FRACTIONAL CONDENSATION PROCESS

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Publication Classification
(51) Int. Cl7 ........................................... C10G 1/10
(52) U.S. Cl. ........................................ 585/241; 585/240; 201/25

ABSTRACT

The amount of limonene and other pyrolytic oils within the condensate gases produced during pyrolysis of scrap tire carcasses or polyisoprene rubbers can be increased by fractionally condensing and liquefying the gaseous products in a series of vertical condensers. As the gases are passed through each successive condenser, fractions of the gases having a boiling point between 930 degrees Fahrenheit and 110 degrees Fahrenheit are separated and recovered.
FRACTIONAL CONDENSATION PROCESS

BACKGROUND

[0001] Passenger cars, buses, and trucks use millions of tires every year presenting a difficult disposal problem. Burning is usually prohibited or tightly regulated because of air pollution concerns. Burning the tires leads to a significant increase in the need for landfills and possible groundwater contamination. As a result, used tires tend to accumulate creating environmental hazards and potential breeding grounds for disease.

[0002] In disposing of used tires by burning or pyrolysis it is desirable to recover hydrocarbon emissions to reduce air pollution. The hydrocarbons can be used as fuel sources replacing expensive petroleum products.

[0003] The conversion of rubber into fuels is generally known. Roy (U.S. Pat. Nos. 5,229,099, 5,208,401, 5,099, 086 and 4,740,270) relate to the vacuum pyrolysis of tires at a temperature of from about 360-415 degrees centigrade (hereinafter “degree C.”) under pressures of less than about 725 millimeters of mercury (hereinafter “mm Hg”) absolute. Roy further discloses the extraction of chemicals from tin-derived pyrolytic oils by subjecting the pyrolytic oils to fractional distillation. The chemicals extracted may include benzene, toluene, xylene, styrene and limonene-dl. Some of the high boiling distillation fraction can be used as an extension oil in the manufacture of various rubber and plastic parts. Also disclosed is a process for producing carbon black by vacuum pyrolysis of used rubber tires. Hanson (U.S. Pat. Nos. 6,149,881 and 5,977,420) disclose a process to increase the amount of limonene produced during pyrolysis of scrap tire carcass or polyisoprene rubber by decreasing residence time of the isoprene gas produced during the thermal degradation of polyisoprene rubber in the high temperature reactor region of an oven. This is accomplished by an oven design, which permits rapid expansion of the gas from the high temperature region of the oven to a cooler region where the gas condenses. Further, the system enables separation of the solid, liquid and gas phases produced during pyrolysis. Takahashi et al. (U.S. Pat. No. 5,414,169) relates to a method of obtaining hydrocarbon oil from waste plastic material or waste rubber material, by thermal cracking the waste material, liquefying the product causing a liquid phase of the product under action of a catalyst to produce a cracking product, and cooling the cracking product thereby obtaining the hydrocarbon oil, and an apparatus used for carrying out the method.

[0004] Padgett et al. (U.S. Pat. No. 5,366,595) discloses a rotatable cylinder, which is loaded and sealed and the oxygen is evacuated. A microwave-heating device then heats the waste material and breaks the waste material down into solid and fluid products. The cylinder is rotated at high speed, creating centrifugal force on the waste material and causing the fluid products to escape from the cylinder. The liquid products are the collected in a heat exchanger chamber where they are cooled. A fractional distillation system then stratifies the fluid products according to weight for purposes of recovery. Apfel’s (U.S. Pat. No. 4,647,443) discloses a process wherein tires are pyrolyzed to partially devolatize a major portion of the hydrocarbons and produce a char that can be separated from the steel and fiberglass. The char can be further pyrolyzed with microwaves to devolatize the remaining hydrocarbons from the char as gas. The hot gases are cooled and partially condensed. The uncondensed gas is used as fuel. The condensed oil is sent to storage. The solid residue from the tire pyrolysis is char, fiberglass and steel. The char is mechanically separated from the glass and steel. The char is milled to break down agglomerates and subsequently pelletized and bagged. The steel and glass are discarded as trash. Coen et al. (U.S. Pat. No. 4,642,401) relates to a process for the production of liquid hydrocarbons from rubber or plastic wastes by treatment at elevated temperatures with a solvent to form a solvent phase charged with liquid hydrocarbons and a residue phase. The solvent phase is separated from the residue, and the solvent phase is then fractionated by distillation.

[0005] Habib (U.S. Pat. No. 4,588,477) relates to a traveling fluidized bed distillation of tire and rubber scrap in a mixture with coarse aggregate. The rubber and aggregates are charged to a vertical still where they are burned. The volatile materials and the pyrolysis oil vapors are drawn at the top for recovery and processing. Fines are recovered and the aggregate still at elevated temperatures are recycled to the top of the column and reused again with additional ground rubber. Noncondensable gases resulting from the “pyrolysis oil” condensation and recovery system can be used for combustion needs in the still, or for steam generation. Another use of this invention is the production of zinc. Lyakhovich et al. (U.S. Pat. No. 4,584,150) discloses a method of making either a softener for rubber mixtures or a furnace fuel oil by heating a solvent and adding rubber wastes material. The waste is thermally decomposed and product separated by distillation.

[0006] Sloterdijk (U.S. Pat. No. 4,317,800) disclosed a process for treating waste containing halogenated hydrocarbons with used metal and/or metal scrap at elevated temperatures. The halogenated hydrocarbons are pyrolyzed and the resulting gas is brought into contact with the used metal and/or metal scrap at high temperatures to form metal halogenides. The metal halogenides are separated from the gaseous mixture by condensation. Haas et al. (U.S. Pat. No. 4,264,568) relates to a method for removing zinc from solid carbon black obtained from the pyrolysis of rubber. The carbon black is contacted at high temperatures with a gas selected from chlorine and hydrogen chloride to form gaseous zinc chloride from the zinc contained in said carbon black, and separating the gaseous zinc chloride from the solid carbon black.

[0007] Reed et al. (U.S. Pat. No. 4,255,129) discloses a method for processing various organic materials by feeding the material to a vertically extending heating chamber and controlling the oxygen therein. The chamber has an internal spiral vibratory conveyor.

[0008] Resultant off-gases are removed from the chamber for burning to heat the chamber or condensing volatile gases. Slobakken et al. (U.S. Pat. No. 4,250,158) discloses a process for pyrolyzing waste tires in an oxygen-limited atmosphere with condensate refluxing. And Chen et al. (U.S. Pat. No. 4,175,211) discloses a process for converting polymeric wastes to liquid, solid, and gaseous products by mixing rubber and/or plastic wastes at high temperatures in a refractory petroleum stream and catalytically cracking the mixture.
[0009] The present invention overcomes the above-noted problems and also has numerous other advantages that will be apparent to those skilled in the art. The present invention is a process wherein the amount of limonene and other pyrolytic oils within the condensate gases produced during pyrolysis of scrap tire carcasses or polyisoprene rubbers can be increased by fractionally condensing and liquefying the condensate gas in a series of vertical condensers. As the condensate gas is passed through each successive condenser, fractions of the condensate gases having a boiling point between 930 degrees Fahrenheit and 110 degrees Fahrenheit are separated and recovered.

SUMMARY OF THE INVENTION

[0010] A process has been developed that overcomes the above-noted problems and also has numerous other advantages that will be apparent to those skilled in the art.

[0011] In using the present invention, the amount of limonene and other pyrolytic oils within the condensate gases produced during pyrolysis of scrap tire carcasses or polyisoprene rubbers can be increased by fractionally condensing and liquefying the condensate gas in a series of vertical condensers. As the condensate gas is passed through each successive condenser, fractions of the condensate gases having a boiling point between 930 degrees Fahrenheit and 110 degrees Fahrenheit are separated and recovered.

[0012] The present invention is a process for recovering valuable gaseous products from scrap rubber tires or polyisoprene rubbers, which have been heated and decomposed in a heated reactor. The gaseous products are fractionally condensed in two or more vertical condensers. Liquid condensate is then recovered. Typically the liquid condensate is a pyrolytic oil having a boiling point between 930 degrees Fahrenheit and 110 degrees Fahrenheit. A typical condensate product is limonene.

[0013] Another aspect of the present invention is that by increasing the number of vertical condensers, increases the range of liquid condensate obtained.

[0014] Another aspect of the present invention is that the fractional condensation is carried on under atmospheric pressure.

[0015] Yet another aspect of the present invention is that air pollution is greatly reduced.

[0016] Other characteristics and advantages of the invention will become apparent upon reading the following description of an embodiment of the invention, provided as a non-limiting example and illustrated by the attached drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a partial schematic flow sheet illustrating an embodiment of the process of the present invention, in which a single vertical condenser is shown for fractionally condensing gases from pyrolyzing scrap tires.

[0018] FIG. 2 is a schematic flow sheet illustrating a preferred embodiment of the process of the present invention, in which three vertical condensers are shown for fractionally condensing gases from pyrolyzing scrap tires.

DETAILED DESCRIPTION OF THE INVENTION

[0019] As shown in FIG. 1, pyrolysis condensate gas 10 from the pyrolysis of scrap tires is fed into the bottom of a first vertical condenser 500. Cooling water is fed into the top of the first vertical condenser 500 and is discharged from the bottom of the first vertical condenser 500. A first condensate liquid 120 is removed from the bottom of said first vertical condenser 500. A second condensate gas 20 is removed from the top of the first vertical condenser 500. The first condensate liquid 120 is collected in a first accumulator 550. The first accumulator 550 has an inert gas blanket to prevent potential explosions from the first condensate liquid 120. Periodically the first condensate liquid 120 is removed from the bottom of the first accumulator 550.

[0020] A typical embodiment of the present invention is shown in FIG. 2, wherein there are a series of three vertical condensers. Pyrolysis condensate gas 10 from the pyrolysis of scrap tires is fed into the bottom of a first vertical condenser 500. Cooling water is fed into the top of the first vertical condenser 500 and is discharged from the bottom of the first vertical condenser 500. A first condensate liquid 120 is removed from the bottom of said first vertical condenser 500. A second condensate gas 20 is removed from the top of the first vertical condenser 500. The first condensate liquid 120 is collected in a second accumulator 550. The second accumulator 550 has an inert gas blanket, typically Nitrogen, to prevent potential explosions from the first condensate liquid 120. Periodically the first condensate liquid 120 is removed from the bottom of the accumulator 550.

[0021] The second condensate gas 20 is fed into the bottom of a second vertical condenser 510. Cooling water is fed into the top of the second vertical condenser 510 and is discharged from the bottom of the second vertical condenser 510. A second condensate liquid 130 is removed from the bottom of said second vertical condenser 510. A third condensate gas 30 is removed from the top of the second vertical condenser 510. The second condensate liquid 130 is collected in a second accumulator 560. The second accumulator 560 has an inert gas blanket to prevent potential explosions from the second condensate liquid 130. Periodically the second condensate liquid 130 is removed from the bottom of the second accumulator 560.

[0022] The third condensate gas 30 is fed into the bottom of a third vertical condenser 520. Cooling water is fed into the top of the third vertical condenser 520 and is discharged from the bottom of the third vertical condenser 520. A third condensate liquid 140 is removed from the bottom of said third vertical condenser 520. A fourth condensate gas 40 is removed from the top of the third vertical condenser 520. The third condensate liquid 140 is collected in a third accumulator 570. The third accumulator 570 has an inert gas blanket to prevent potential explosions from the third condensate liquid 140. Periodically the third condensate liquid 140 is removed from the bottom of the third accumulator 570. The fourth condensate gas 40 is fed to a coalescing filter 600.

[0023] The size and number of vertical condensers is dependent upon the fraction of condensed liquids that is desired. A typical distribution of condensed liquids is given in Table 1.
<table>
<thead>
<tr>
<th>Condensation Range</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>90%</td>
<td>326</td>
</tr>
<tr>
<td>80%</td>
<td>226</td>
</tr>
<tr>
<td>70%</td>
<td>226</td>
</tr>
<tr>
<td>60%</td>
<td>302</td>
</tr>
<tr>
<td>50%</td>
<td>255</td>
</tr>
<tr>
<td>40%</td>
<td>234</td>
</tr>
<tr>
<td>30%</td>
<td>204</td>
</tr>
<tr>
<td>20%</td>
<td>176</td>
</tr>
<tr>
<td>10%</td>
<td>142</td>
</tr>
<tr>
<td>Final</td>
<td>85</td>
</tr>
</tbody>
</table>

The condensed liquids are usable as fuel for the pyrolysis of scrap tires. Certain fractions of the condensed liquids may include, but are not limited to, benzene, toluene, xylene, styrene and limonene-dl.

The preferred embodiments of the present invention disclosed herein have been discussed for the purpose of familiarizing the reader with the novel aspects of the invention. Although preferred embodiments of this invention have been shown, many changes, modifications, and substitutions may be made by one having ordinary skill in the art without departing from the scope and spirit of the invention as described in the following claims.

I claim:

1. A process for recovering valuable gaseous products from scrap rubber tires or polyisoprene rubbers that have been heated and decomposed in a heated reactor comprising:
   - at least two vertical condensers for condensing a fractional portion of said gaseous product and recovering at least one liquid condensate.
   - The process of claim 1 in which the gaseous product is a pyrolytic gas.
   - The process of claim 1 in which the liquid condensate is a pyrolytic oil having a boiling point between 930 degrees Fahrenheit and 110 degrees Fahrenheit.
   - The process of claim 3 in which the liquid condensate includes but is not limited to limonene.
   - The process of claim 1 having at least 4 vertical condensers.
   - The process of claim 5 in which the gaseous product is a pyrolytic gas.
   - The process of claim 5 in which the liquid condensate is a pyrolytic oil having a boiling point between 930 degrees Fahrenheit and 110 degrees Fahrenheit.
   - The process of claim 7 in which the liquid condensate includes but is not limited to limonene.

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