**Title:** THE METHOD OF THERMOCATALYTIC DEPOLYMERIZATION OF WASTE PLASTICS, A SYSTEM FOR THERMOCATALYTIC DEPOLYMERIZATION OF WASTE PLASTICS AND A REACTOR FOR THERMOCATALYTIC DEPOLYMERIZATION OF WASTE PLASTICS

According to the method of thermocatalytic depolymerization of waste plastics, in the thermocatalytic reactor (6) the reaction mixture in liquid state is stirred and separated into at least two layers, situated at different levels, whereby each of these layers is heated up irrespective of the other, using heating elements principally oriented crosswise with respect to the vertical axis of the reactor, in a favourable embodiment in the form of electric heaters (10) placed in protective tubes grouped in bundles, in a favourable embodiment stabilized with inert gases or metal oxides. A system for thermocatalytic depolymerization of waste plastics is comprised of a secondary depolymerization device (21), in which gaseous products of a catalytic reaction collected from thermocatalytic reactor (6) are subject to depolymerization, whereby the device is connected to the reactor via a connector pipe supplying gaseous products (20) and is connected to fraction condenser (24) via a connector pipe collecting gaseous products (22). A reactor is fitted at least one upper level for dispensing the reaction mixture, located above the reaction mixture surface contained at the bottom of the body (7), which level has the form of perforated dispensing trays (13) or dispensing troughs located crosswise with respect to the vertical axis of the body (7), whereby the reaction mixture at each level has separate heating with heating elements (10) situated in planes which are crosswise to the vertical axis of the body (7), immersed in the bottom layer of the reaction mixture and as close as possible above or below dispensing trays (13), whereby the device used for stirring and raising the liquid to dispensing trays is an electrically driven mixing pump (12), situated to the reactor bottom.
The method of thermocatalytic depolymerization of waste plastics, a system for thermocatalytic depolymerization of waste plastics and a reactor for thermocatalytic depolymerization of waste plastics

The invention relates to a method of thermocatalytic depolymerization of waste plastics, a system for thermocatalytic depolymerization of waste plastics and a reactor for thermocatalytic depolymerization of waste plastics. The method, system and reactor are particularly suitable for depolymerization of polyolefins and polystyrene.

A system is known from the Polish Patent Specification PL 188936 for transforming polyolefin waste into liquid hydrocarbons. The system has a reactor, in the form of a vertical storage silo, provided with a feed hopper connected to a device for dosing polyolefin raw material and a catalyst, an exhaust pipe for waste gas, a connector pipe for collecting the product, a mixer and a screen, as well as a heating system in the form of a combustion chamber surrounding the reactor silo from the bottom. The combustion chamber is heated with at least one burner supplied with reaction products. The reactor has a heating system in the form of a combustion chamber surrounding it from the bottom, heated, in a favourable embodiment, with at least one burner supplied with reaction products, whereby in the combustion chamber, symmetrically along the perimeter of the reactor, in a favourable embodiment in several rows, there are pass-through heating pipes, which pass through the interior of the reactor above the top edge of the mixer, and further through the screen to the exhaust chamber for waste gas. The system furthermore contains a product condenser, a buffer tank for raw material and a distillation column. The buffer tank has a level sensor, which is integrated with an automatic control system for the device which dispenses raw material into the reactor.

Finely divided polyolefin material, along with a catalyst of the group comprising cements, heavy metal silicates and heavy metal resinites, are fed into the reactor, where they are gradually heated to the maximum temperature of 600°C. Reaction products discharged through the pipe for collecting the product from the reactor are steered to the condenser, where they are cooled and condensed, and then steered to the buffer tank, heated to 40°C. From the buffer tank the crude product is steered to the distillation column, where it is separated into fractions of different boiling temperatures. The
product thus obtained may serve as a raw material for producing petrol, gas oil or eco heating oil.

A reactor unit is known from the Polish Patent Application P-352344 for continuous thermocatalytic transformation of waste plastics, in particular polyolefin plastics, equipped with a heating unit with a combustion chamber with at least one burner and a thermocatalytic reactor with a catalyst. The combustion chamber is made of refractory ceramics, has a burner inside, which burns the gas used for sawdust gasification and is placed in a casing made of pearlite brick and mineral wool and is protected with steel sheet on the outside. In the top part of this casing there is an intermediate heating chamber equipped with heating partitions made of cast iron grid resting on chamotte supports. Above the intermediate heating chamber there is a double-sloping bottom of the catalytic reactor. The catalytic reactor has the form of a horizontal vessel of a channel cross section with the web facing upwards, and has an upper chamber and two side chambers. The upper chamber houses a cooler channel which further turns into a channel discharging the volatile fractions into the cooler. The cooler channel has an escapement for condensed gases. The lower part of the reactor vessel is a tank with double-sloping bottom.

A method is known from the Polish Patent Application P-356491 for continuous processing of olefin plastic waste into a mixture of unsaturated and saturated hydrocarbons, in which the charge is portioned, put in the processing line in a continuous fashion under pressure, plasticized in a melting crucible, pressed into an exchanger, liquefied, transformed catalytically with a catalyst distributed evenly in the reaction material, discharged in gaseous form into a cooler and then condensed. The plasticized charge is melted in the exchanger and then moved gravitation-wise into a stabilizer.

A method is known from the Polish Patent Application P-358774 for continuous processing of polyolefin plastic waste into a mixture of unsaturated and saturated hydrocarbons, which form a high quality paraffin, in which the charge is fed continuously, plasticized in a melting crucible, liquefied and transformed thermocatalytically, whereby the whole process from charging to collecting gaseous product and removing pollution is pursued in one stage in one inner vessel of an integrated vertical melter-exchanger-reactor device, and a homogeneous block of charge material is made from the plasticized and liquefied charge, which falls gravitation-wise.
A characteristic feature of the device used for processing as per this method is that it is a modular integrated vertical melter-exchanger-reactor device in which the whole process is pursued in one stage, from charging to removing pollution, in one inner vessel. The charge is fed through a feed hopper, the gaseous product is collected through a channel in the vessel bottom and pollution accumulates in a tank located outside the vessel.

A device is known from the Polish Patent Application P-372777 for thermal depolymerization of waste plastics in the form of a reactor equipped with turbine mixers and bundles of heating pipes which are distributed alternately in a long, narrow and flat case and are constantly below the surface of melted plastic supplied to the device through a collecting pipe. Heating pipes are supplied with a liquid with the temperature of 500°C, in a favourable embodiment fusible metal, e.g. Wood's alloy. Among mixers and bundles of heating pipes there are vertical partitions which do not touch the sides of the reactor, and ensure longitudinal flow of the liquid in the heater. A multisegment vapour condenser is coupled with the reactor and is equipped with vertical pipe exchangers grouped in sections equipped with individual fan coolers. Each section has a different liquid as a cooling agent, with the temperature ensuring condensation of the selected fraction.

The method of thermal depolymerization of waste plastics consists in selective condensation of some fractions with high boiling temperatures from depolymerization product vapours, and this liquid is mixed with new portions of plastics in proportions and at temperatures which ensure they will not undergo depolymerization and will not harden when cooled to ambient temperature; further on they are placed again in the reactor and depolymerized in a layer as thin as possible, in sections of heating pipes supplied with a liquid with the temperature of up to 500°C, in a favourable embodiment with a fusible material, especially Wood's alloy.

The efficiency of the processes known to date usually amounts to approx. 60% of the merchandise compared to charge.

It is an object of the invention relating to the thermocatalytic depolymerization of waste plastics, in particular polyolefin plastics, to a mixture of unsaturated and saturated hydrocarbons, in which finely divided raw material is plasticized in a melting crucible, liquefied by heating and transformed catalytically in a thermocatalytic reactor in the presence of a catalyst, and reaction products in gaseous form are discharged to a
fraction condenser, where they are cooled, condensed and separated into fractions of
different boiling temperatures to have, in the thermocatalytic reactor, the reaction
mixture in liquid state stirred and separated into at least two layers, situated at different
levels, whereby each of these layers is heated up irrespective of the other, using heating
elements principally oriented crosswise with respect to the vertical axis of the reactor, in
a favourable embodiment in the form of electric heaters placed in protective tubes
grouped in bundles, in a favourable embodiment stabilized with inert gases, in a
favourable embodiment CO₂ or metal oxides. In a favourable embodiment, the reaction
mixture is stirred, separated and raised using a mixing pump, in a favourable
embodiment a high performance positive-displacement propeller pump, whereby the
mixture is fed into perforated dispensing trays or dispensing troughs, located above the
mixture bottom layer surface, crosswise with respect to the vertical axis of the reactor.
In a favourable embodiment, kinetic and thermal energy of the reaction mixture is
supported by bubbling, using CO₂ or other inert gas, whereby, in a favourable
embodiment, gas from the stabilizing circuit of electric heaters is used. In a favourable
embodiment, products in gaseous form obtained from the catalytic reaction, before
being fed into fraction condenser, are passed through a porous catalyst layer, in a
favourable embodiment in the form of a granulated product, contained in a secondary
depolymerization device. In a favourable embodiment, non-condensed postcondensation
gases from the fraction condenser are fed into a power generator with a combustion
engine and a current generator, whereby, in a favourable embodiment, generated electric
power is used for electric heaters and other system devices. In a favourable
embodiment, the catalyst is supplied into the thermocatalytic reactor in doses or
continuously. In a favourable embodiment, the catalyst is supplied into the tank of the
secondary depolymerization device in doses or continuously. In a favourable
embodiment, the catalyst worn out in the process, along with the carbonization product
generated in the reactor, is discharged from the reactor into the filter, in a favourable
embodiment a ceramic filter, with oil recycling to thermocatalytic reactor.

The invention pertaining to the system for thermocatalytic depolymerization of
waste plastics, in particular polyolefin plastics, featuring a raw material storage silo and
feeder, a melting crucible, a heater and a thermocatalytic reactor equipped with heating
elements, connected to a fraction condenser, is characterized by the fact that it has a
secondary depolymerization device in which gaseous products of a catalytic reaction
collected from thermocatalytic reactor are subject to depolymerization, whereby the
device is connected to the reactor via a connector pipe supplying gaseous products and
is connected to fraction condenser via a connector pipe collecting gaseous products. In a
favourable embodiment, the secondary depolymerization device has the form of a
vertical pass-through tank filled with porous layer of the catalyst, in a favourable
embodiment in the form of granulated product. In a favourable embodiment, the
secondary depolymerization device has a catalyst feeder and a device discharging worn-
out catalyst. In a favourable embodiment, the thermocatalytic reactor has a device for
separating liquid reaction material into layers situated one above the other in the form of
a mixing pump, horizontal dispensing trays or dispensing troughs located above the
reaction mixture surface and heating elements assigned to these layers. In a favourable
embodiment, the heating elements of thermocatalytic reactor are electric heaters placed
in tubes, grouped in bundles and mounted separately in openings along the perimeter of
the body, oriented centripetally and located at two levels, the lower level near the
bottom of the reactor and the upper level, above or below perforated dispensing trays or
dispensing troughs located above the liquid reaction mixture surface, crosswise with
respect to the vertical axis of the body. Electric heaters are heating elements placed in
protective tubes, stabilized with carbon dioxide CO₂ or other inert gas. In a favourable
embodiment, the reactor has sparge pipes installed inside, supplying CO₂ or other inert
gas collected from electric heaters pipes to the reaction mixture producing the effect of
bubbling and additional heating of the mixture. In a favourable embodiment, the
thermocatalytic reactor has a catalyst dispenser equipped with a feeder and, in the
bottom section, a device for discharging worn-out catalyst along with the carbonization
product, with oil recycling to the reactor, thereby, in a favourable embodiment, the
device has a gear pump and a ceramic filter. In a favourable embodiment, the fraction
condenser is connected, via a pipe discharging non-condensed postcondensation gases,
to the power generator unit equipped with a combustion engine and a current generator.

The invention pertaining to the reactor for thermocatalytic depolymerization of
waste plastics featuring a body in the form of a closed vessel, with thermal insulation,
within which heating elements in the form of tubes and a mixer are mounted, is
characterized by the fact that it has at least one upper level for dispensing the reaction
mixture, located above the reaction mixture surface contained at the bottom of the body,
which level has the form of perforated dispensing trays or dispensing troughs located
crosswise with respect to the vertical axis of the body, whereby the reaction mixture at each level has separate heating with heating elements situated in planes which are crosswise to the vertical axis of the body, immersed in the bottom layer of the reaction mixture and as close as possible above or below dispensing trays, whereby the device used for stirring and raising liquid to dispensing trays is an electrically driven mixing pump, situated close to the reactor bottom. In a favourable embodiment, the heating elements have the form of electric heaters in protective tubes, stabilized with CO₂ or other inert gas, whereby electric heaters are grouped in bundles and mounted separately in openings along the perimeter of the body and oriented centripetally. In a favourable embodiment, the body has the shape of a vessel closed with covers, an upper one and a lower one, whereby the lower cover, which forms the bottom, and the upper cover have, in a favourable embodiment, the shape of cones, convex on the outside. In a favourable embodiment, the mixing pump is located in a cylindrical vertical chute located centrally in the bottom layer of the reaction mixture. In a favourable embodiment, in the bottom section, there is a device for continuous discharging of worn-out catalyst and carbonization product, in a favourable embodiment in the form of a pump and a filter, in a favourable embodiment a ceramic filter, with oil recycling to thermocatalytic reactor. In a favourable embodiment, the reactor has sparge pipes, located inside the body and connected to electric heater pipes, which collect CO₂ or other inert gas from heaters and supply it to the reaction mixture bottom layer at the bottom of the reactor, producing the effect of bubbling and additional heating of the mixture. In a favourable embodiment, the reactor is equipped with a catalyst dispenser. In a favourable embodiment, the catalyst dispenser has a catalyst feeder.

The solution according to the invention is characterized by high process efficiency, enables about 90% of merchandise to be obtained compared to charge, which is a considerable increase compared to known methods. Electric heaters in the reactor, stabilised with carbon dioxide flow, make it possible to operate at a low temperature gradient and main heat resistance of heat exchange on the melted side of the raw material and depolymerization products. As a result, with simultaneous intense stirring, greater quantities of carbonization product are prevented and precise temperature control is enabled as a consequence of minimum thermal inertia of heating elements. Increased evaporation area in the reactor, obtained by separating the heated product into layers and independent heating of dispensing trays, as well as using the
phenomenon of bubbling the reaction mixture with hot carbon dioxide enables volatile products to escape the reaction zone quickly and to come into contact with the catalyst at a given temperature and pressure, preventing unfavourable excess gas. A high performance straightway pump ensures quick homogenization of the reaction mixture with new portions of melted raw material supplied systematically and under small pressure from the melting crucible and prevent local temperature drops in the reactor where the melted raw material is fed. Using non-condensed postcondensation gases to drive the power generator considerably reduces the costs of operating the system.

The solution as per the invention is explained in greater detail in examples and in the drawing in which Fig. 1 is a schematic diagram of the system for thermocatalytic depolymerization of waste plastics, Fig. 2 is a schematic representation of the reactor for thermocatalytic depolymerization of waste plastics as an axial section, Fig. 3 shows the cross section of the reactor taken on the line I-I plane in Fig. 2, Fig. 4 shows a schematic diagram of the secondary depolymerization device.

**Example I**
The system for thermocatalytic depolymerization of waste plastics has a raw material storage silo 1 in which finely divided processed polyolefin plastic or polystyrene waste is placed, with a charging hopper 2 placed below, equipped with a screw conveyor 3, used to transport the plastic to the melting crucible 4, where it is heated to the temperature of 180°C and plasticized. Melting crucible 4 is connected to thermocatalytic reactor 6 via a pipeline, through heater 5. Thermocatalytic reactor 6 has the body 7 in the shape of a cylindrical vessel, whose bottom 8 and upper cover 9 have the shape of cones, convex on the outside. In reactor 6 there are electric heaters 10 in the form of heating elements in protective tubes, mounted in openings along the perimeter of body 7. The temperature of electric heaters 10 is stabilized with carbon dioxide CO₂ or other inert gas or metal oxides. The tubes with electric heaters inside are grouped in bundles of several pieces each and evenly distributed along the perimeter, centripetally. Electric heaters are mounted in the body separately, in openings along the perimeter of the body and are dismantled by taking the tubes out of the openings, which makes it possible to clean the tubes off the carbonization product sediment or to replace defective heaters. Bundles of electric heaters are placed at two levels, of which the lower level is near bottom 8, where heaters are completely immersed in the reaction mixture. The electric heaters of the upper level are located as close as possible to perforated metal dispensing
trays 13 (above or below the trays) located crosswise with respect to the vertical axis of the reactor above the reaction mixture layer surface of the lower level. Inside the body 7, in its bottom part, there is a cylindrical vertical chute 11, with a mixing pump 12 at the bottom, e.g. an electrically driven positive-displacement propeller pump of high performance, approx. 100 m³/h. The mixing pump 12 takes the melted reaction material from bottom 8 and transports it at the height above the upper level of electric heaters 10, to perforated dispensing trays of the second dispensing level. Dispensing trays 13 or dispensing troughs, not marked in the drawing, form the second dispensing level, where a thin layer of the reaction mixture evaporates quickly and is supplied on a regular basis with mixing pump 12, whereas any excess, additionally heated with upper heaters, flows through openings to the lower layer at the bottom of the vessel. This solution increases stirring intensity, maximizes heat exchange between heaters and the melted reaction material, intensifies the contact of the melted raw material with the catalyst and increases evaporation area. All of the above considerably speeds up the reactions of the process in the thermocatalytic reactor. Inside the body of reactor 6, near its bottom, there are sparge pipes 14 connected to electric heaters 10, which discharge carbon dioxide CO₂ or other inert gas from these heaters to the reaction mixture. Heated in heater tubes to the temperature of about 400°C, the gas penetrates the reaction mixture through openings in sparge pipes 14 causing a bubbling effect and also additionally heats up the mixture. This supports stirring intensity, increases the evaporation area of the reaction mixture and speeds up heat distribution. At a start-up phase, hot carbon dioxide heats an empty device to operating temperature and during operation, enables the temperature of electric heaters to be controlled precisely. The reactor 6 is equipped with catalyst dispenser 15 located on the upper cover 9, supplying the catalyst to the melted material. The catalyst dispenser is equipped with a catalyst feeder 16. In the hollow of the reactor bottom 8 there is a drain hole to which filter 18 is connected, enabling deactivated catalyst and carbonization product to be removed from the reaction mixture. In the upper cover 9, there is an outlet pipe 19 for the vapours of the depolymerizate – gaseous products of depolymerization, connected, via a pipeline, to the pipe 20 supplying depolymerizate vapours to the secondary depolymerization device 21 (or directly to the pipeline of the fraction condenser 24). The secondary depolymerization device 21 has the form of a vertical cylindrical pass-through tank, in which the catalyst in granulated form or in other porous form is placed. This device is used for the catalytic process of depolymerization of gaseous products obtained from
preliminary depolymerization in reactor 6 of higher molecular weight, given that in the
depolymerize vapours there are 20% to 30% hydrocarbons vapours whose chains are
too long chain (paraffins). The connector pipe 20 supplying gaseous products to the
device 21 is situated in the upper part of the tank, where the catalyst feeder 17, which
continuously supplies granulated catalyst, is also found. In the bottom part of the tank
there is a connector pipe 22 collecting gaseous depolymerize products, connected to
the pipeline of the fraction condenser 24, as well as a device discharging catalyst 23,
which continuously discharges worn-out catalyst. This device makes it possible to
control the time in which gaseous depolymerize products are in contact with the
catalyst by controlling the thickness of the catalyst layer. The secondary
depolymerization device 21 is situated on the pipeline connecting the power generator
with the fraction condenser 24. The fraction condenser 24 has the shape of a cuboid and
is filled with pipes supplying the cooling liquid in a direction opposite to the direction
of hot vapours depolymerization products surrounding the pipes. The condensate, which
flows gravitation-wise, along the condenser pipes, accumulates at its bottom without
further possibility of individual fractions mixing with one another and is discharged to
separate tanks. The fraction condenser 24 is connected, via a pipe, to the power
generator 25 in the form of a combustion engine driving the current generator.
Flammable process gases, which normally do not condense (hydrocarbons with chain
length of C1 to C4) extracted with a fan pump with a slight negative pressure, encounter
a mist eliminator in the end part of the condenser and are further steered to the gas
power generator and used to produce electric power needed to drive electric heaters and
other system devices. The use of electric heaters in the reactor, stabilized with carbon
dioxide, enables the device to operate at low temperature gradient and main heat
resistance of heat exchange on the melted side of the raw material and depolymerization
products. As a result, with simultaneous intense stirring, greater quantities of
carbonization product are prevented and precise temperature control is enabled as a
consequence of minimum thermal inertia of heating elements (there is no medium
transporting heat at greater distances in the heating system). Increased evaporation area
in the reactor, obtained by using heated dispensing trays and the phenomenon of
bubbling the reaction mixture with hot carbon dioxide enables volatile products to
escape the reaction zone quickly and to come into contact with the catalyst at a given
temperature and pressure, preventing unfavourable excess gas.
Example II

Finely divided polyolefin plastic is fed to the storage silo 1 from which it is further fed to a charging hopper 2 and further on, passed via a screw conveyor 3 to the melting crucible 4. In the melting crucible the granulated product PE + PP is mixed with the paraffin fraction with the temperature of 280°C and then it melts and is heated to the temperature of 180°C with part of the heat of this fraction and regenerated heat supplied indirectly. Subsequently, melted raw material is discharged, via heater 5, to the thermocatalytic reactor 6. Vapours from the melting crucible are extracted via a fan, which is not marked in the drawing, and steered, along with the gaseous fraction, for combustion. In the thermocatalytic reactor 6 the raw material is heated with electric heaters to the temperature of 420°C, with aluminosilicate catalyst being fed at the same time, and mixed intensely using a high performance mixing pump 12. The catalyst is fed with dispenser 16 to reactor 6 above the reaction mixture surface in the amount of 1.5% of its content in the reactor. The worn-out catalyst, along with the carbonization product, form production waste, which is extracted from the reactor with a gear pump to ceramic filter 18 with oil recycling to the reactor. The process of stirring and heating is additionally supported by bubbling with heated carbon dioxide CO₂, which stabilizes the temperature of electric heaters, and causes polyethylene and polypropylene carbon chain to break up, which is known as catalytic cracking. As a result, a mixture of hydrocarbons with carbon chain length from C₂ to C₃₄ is produced. Transformations that take place in the reactor gradually cause the catalyst to wear out. A worn-out catalyst, along with the carbonization product, is periodically extracted from the reactor in the from of an oil slurry through a bottom drain pipe, from where it is steered, via gear pump, to ceramic filer 18 with oil recycling to the reactor. Given the requirements concerning the composition of the cracking product, the process has two stages, i.e. first, in thermocatalytic reactor 6 on finely divided catalyst dispersed in the liquid phase of the reaction mixture with the temperature of 400°C, and second, in the secondary depolymerization device 21 tank, on a granulated catalyst bed, with a simultaneous flow of pre-cracked hydrocarbons with the temperature of 420°C. The granulated catalyst used in the catalytic cracking process in the vapour phase also undergoes gradual deactivation and is periodically extracted from the tank using extraction device 23 and steered for regeneration. Shortages in the tank are replenished with fresh catalyst. Vapours and gases with the temperature 420°C, extracted from the secondary depolymerization tank, are steered to fraction condenser 24, where they are cooled in
between pipes to 35°C with a simultaneous condensation of the paraffin fraction (420°C – 280°C) and gas oil (280°C – 180°C) as well as a petrol fraction (180°C – 35°C). Condensed fractions are steered to storage silos, whereby the paraffin fraction in the necessary quantity, is steered to the melting crucible 4, where it is mixed with the raw material. Flammable process gases from the fraction condenser 24, which normally do not condense (hydrocarbons with chain length from C₁ to C₄) are steered to a gas power generator and used to produce electric power needed for electric heaters and other system devices.
Claims

1. The method of thermocatalytic depolymerization of waste plastics, in particular polyolefin plastics, to a mixture of unsaturated and saturated hydrocarbons, in which finely divided raw material is plasticized in a melting crucible, liquefied by heating and transformed catalytically in a thermocatalytic reactor in the presence of a catalyst, and reaction products in gaseous form are discharged to a fraction condenser, where they are cooled, condensed and separated into fractions of different boiling temperatures, characterized in that in the thermocatalytic reactor (6) the reaction mixture in liquid state is stirred and separated into at least two layers, situated at different levels, whereby each of these layers is heated up irrespective of the other, using heating elements principally oriented crosswise with respect to the vertical axis of the reactor, in a favourable embodiment in the form of electric heaters (10) placed in protective tubes grouped in bundles, in a favourable embodiment stabilized with inert gases or metal oxides.

2. A method according to claim 1, characterized in that the reaction mixture is stirred, separated and raised using a mixing pump (12), in a favourable embodiment a high performance propeller pump, whereby the mixture is fed into perforated dispensing trays (13) or dispensing troughs, located above the mixture bottom layer surface, crosswise with respect to the vertical axis of the reactor (6).

3. A method according to claim 1 or 2, characterized in that kinetic and thermal energy of the reaction mixture is supported by bubbling, using CO₂ or other inert gas, whereby, in a favourable embodiment, gas from the stabilizing circuit of electric heaters (10) is used.

4. A method according to claim 1 or 3, characterized in that products in gaseous form obtained from the catalytic reaction, before being fed into fraction condenser (24), are passed through a porous catalyst layer, in a favourable embodiment in the form of a granulated product, contained in a secondary depolymerization device (21).

5. A method according to claim 1 or 4, characterized in that non-condensed postcondensation gases from the fraction condenser (24) are being fed into a power generator (25) equipped with a combustion engine and a current generator, whereby, in
a favourable embodiment, generated electric power is used to drive electric heaters (10) and other system devices.

6. A method according to claim 1 or 4, **characterized in that** the catalyst is supplied into the thermocatalytic reactor (6) in doses or continuously.

7. A method according to claim 4, **characterized in that** the catalyst is supplied into the tank of the secondary depolymerization device (21) in doses or continuously.

8. A method according to claim 1 or 6, **characterized in that** the catalyst worn out in the process, along with the carbonization product generated in the reactor (6), is discharged from the reactor into the filter (18), in a favourable embodiment a ceramic filter, with oil recycling to thermocatalytic reactor (6).

9. A system for thermocatalytic depolymerization of waste plastics, in particular polyolefin plastics, featuring a raw material storage silo and feeder, a melting crucible, a heater and a thermocatalytic reactor equipped with heating elements, connected to a fraction condenser, **characterized in that** it has a secondary depolymerization device (21), in which gaseous products of a catalytic reaction collected from thermocatalytic reactor (6) are subject to depolymerization, whereby the device is connected to the reactor via a connector pipe supplying gaseous products (20) and is connected to fraction condenser (24) via a connector pipe collecting gaseous products (22).

10. A system according to claim 9, **characterized in that** secondary depolymerization device (21) has the form of a vertical pass-through tank filled with porous layer of the catalyst, in a favourable embodiment in the form of granulated product.

11. A system according to claim 10, **characterized in that** secondary depolymerization device (21) has a catalyst feeder (17) and a device discharging worn-out catalyst (23).

12. A system according to claim 9, **characterized in that** thermocatalytic reactor (6) has a device for separating liquid reaction material into layers situated one above the other in the form of a mixing pump (12), horizontal dispensing trays (13) or dispensing troughs located above the reaction mixture surface and heating elements (10) assigned to these layers.
13. A system according to claim 12, characterized in that the heating elements of thermocatalytic reactor (6) are electric heaters (10) placed in tubes, grouped in bundles and mounted separately in openings along the perimeter of the body (7), oriented centripetally and located at two levels, the lower level near the bottom (8) of the reactor and the upper level, above or below perforated dispensing trays (13) or dispensing troughs located above the liquid reaction material surface, crosswise with respect to the vertical axis of the body (7).

14. A system according to claim 12 or 13, characterized in that reactor (6) has sparge pipes (14) installed, which discharge CO₂ or other inert gas from electric heaters (10) pipes to the reaction mixture.

15. A system according to claim 9, characterized in that thermocatalytic reactor (6) has catalyst dispenser (15) equipped with a feeder (16) and, in the bottom section, a device for discharging worn-out catalyst, along with the carbonization product, with oil recycling to the reactor, whereby, in a favourable embodiment, the device has a gear pump and a ceramic filter (18).

16. A system according to claim 9, characterized in that fraction condenser (24) is connected, via a pipe discharging non-condensed postcondensation gases, to power generator (25) equipped with a combustion engine and a current generator.

17. A reactor for thermocatalytic depolymerization of waste plastics featuring a body in the form of a closed vessel, with thermal insulation, within which heating elements in the form of tubes and a mixer are mounted, characterized in that it has at least one upper level for dispensing the reaction mixture, located above the reaction mixture surface contained at the bottom of the body (7), which level has the form of perforated dispensing trays (13) or dispensing troughs located crosswise with respect to the vertical axis of the body (7), whereby the reaction mixture at each level has separate heating with heating elements (10) situated in planes which are crosswise to the vertical axis of the body (7), immersed in the bottom layer of the reaction mixture and as close as possible above or below dispensing trays (13), whereby the device used for stirring and raising the liquid to dispensing trays is an electrically driven mixing pump (12), situated to the reactor bottom.
18. A reactor according to claim 17, characterized in that the heating elements have close the form of electric heaters (10) in protective tubes, stabilized with CO₂ or other inert gas, whereby electric heaters are grouped in bundles and mounted separately in openings along the perimeter of the body and oriented centripetally.

19. A reactor according to claim 17, characterized in that the body (7) has the shape of a vessel closed with covers, an upper one and a lower one, whereby the lower cover, which forms the bottom (8), and the upper cover (9) have, in a favourable embodiment, the shape of cones, convex on the outside, whereby the mixing pump (12) is located in a cylindrical vertical chute (11) located centrally in the bottom layer of the reaction mixture.

20. A reactor according to claim 17, characterized in that it has, in the bottom section, a device for discharging worn-out catalyst and carbonization product, in a favourable embodiment in the form of a pump and a filter (18), in a favourable embodiment a ceramic filter, with oil recycling to thermocatalytic reactor (6).

21. A reactor according to claim 18 or 19, characterized in that it has sparge pipes (14), connected to electric heater (10) pipes, which discharge CO₂ or other inert gas from heaters to the reaction mixture bottom layer at the bottom (8) of the reactor.

22. A reactor as claimed in Claim 17 or 19, characterized in that it is equipped with catalyst dispenser (15).

23. A reactor according to claim 22, characterized in that the catalyst dispenser (15) has a catalyst feeder (16).
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

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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)

| CO8J | C10G | B01J | C1OB |

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 practical, search terms used)

EPO-Internal, WPI Data, COMPENDEX, INSPEC, IBM-TDB

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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X Further documents are listed in the continuation of Box C. X See patent family annex.

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**Date of the actual completion of the international search**

13 February 2009

**Date of mailing of the international search report**

25/02/2009

**Name and mailing address of the ISA**

European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016

**Authorized officer**

Hein, Friedrich
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