

SYSTEM AND METHOD FOR CONVERTING PLASTIC/RUBBER TO HYDROCARBON FUEL BY THERMO-CATALYTIC PROCESS

BACKGROUND OF THE INVENTION

Field of the invention

- 5 The present disclosure relates to a system and a method for thermo-catalytic process. In particular, the present invention relates to a system and a method for converting plastic/rubber waste to an alternative hydrocarbon fuel using thermo-catalytic process.

Background art

- 10 There is an overwhelming demand for fuel, for both industrial and domestic purposes. With limited resources of conventional fuels like fossil fuels, crude oil, wood, natural gas and nuclear material (uranium), it is improbable to meet this high fuel demand at a reasonable price. Also, the increasing environmental concerns have resulted in an increased interest in alternative, sustainable fuels from renewable or waste sources. Some well-known alternative fuels include biodiesel, bioalcohol (methanol, ethanol, butanol), chemically
15 stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, and other biomass sources.

- One such waste source comprising potential valuable resources is the plastic and rubber waste. Throughout the world millions of tons of waste plastic and rubber are produced every year. The disposal of these wastes is difficult as burning is prohibited in most of the
20 countries due to the air pollution concerns, and landfilling requires huge space and can lead to contamination. As a result, these wastes accumulate creating a major environmental hazard. A preferred way to dispose these wastes is to recover the valuable carbonaceous material there from. The recovered carbonaceous material can be used as a fuel source.

- Several methods have been suggested to produce hydrocarbon fuels from waste plastic or
25 rubber. These methods generally include decomposition of the waste by catalytic and thermal cracking in the presence/absence of a catalyst. A major hindrance in the recovery of the carbonaceous material from the plastic/rubber waste is due to the high strength of chemical bonds in macromolecules of the plastic/rubber.

- Such a method for converting waste plastic into hydrocarbon oil is disclosed in US Patent No.
30 6774271. The method comprises cracking the waste plastic in a thermal cracking reactor at a temperature between 270 – 800 °C to obtain partly gaseous and partly liquid hydrocarbons, and residues. The liquid hydrocarbons are fully cracked into gaseous hydrocarbons. Chlorine is removed from the gaseous hydrocarbons which are then catalytically cracked with an acid catalyst. The catalytically cracked gaseous hydrocarbons
35 are cooled to obtain the hydrocarbon oil.

US Patent No. 5414169 discloses another method for obtaining hydrocarbon oil from waste plastic material or waste rubber material. The method comprises subjecting the waste material to thermal cracking so as to obtain a thermal cracking product. The thermal cracking product is liquefied in the presence of a catalyst, causing a liquid phase cracking reaction of the liquefied product, to produce a cracking product. The cracking product so obtained is cooled to obtain the hydrocarbon oil.

Still another method for catalytically cracking waste plastics is disclosed in US Patent No. 8350104, by which polyethylene composed of linear chain molecules can be decomposed at a low temperature and very little residue is produced. The method comprises loading the waste plastic as a raw material in a reaction vessel into a granular FCC catalyst heated to a temperature between 350 to 500 °C to decompose and gasify the waste particles in contact with the catalyst.

Yet another method for producing hydrocarbonaceous fluid is disclosed in US Application No. 20110124932. The method comprises melting a feed of substantially solid waste plastic in an aerobic atmosphere to produce a waste plastic melt, distilling at least a portion of the waste-plastic melt to produce a hydrocarbonaceous distillate, and collecting the hydrocarbonaceous distillate.

A catalyst for the low-temperature pyrolysis of hydrocarbon-containing polymer materials, mainly intended for use in recycling of rubber waste materials, is disclosed in US Patent No. 6743746. The catalyst is prepared from a carbon-iron component in the form of microscopic carbon particles and ultra-dispersed iron particles. The catalyst further contains a metal-carbon component.

A process for vaporizing rubber and separating the vaporized rubber into its usable components is disclosed in US Patent No. 6538166. The process comprises heating a quantity of rubber in an atmosphere at a negative pressure and at a temperature between 340 and 510 °C to obtain vaporized rubber. A venturi separator sprays the vaporized rubber with oil having a boiling temperature greater than 175 °C. The oil binds to heavy oil in the hydrocarbon constituents in the vaporized rubber. A remaining portion of the vaporized rubber is condensed such that light oils in the hydrocarbon constituents liquefy and are separated from hydrocarbon gases.

A major drawback of the traditional methods is that the conversion process of the solid waste into gaseous state is hardly controllable. Further, the raw material generally needs a pre-treatment, which increases the process time, labor and energy consumption. Commonly, the process comprises two separate steps for thermal cracking and catalytic cracking, both being conducted at high temperatures, thus the process demands very high energy usage. The known catalysts have a low efficiency, particularly at low temperature, thus carbonization occurs mostly at high temperature, at which oil recovery is reduced due to high loss of dry gas. Further, the product so obtained has a low stability against oxidation. In

addition, the known methods for rubber vaporization are environmentally detrimental because of the release of sulfur compounds, carcinogenic carbon black and other toxic substances. There is therefore a need for a simple, safe and efficient process for converting waste plastic/rubber into hydrocarbon fuel, which provides a stable operation, easy maintenance, and improved catalyst activity.

SUMMARY OF THE INVENTION

To accomplish the above-mentioned objective, it is an object of the present invention to provide a system (100) of converting solid waste of plastics/rubber into hydrocarbon fuel, said system (100) comprising: (i) a thermal cracking reactor (110) for cracking the solid waste and a catalyst as feed at a temperature in the range of 200-475 °C to obtain a catalytic thermal cracking product containing a gaseous hydrocarbon stream and a coke residue; and (ii) a condenser (120) for receiving said gaseous hydrocarbon stream and cooling said gaseous hydrocarbon stream to obtain an at least partly condensate stream containing a liquid hydrocarbon oil of smaller molecules and non-condensable gaseous hydrocarbons, wherein said thermal cracking reactor (110) having an operative top side-wall (103) and an operative bottom side-wall (105) is positioned in horizontal and comprising a feed inlet (104) at one end and a gas outlet (116) at an opposite end on said operative top side-wall (103), a residue outlet (118) at said operative bottom side-wall (103), and an agitator device (106) centrally positioned between said side-walls (103, 105) along the operative longitudinal axis of said reactor (110), and wherein the condenser (120) is in operative communication with said gas outlet (116) of said reactor.

Another object of the present invention is to provide a method of converting solid waste of plastics/rubber into hydrocarbon fuel, said system (100) comprising the steps of: (i) feeding the solid waste together with a catalyst into a thermal cracking reactor (110) which is horizontally positioned, wherein the cracking reactor (110) is provided with an operative top side-wall (103) and an operative bottom side-wall (105), a residue outlet (118) at said operative bottom side-wall (103), having a feed inlet (104) at one end thereof and a gas outlet (116) at the opposite end on the operative top side-wall (103), and an agitator device (106) centrally positioned between the side-walls (103,105) along the operative longitudinal axis of the reactor (110); (ii) subjecting the solid waste in the reactor to thermal cracking at a temperature in the range of 200 to 475 C to obtain a catalytic thermal cracking product containing a gaseous hydrocarbon stream and coke residue; (iii) receiving the gaseous hydrocarbon stream in a condenser (120) and discharging the coke residue from step (ii) at the residue outlet (118); (iv) cooling the gaseous hydrocarbon stream in the condenser (120) to obtain an at least partly condensate streaming containing a liquid hydrocarbon oil of smaller molecules and non-condensable gaseous hydrocarbons; and (v) passing the purified non-condensable gaseous hydrocarbons to a burner chamber (134) for burning.

Accordingly, yet an object of the present disclosure is to provide a system and a method of converting solid waste of plastics/rubber into hydrocarbon fuel with great efficient.

Another object of the present disclosure is to provide a system and a method of converting solid waste of plastics/rubber into hydrocarbon fuel, which is simple, cost-effective, conserves energy, and produces minimum residue and by-products.

Yet another object of the present disclosure is to provide a system and a method of converting solid waste of plastics/rubber into hydrocarbon fuel, which provides improved catalyst activity.

Still another object of the present invention is to provide a system for converting solid waste of plastics/rubber into hydrocarbon fuel, further comprising an oil storage tank (142) which is in operative communication with the condenser (120) to receive condensate stream from the condenser (120).

Yet still another object of the present invention is to provide a method for converting solid waste of plastics/rubber into hydrocarbon fuel, wherein the catalyst is selected from the group consisting of aluminum silicate, barium silicate, beryllium silicate, calcium silicate, iron silicate, magnesium silicate, manganese silicate, potassium silicate, sodium silicate, zirconium silicate, copper silicate, tin silicate, iron silicate, lead silicate, tungsten silicate, cesium silicate, lithium silicate, aluminum, bismuth, copper (cuprum), iron (ferrum), lead, magnesium, manganese, nickel, tin (stannum), tungsten, zinc, aluminum oxide, bismuth oxide, copper (cuprum) oxide, iron (ferrum) oxide, lead oxide, magnesium oxide, manganese oxide, nickel oxide, tin (stannum) oxide, tungsten oxide, zinc oxide, aluminum carbonate, calcium carbonate, sodium carbonate, bismuth carbonate, copper (cuprum) carbonate, iron (ferrum) carbonate, lead carbonate, magnesium carbonate, manganese carbonate, nickel carbonate, tin (stannum) carbonate, tungsten carbonate, zinc carbonate, silicon carbide, calcium carbide, natural and synthetic zeolite, alumina, fuller's earth, bauxites, metal borates, metal borides, ZSM-5, FCC Y-catalyst, NiMo over γ -alumina, NiW loaded on amorphous silica-alumina, cobalt loaded active carbon (Co-AC), DHC-8 (commercial silica-alumina catalyst), HZSM-5, activated red mud, calcined kaolin, Eckalite 1, Siltol CPT-30, Siltol MT 100, Mizukasisieves Y-420, Re Y-zeolite, acidic alumina, Na Y-zeolite, and H Y-zeolite.

Yet still an object of the present invention is to provide a method for converting solid waste of plastics/rubber into hydrocarbon fuel, wherein the catalyst is a mixture containing at least one metal silicate, at least one metal oxide, at least one zeolite type compound, and at least one additive.

Another object of the present invention is to provide a method for converting solid waste of plastics/rubber into hydrocarbon fuel, wherein the catalyst is a mixture containing at least one metal silicate, at least one metal oxide, at least one zeolite type compound, and at least one additive.

A further object of the present invention is to provide a method for converting solid waste of plastics/rubber into hydrocarbon fuel, wherein the catalyst has a particle size in the range of 0.1 mm to 10mm.

BRIEF DESCRIPTION OF THE DRAWINGS

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Various other objects, features, and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings in which like reference characters designate the same or similar parts throughout the several views, and wherein:

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FIG. 1 is a schematic view showing shows a thermal cracking arrangement according to the present invention;

FIG. 2 is a simplified explanatory flow diagram showing the process of thermal cracking in accordance with the present invention, and

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FIG. 3 is a schematic view showing the conversion of feed to obtain the gaseous hydrocarbon in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

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As used in the present invention, the term "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The use of the expression "at least" or "at least one" suggests the use of one or more elements or ingredients or quantities, as the use may be in the embodiment of the disclosure to achieve one or more of the desired objects or results.

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Any discussion of documents, acts, materials, devices, articles or the like that has been included in this specification is solely for the purpose of providing a context for the disclosure. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the disclosure as it existed anywhere before the priority date of this application.

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The numerical values mentioned for the various physical parameters, dimensions or quantities are only approximations and it is envisaged that the values higher/lower than the numerical values assigned to the parameters, dimensions or quantities fall within the scope of the disclosure, unless there is a statement in the specification specific to the contrary.

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The present disclosure envisages a system and a method thereof for efficiently producing a clean hydrocarbon oil of smaller molecules having a high calorific value from solid plastic or rubber waste. The system of the present disclosure is simple, cost-effective, conserves

energy, and produces minimum residue and by-products. The system of the present disclosure further enhances the catalyst activity. The method provides a better control over the temperature of the liquid fraction and thereby greatly improves the efficiency of the cracking process and the yield.

FIG. 1 of the accompanying drawing illustrates a preferred embodiment of the present system and method of converting solid plastic or rubber waste to hydrocarbon oil in accordance with the present invention. The present system for performing a batch process to convert solid plastic/rubber waste to hydrocarbon fuel is referenced by the numeral **100** in the **Fig. 1**. The system **100** comprises a thermal cracking reactor **110** for cracking a feed of the solid plastic/rubber waste in the presence of a catalyst. The reactor **110** is horizontally positioned and includes an operative top side-wall **103** and an operative bottom side-wall **105**. A feed inlet **104** is provided at one end of the operative top side-wall **103** and a gas outlet **116** is provided at a second opposite end of the operative top side-wall **103**. A residue outlet **118** is provided at the operative bottom side-wall **105**. An agitator device **106** is centrally positioned between the side-walls **103** & **105**, placed along the operative longitudinal axis of the reactor **110**. The screw-type agitator device **106** is operated by means of a motor **102**. The horizontally positioned reactor **110** is supported by means of beam support **112** and **114**. The reactor **110** comprises a heating means **108**. A first temperature gauge **122** is provided in the reactor **110** to monitor the temperature conditions in the reactor **110**.

The solid plastic/rubber waste denoted as SW and the catalyst denoted as CT are fed in the reactor **110** through the feed inlet **104**. Optionally, heavy oil may be added along with the feed. After addition of the feed, all air from the reactor **110** is removed to create a vacuum. The ratio of the catalyst CT to the solid waste is typically in the range of 0.01:1 to 0.05:1. The catalyst preferably has a particle size in the range of 0.1 mm to 10 mm and the solid waste is shredded to have a particle size of less than 20 mm.

The catalyst is typically a mixture containing at least one metal silicate, at least one metal oxide, at least one zeolite type compound, and at least one additive. The catalyst is selected from a group consisting of aluminum silicate, barium silicate, beryllium silicate, calcium silicate, iron silicate, magnesium silicate, manganese silicate, potassium silicate, sodium silicate, zirconium silicate, copper silicate, tin silicate, iron silicate, lead silicate, tungsten silicate, cesium silicate, lithium silicate, aluminum, bismuth, copper (cuprum), iron (ferrum), lead, magnesium, manganese, nickel, tin (stannum), tungsten, zinc, aluminum oxide, bismuth oxide, copper (cuprum) oxide, iron (ferrum) oxide, lead oxide, magnesium oxide, manganese oxide, nickel oxide, tin (stannum) oxide, tungsten oxide, zinc oxide, aluminum carbonate, calcium carbonate, sodium carbonate, bismuth carbonate, copper (cuprum) carbonate, iron (ferrum) carbonate, lead carbonate, magnesium carbonate, manganese carbonate, nickel carbonate, tin (stannum) carbonate, tungsten carbonate, zinc carbonate, silicon carbide, calcium carbide, natural and synthetic zeolite, alumina, fuller's earth,

bauxites, metal borates, metal borides, ZSM-5, FCC Y-catalyst, NiMo over γ -alumina, NiW loaded on amorphous silica-alumina, cobalt loaded active carbon (Co-AC), DHC-8 (commercial silica-alumina catalyst), HZSM-5, activated red mud, calcined kaolin, Eckalite 1, Siltan CPT-30, Siltan MT 100, Mizukasieves Y-420, Re Y-zeolite, acidic alumina, Na Y-zeolite, and H Y-zeolite.

The feed is gradually pushed downwards along the operative longitudinal axis of the reactor **110** by the agitator device **106** to enable complete gasification of the hydrocarbons in the solid waste. The feed is cracked at a temperature in the range of 200 to 475 °C to obtain a catalytic thermal cracking product containing a gaseous hydrocarbon stream and coke residue.

In accordance with the preferred embodiment of the present invention, the mechanisms of catalytic thermal cracking are as follows:

- end chain cracking: the polymer is broken up from the end group successively yielding the corresponding monomer;

- random chain cracking: long chain polymer/hydrocarbon chain is broken up randomly into fragment of uneven length of lower hydrocarbons; and

- chain stripping: elimination of reactive substitute or side groups on the polymer chain leading to evolution of a cracking products and also small charring of polymers.

During the reaction, the solid molecules penetrate the catalyst and adsorb on the active areas. The catalyst provides a large reactive surface and better selectivity. The catalyst facilitates the cracking of the plastic at lower temperature than a normal pyrolysis process. Thus the catalyst decreases the retention time and increases the rate of the reaction.

The coke residue is discharged at the residue outlet **118** and the gaseous hydrocarbon stream is discharged at the gas outlet **116**. A second temperature gauge **123** is provided to monitor the temperature of the gaseous hydrocarbon denoted as GH stream leaving the reactor **110**. A condenser **120** is provided in operative communication with the gas outlet **116** of the reactor **110** for receiving the gaseous hydrocarbon stream. The condenser receives cold water at a temperature between 5 to 25 °C via a water inlet **126** for cooling the gaseous hydrocarbon stream to obtain an at least partly condensate stream containing a liquid hydrocarbon oil of smaller molecules and non-condensable gaseous hydrocarbons. The heated water thereby obtained is discharged at the water outlet **124**. The condenser **120** is supported by support stands **128**. An oil storage tank **142** is provided in operative communication with the condenser **120** to receive the condensate stream. The condensate stream from the condenser **120** is collected in the oil storage tank **142**. The storage tank **142** is provided with a pressure gauge **130**. The liquid hydrocarbon oil can be discharged via an oil outlet **140**. The non-condensable gaseous hydrocarbons are conveyed through scrubbing units. The scrubbing units are selected from a sodium hydroxide (1 to 5% solution)

scrubbing unit **143**, a calcium hydroxide (1 to 5% solution) scrubbing unit **144** and a water scrubbing unit **145**. The scrubbing units are provided in operative communication with the oil storage tank **142** for receiving the non-condensable gaseous hydrocarbons for purifying. The scrubbing units are provided with a pressure gauge **130**. The purified non-condensable gaseous hydrocarbons are then conveyed to a burner chamber **134** through a non-condensable gas outlet **132**. The burner chamber **134** is adapted to burn the non-condensable gases as a flame **136**. The burner chamber **134** is supported on a burner stand **138**.

The process yield for plastic waste is 70 – 85% oil, 10 – 20% coke and 5 – 10% non-condensable gases. The process yield for rubber waste is 40 – 50% oil, 30 – 50% coke, and 5 – 10% non-condensable gas. The hydrocarbon oil is suitable for use as a raw material in the manufacturing of polymers, petroleum, or as a liquid fuel in industrial processes or as a fuel for combustion engines such as boilers, or as a bunker fuel. The coke residue can be used as a fuel in thermal power plants and metallurgical industries.

FIG. 2 is a simplified explanatory flow diagram showing the process of thermal cracking in accordance with the present invention. In accordance with the present invention, the method comprises the steps of:

Step S1:(i) feeding the solid waste together with a catalyst into a thermal cracking reactor **110** which is horizontally positioned, wherein the cracking reactor **110** is provided with an operative top side-wall **103** and an operative bottom side-wall **105**, a residue outlet **118** at said operative bottom side-wall **103**, having a feed inlet **104** at one end thereof and a gas outlet **116** at the opposite end on the operative top side-wall **103**, and an agitator device **106** centrally positioned between the side-walls **103,105** along the operative longitudinal axis of the reactor **110**;

Step S2:(ii) subjecting the solid waste in the reactor to thermal cracking at a temperature in the range of 200 to 475 C to obtain a catalytic thermal cracking product containing a gaseous hydrocarbon stream and coke residue CR;

Step S3:(iii) receiving the gaseous hydrocarbon stream in a condenser **120** and discharging the coke residue CR from step (ii) S2 at the residue outlet **118**;

Step S4:(iv) cooling the gaseous hydrocarbon GH stream in the condenser **120** to obtain an at least partly condensate streaming containing a liquid hydrocarbon oil of smaller molecules and non-condensable gaseous hydrocarbons GH;

Step S5:(v) collecting the condensate stream in an oil storage tank and conveying the non-condensable gaseous hydrocarbons to scrubbing unit to purify the non-condensable gaseous hydrocarbons GH ; and

Step 6 :(vi) passing the purified non-condensable gaseous hydrocarbons to a burner chamber (134) for burning.

FIG. 3 is a schematic view showing the conversion of feed to obtain the gaseous hydrocarbon in accordance with the present invention.

- 5 As shown, the solid waste denoted as SW and a catalyst denoted as CT are fed into the reactor 110. Optionally, a heavy oil, denoted as HO may be added along with the feed. The product from the process includes gas hydrocarbon GH and a coke residue CR.

The analysis of various fuel samples obtained by the method of the present disclosure described herein is given in **Table 1 - 5**.

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TABLE 1: Analysis of a hydrocarbon oil obtained by thermal cracking of waste plastic

Test	Unit	Method	Result
ASTM Color	~	ASTM D1500-07	> 8.0
Pour Point	° C	ASTM D97-11	+ 30
Flash Point (PMCC)	° C	ASTM D93-11	< Ambient
Fire Point	° C	ASTM D92-05a(2010)	< 40.0
Sediment by Extraction	Mass %	ASTM D473-07	0.22
Sulphur Content	Mass %	ASTM D4294-10	0.76
Density @ 15° C	kg / L	ASTM D4052-09	1.0398
Gross Calorific Value	MJ / kg	ASTM D4868-00(2010)	40.66
Gross Calorific Value	kcal/kg	ASTM D4868-00(2010)	9711.5
Kinematic Viscosity @ 40° C	cSt	ASTM D445-11a	117.5

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TABLE 2: Analysis of a hydrocarbon oil obtained by thermal cracking of waste plastic (from municipal solid waste)

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No.	Test	Unit	Method	Result
1	ASTM Color	~	ASTM D1500-07	> 8
2	Pour Point	° C	ASTM D97-11	+ 18
3	Flash Point (PMCC)	° C	ASTM D93-11	Below Ambient
4	Fire Point	° C	ASTM D92-05a (2010)	< 40
5	Sediment by Extraction	Mass %	ASTM D473-07	0.06
6	Sulphur Content	Mass %	ASTM D4294-10	1.66
7	Density @ 15° C	kg / m ³	ASTM D 4052-09	0.9514
8	Gross Calorific Value	MJ / kg	ASTM D240-09	38.370
9	Gross Calorific Value	kcal/kg	ASTM D240-09	9,164.5
10	Kinematic Viscosity @ 40° C	cSt	ASTM D445-11a	13.78

TABLE 3: Analysis of Distilled Oil

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No.	Test	Unit	Method	Result
1	ASTM Color	~	ASTM D1500-07	1.0
2	Pour Point	° C	ASTM D97-08	<-18
3	Flash Point (PMCC)	° C	ASTM D93-08 (Proc A)	< Ambient
4	Fire Point (COC)	° C	ASTM D92-05a	< Ambient
5	Sediment by Extraction	Mass %	ASTM D473-07	< 0.01
6	Sulphur	Mass %	ASTM D4294-08a	0.0257
7	Density @ 15° C	Kg / L	ASTM D4052-96(02)e1	0.8821
8	Gross Calorific Value	KJ / Kg	ASTM D240-02(07)	39,720
9	Kinematic Viscosity @ 40° C	mm ² / s	ASTM D445-06	0.7180

TABLE 4: Analysis of Residual Oil (after distillate)

No.	Test	Unit	Method	Result
1	ASTM Color	~	ASTM D1500-07	> 8
2	Pour Point	° C	ASTM D97-08	0
3	Flash Point (PMCC)	° C	ASTM D93-08 (Proc A)	73.0
4	Fire Point (COC)	° C	ASTM D92-05a	122.0
5	Sediment by Extraction	Mass %	ASTM D473-07	0.29
6	Sulphur	Mass %	ASTM D4294-08a	0.0499
7	Density @ 15° C	Kg / L	ASTM D4052-96(02)e1	1.0426
8	Gross Calorific Value	KJ / Kg	ASTM D240-02(07)	37,645
9	Kinematic Viscosity @ 40° C	mm ² / s	ASTM D445-06	64.83

TABLE 5: Analysis of a hydrocarbon oil obtained by thermal cracking of waste rubber

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No.	Test	Unit	Method	Result
1	ASTM Color	~	ASTM D1500-07	> 8
2	Pour Point	° C	ASTM D97-08	+ 12
3	Flash Point (PMCC)	° C	ASTM D93-08	< Ambient
4	Fire Point	° C	ASTM D92-05a	< 40.0
5	Sediment by Extraction	Mass %	ASTM D473-07	0.12
6	Sulphur Content	Mass %	ASTM D4294-09	1.36
7	Density @ 15° C	kg / L	ASTM D1298-99(05)	0.9785
8	Gross Calorific Value	kJ / kg	ASTM D240-09	37.495
9	Gross Calorific Value	kCal/kg	ASTM D240-09	8,956
10	Kinematic Viscosity @ 40° C	cSt	ASTM D445-09	7.300

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The results shown in the above examples clearly demonstrate that the present invention is

well adapted to carry out the objects and attain the end and advantages mentioned as well as those inherent therein. While modifications may be made by those skilled in the art, such modifications are encompassed within the spirit of the present invention as defined by the specification and the claims.

CLAIMS

1. A system (100) of converting solid waste of plastics/rubber into hydrocarbon fuel, said system (100) comprising:

5 (i) a thermal cracking reactor (110) for cracking the solid waste and a catalyst as feed at a temperature in the range of 200-475 °C to obtain a catalytic thermal cracking product containing a gaseous hydrocarbon stream and a coke residue; and

(ii) a condenser (120) for receiving said gaseous hydrocarbon stream and cooling said gaseous hydrocarbon stream to obtain an at least partly condensate stream containing a
10 liquid hydrocarbon oil of smaller molecules and non-condensable gaseous hydrocarbons, wherein said thermal cracking reactor (110) having an operative top side-wall (103) and an operative bottom side-wall (105) is positioned in horizontal and comprising a feed inlet (104) at one end and a gas outlet (116) at an opposite end on said operative top side-wall (103), a residue outlet (118) at said operative bottom side-wall (103), and an agitator device (106)
15 centrally positioned between said side-walls (103, 105) along the operative longitudinal axis of said reactor (110), and wherein the condenser (120) is in operative communication with said gas outlet (116) of said reactor (110).

2. The system of Claim 1, further comprising an oil storage tank (142) which is in operative communication with the condenser (120) to receive condensate stream from the
20 condenser (120).

3. The system of Claim 2, wherein the oil storage tank (142) comprises a scrubbing unit in operative communication with the oil storage tank (142) for receiving and non-condensable gaseous hydrocarbons for purifying.

4. The system of Claim 3, wherein the oil storage tank (142) comprises a burner
25 chamber (134) for receiving purified non-condensable gaseous hydrocarbons for burning.

5. The system of Claim 3, wherein the scrubbing unit is a sodium hydroxide scrubbing unit (143).

6. The system of Claim 3, wherein the scrubbing unit is a calcium hydroxide scrubbing unit (144).

30 7. The system of Claim 3, wherein the scrubbing unit is a water scrubbing unit (145).

8. The system of Claim 1, wherein the agitator device (106) is used to push downwards the feed entering the reactor (110) at the fed inlet (104) along the operative longitudinal axis of the reactor (110) so as to enable completion of gasification of the hydrocarbons in the solid waste.

9. The system of Claim 2, wherein the burner chamber (134) is in operative communication with the scrubbing unit (145) for receiving purified non-condensable gaseous hydrocarbons for burning.

10. A method of converting solid waste of plastics/rubber into hydrocarbon fuel, said system (100) comprising the steps of:

(i) feeding the solid waste together with a catalyst into a thermal cracking reactor (110) which is horizontally positioned, wherein the cracking reactor (110) is provided with an operative top side-wall (103) and an operative bottom side-wall (105), a residue outlet (118) at said operative bottom side-wall (103), having a feed inlet (104) at one end thereof and a gas outlet (116) at the opposite end on the operative top side-wall (103), and an agitator device (106) centrally positioned between the side-walls (103,105) along the operative longitudinal axis of the reactor (110);

(ii) subjecting the solid waste in the reactor to thermal cracking at a temperature in the range of 200 to 475 C to obtain a catalytic thermal cracking product containing a gaseous hydrocarbon stream and coke residue;

(iii) receiving the gaseous hydrocarbon stream in a condenser (120) and discharging the coke residue from step (ii) at the residue outlet (118);

(iv) cooling the gaseous hydrocarbon stream in the condenser (120) to obtain an at least partly condensate streaming containing a liquid hydrocarbon oil of smaller molecules and non-condensable gaseous hydrocarbons;

(v) collecting the condensate stream in an oil storage tank and conveying the non-condensable gaseous hydrocarbons to scrubbing unit to purify the non-condensable gaseous hydrocarbons; and

(v) passing the purified non-condensable gaseous hydrocarbons to a burner chamber (134) for burning.

11. The method of Claim 10, wherein the solid waste is shredded into a particle size of less than 20 mm.

12. The method of Claim 10, wherein the catalyst is selected from the group consisting of aluminum silicate, barium silicate, beryllium silicate, calcium silicate, iron silicate, magnesium silicate, manganese silicate, potassium silicate, sodium silicate, zirconium silicate, copper silicate, tin silicate, iron silicate, lead silicate, tungsten silicate, cesium silicate, lithium silicate, aluminum, bismuth, copper (cuprum), iron (ferrum), lead, magnesium, manganese, nickel, tin (stannum), tungsten, zinc, aluminum oxide, bismuth oxide, copper (cuprum) oxide, iron (ferrum) oxide, lead oxide, magnesium oxide, manganese

oxide, nickel oxide, tin (stannum) oxide, tungsten oxide, zinc oxide, aluminum carbonate, calcium carbonate, sodium carbonate, bismuth carbonate, copper (cuprum) carbonate, iron (ferrum) carbonate, lead carbonate, magnesium carbonate, manganese carbonate, nickel carbonate, tin (stannum) carbonate, tungsten carbonate, zinc carbonate, silicon carbide, calcium carbide, natural and synthetic zeolite, alumina, fuller's earth, bauxites, metal borates, metal borides, ZSM-5, FCC Y-catalyst, NiMo over γ -alumina, NiW loaded on amorphous silica-alumina, cobalt loaded active carbon (Co-AC), DHC-8 (commercial silica-alumina catalyst), HZSM-5, activated red mud, calcined kaolin, Eckalite 1, Siltol CPT-30, Siltol MT 100, Mizukasisieves Y-420, Re Y-zeolite, acidic alumina, Na Y-zeolite, and H Y-zeolite.

- 10 13. The method of Claim 12, wherein the catalyst is a mixture containing at least one metal silicate, at least one metal oxide, at least one zeolite type compound, and at least one additive.
14. The method of Claim 12, wherein the catalyst has a particle size in the range of 0.1 mm to 10mm.
- 15 15. The method of Claim 11, wherein the ratio of the catalyst to the solid waste is in the range of 0.01:1 to 0.05:1.