrocarbons with lower molecular weights and consisting in that the cracking reaction is conducted in the mass of the liquid hydrocarbons feedstock under conditions specific for running such a reaction and in the presence of the catalyst or without it, when the gas-steam mixture of reaction products is received and **characterized in that** the process of cracking is conducted within the reaction system embracing the first reaction zone and the second reaction zone; hydrocarbons feedstock in a liquid state is introduced into the first reaction zone where such a temperature is maintained which enables running of cracking reaction; vapours of cracking products are carried away from the upper part of the first zone whereas the liquid reaction mixture from the lower part of this zone flows into the lower part of the mentioned second zone, where the reaction mixture flowing in from below is divided in numerous streams flowing upwards. Into every of such liquid streams, a stream of gas is introduced from below which, along with the reaction mixture, forms a liquid-gas mixture which is heated when flowing upwards by indirect exchange of heat with the heating medium and then the heated mixture flowing out up above from the mentioned second zone is turned back into the first reaction zone and the vapours of products as carried away up above from the first zone are submitted to separation.
2. The method according to the claim 1 and **characterized in that** the gas as introduced into the liquid streams of the reaction mixture in the second reaction zone is the gas being a product of the cracking process or the gas originating from any other source e.g. natural gas, liquefied petroleum gas, vaporized light hydrocarbons including hydrocarbons received in the cracking process or inert gases not containing oxygen.
3. The method according to the claim 1 and **characterized in that** the heated liquid-gas mixture from the second reaction zone is introduced into the first reaction zone above the mentioned lower part of the first reaction zone; from this lower part the reaction mixture flows into the second reaction zone.
4. The method according to the claim 3 and **characterized in that** the heated liquid-gas mixture from

the second reaction zone is introduced into the first reaction zone above the level of the liquid reaction mixture closed in this zone.

5. The method according to the claim 1 and **characterized in that** in the first reaction zone the temperature ranging from 350°C up to 450°C is maintained.
6. The method according to the claim 1 and **characterized in that** the heating medium is passed cocurrently or counter-currently in relation to the direction of flow of the liquid-gas mixture.
7. The method according to the claim 1 or 4 and **characterized in that** the hot combustion gas is the heating medium.
8. The method according to the claim 5 and **characterized in that** the combustion gas is obtained as a result of combustion of gas being the product of cracking or combustion of any other fuel originating from other sources, including also solid fuels.
9. The method according to the claim 1 and **characterized in that** vapours of cracking products, which are carried away from the upper part of the first reaction zone, are separated into hydrocarbons with the boiling point of up to 350°C and hydrocarbons with the boiling point of over 350°C.
10. The method according to the claim 9 and **characterized in that** hydrocarbons with the boiling point of over 350°C are turned back to the reaction system, preferably to the first reaction zone.
11. The method according to the claim 1 and **characterized in that** the following hydrocarbons feedstock is submitted to processing: plastics waste, used lubricating oils and lubricants, distillation residues, residues received in various technological processes, vegetable and animal fats (both used and fresh).
12. The method according to the claim 1 or 11 and **characterized in that** hydrocarbons feedstock is submitted to processing with the application of the method of catalytic cracking conducted in the presence of hydrogen.
13. The system for hydrocarbons feedstock processing using the method of thermal or catalytic cracking as designed for hydrocarbons with lower molecular weights and **characterized in that** it contains the tank-type reactor (1) and the tubular reactor (5) situated one next to each other; the tank-type reactor is provided with the inlets to feed raw-materials and a catalyst, the outlets to carry away the products and remove impurities whereas the tubular reactor is provided with the parallel tubes (6) mounted in the cas-

ing and directed from below to the top. These tubes along with the lower chamber (6a) combining the lower open ends of the above tubes and with the upper chamber (6b) combining the upper open ends of the tubes form a separate tubular space in the casing, which is connected with the tank-type reactor (1) by means of pipes in such a way, that one pipe (4) connects the lower part of the tank-type reactor with the lower inlet into the tubular space, whereas the second pipe (12) connects the upper outlet from the tubular space with the tank-type reactor, where the inlet of the mentioned second pipe (12) leading to the tank-type reactor is situated above the mentioned lower part of the said tank-type reactor (1). Each tube (6) of the tubular reactor has a small tube (7) installed on its lower end, with an inlet directed in principal coaxially to the tube's (6) surface; inlet ends of the small tubes are connected with the collector (8); the diameter of the small tubes (7) is significantly less than the diameter of the tubes (6); the casing of the tubular reactor has accordingly an inlet and an outlet to feed and to carry away the heating medium.

14. The system according to the claim 13 and **characterized in that** the tank-type reactor (1) is a vertical, cylindrical tank.
15. The system according to the claim 13 and **characterized in that** the tubular reactor (5) has the casing provided with the inlet and outlet stub pipes.
16. The system according to the claim 13 and **characterized in that** the tubular reactor (5) has the casing with at least one burner and with the outlet stub pipe mounted in it.

40

45

50

55

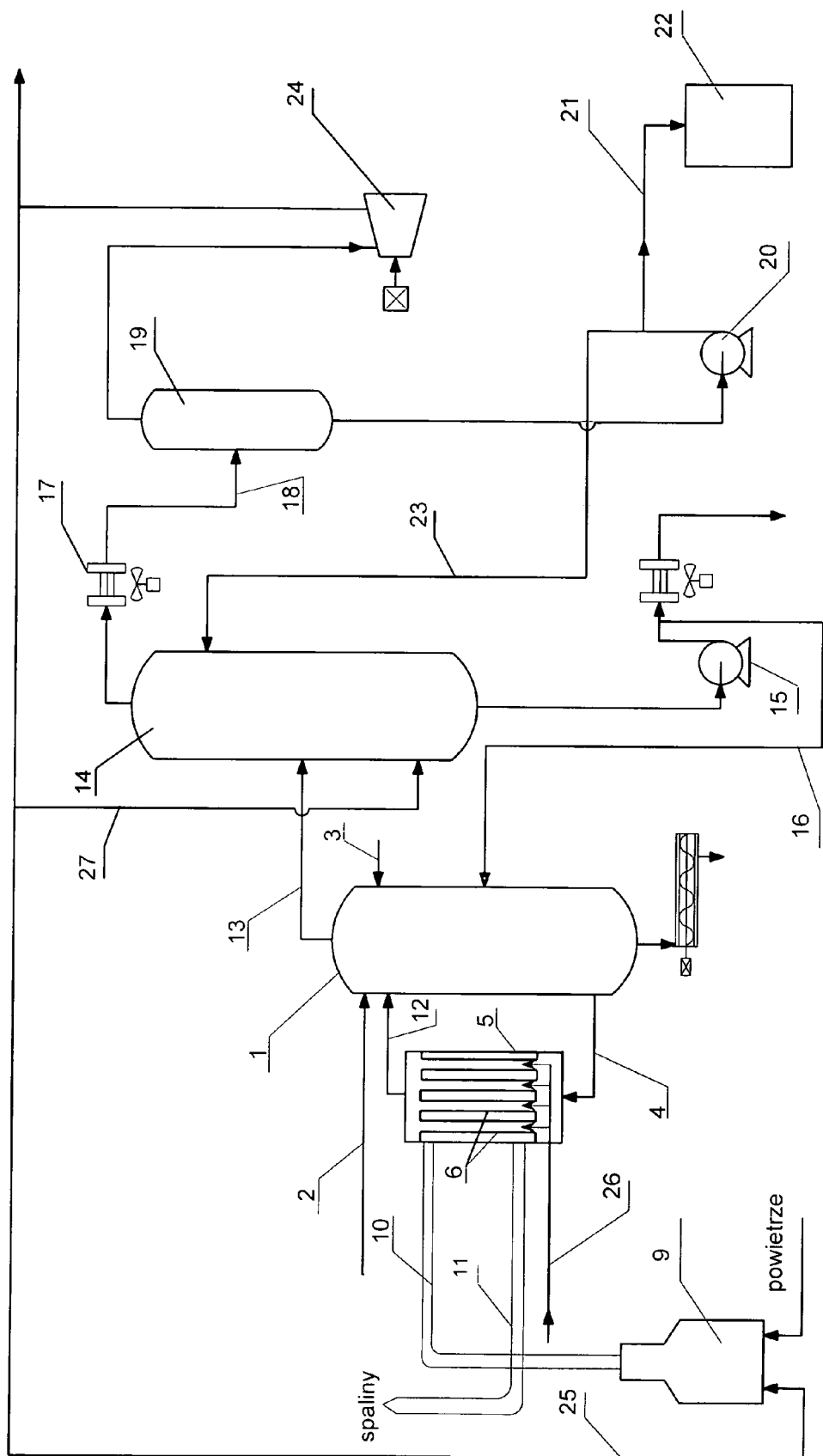
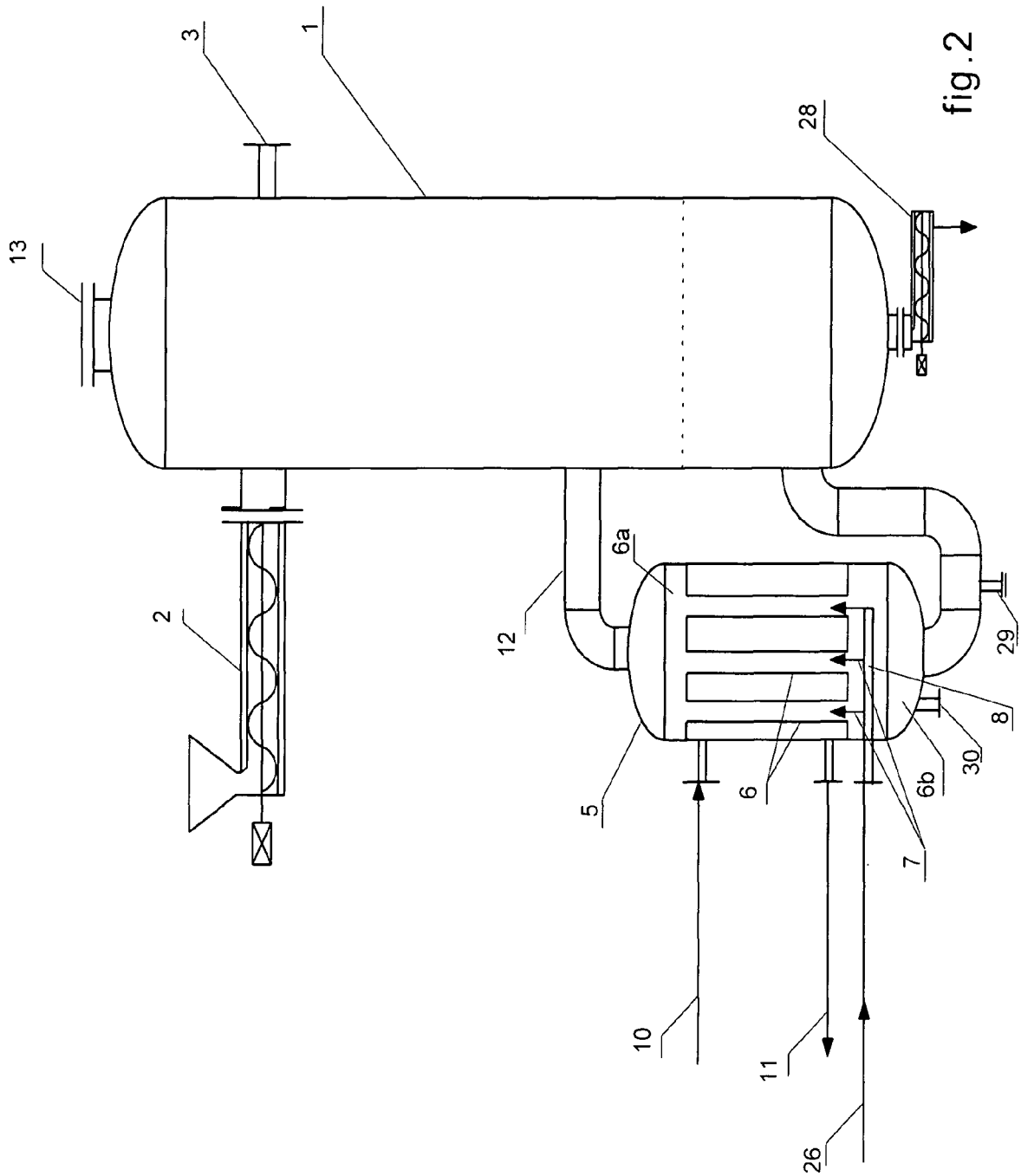


fig.1





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 46 0034

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
D,Y	DE 100 49 377 A1 (EVK DR. OBERLAENDER GMBH & CO KG) 18 April 2002 (2002-04-18) * column 1, paragraph 1; figure 1 * * column 2, paragraphs 13,14 * * column 3, paragraph 18-20 * * column 9, paragraph 71 * -----	1-16	C10G1/10 C10G9/00 C10G11/00 C10B53/07
Y	US 3 108 048 A (MCDONALD GERALD W. G) 22 October 1963 (1963-10-22) * figure 1 * * column 1, lines 33-40 * * column 2, lines 5-33 * * column 3, lines 49-71 * -----	1-16	
A	DE 41 12 977 A1 (GFK GESELLSCHAFT FUER KOHLEVERFLUESSIGUNG MBH, 6600 SAARBRUECKEN, DE;) 22 October 1992 (1992-10-22) * figure * * column 2, line 39 - column 3, line 17 * -----	1-16	
A	FR 2 675 499 A (INSTITUT FRANCAIS PETROLE; INST FRANCAIS DU PETROL) 23 October 1992 (1992-10-23) * figure * * page 7, lines 14-30 * * page 8, lines 19-25 * -----	1-16	TECHNICAL FIELDS SEARCHED (IPC) C10G C10B B01J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 March 2006	Examiner Harf, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

4
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 46 0034

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-03-2006

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10049377	A1	18-04-2002	NONE
US 3108048	A	22-10-1963	NONE
DE 4112977	A1	22-10-1992	NONE
FR 2675499	A	23-10-1992	NONE

EPO FORM P0459

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