United States Patent [19]

Albright et al.

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[54] **CRACKING REACTOR**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 252,512, May 8, 1972, abandoned.

[52] **U.S. Cl.**..... **23/284,** 23/252 R, 23/277 R, 259/4, 260/679 R, 260/683 R

[51] **Int. Cl.**..... **B01f 3/04,** B01j 1/00, C07c 11/04

[58] **Field of Search**..... 23/284, 285, 277 R, 252 R, 23/277 C; 260/677 R, 679 R, 683 R, 678; 196/115, 123, 126, 129; 48/94, 75, 105; 259/4

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[57] **ABSTRACT**

A reactor adapted for the cracking of hydrocarbons with hot gas comprising:

A. a circular convex lens shaped hollow structure having (i) two walls, which are joined at their peripheries to form the structure, at least one of said walls being provided with an orifice disposed substantially centrally therein; and (ii) at least one hollow inlet feed chamber open at both ends passing through a wall of the structure, one end of said feed chamber being disposed in the interior of the structure at about the juncture of the walls in such a manner that vapor, which is passed through said chamber, will flow substantially tangentially to the juncture, provided that the rate of flow is sufficient therefor, creating a vortex-like flow within the structure; and

B. at least one hollow tube open at both ends;

wherein:

a. one end of the tube is connected to the structure at its orifice in substantially concentric alignment therewith and in open communication with the structure;

b. the ratio of the length of the structure measured along a theoretical axis, which joins the center points of the walls, to the diameter of the structure measured across a theoretical plane perpendicular to the theoretical axis and bisecting the structure is about 0.05:1 to about 1:1;

c. the ratio of the equivalent diameter of the orifice of the structure to the equivalent diameter of the tube is about 1:1 to about 0.1:1.

d. the tube has a length to equivalent diameter ratio of about 5:1 to about 200:1; and

e. the ratio of the volume of the structure to the volume of the tube is about 0.01:1 to about 5:1.

7 Claims, 4 Drawing Figures

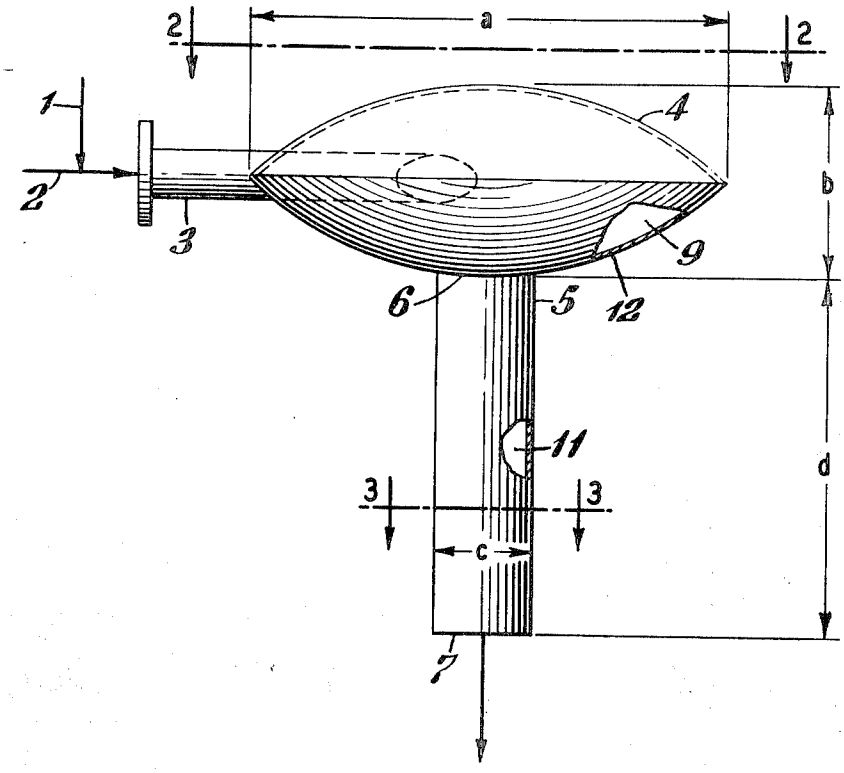


Fig. 1

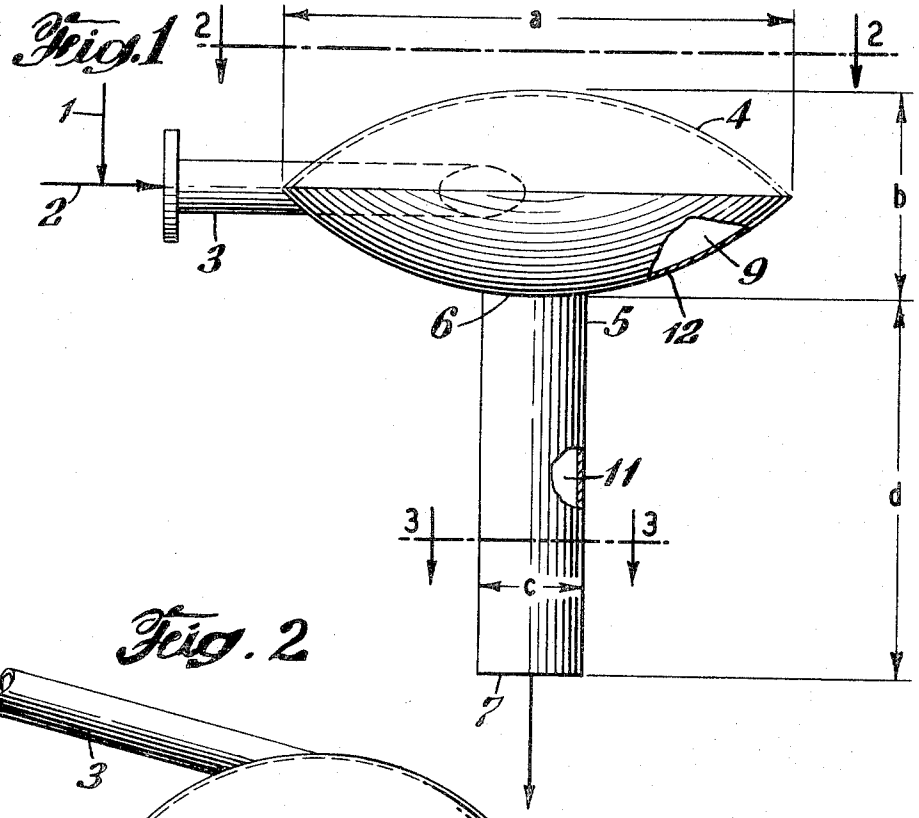


Fig. 2

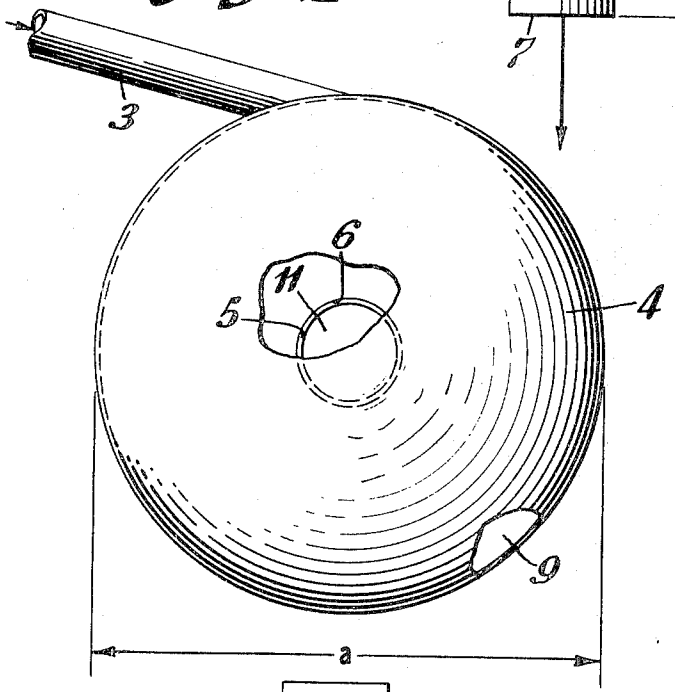


Fig. 3

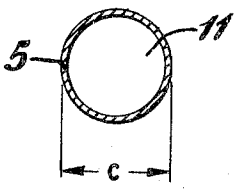
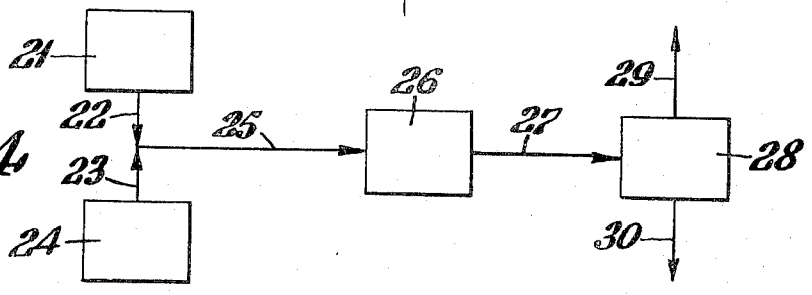


Fig. 4



CRACKING REACTOR

This application is a continuation-in-part of application Ser. No. 252,512, filed on May 8, 1972, now abandoned.

FIELD OF THE INVENTION

This invention relates to an improvement in the systems presently used for the thermal cracking of hydrocarbons with hot gases and more particularly, to an improved cracking reactor for such systems.

DESCRIPTION OF THE PRIOR ART

Thermal cracking of hydrocarbon feedstocks has for many years been a major source for supplying the needs of the chemical industry with the most basic of chemicals such as ethylene and propylene, the former being used chiefly in the production of low and high density polyethylene, ethylene oxide and vinyl chloride, and the latter for the production of isopropyl alcohol, acrylonitrile, polypropylene and propylene oxide.

Natural gas or various components thereof and naphtha are currently the major feedstocks from which ethylene, propylene and acetylene are derived by thermal cracking; however, shortages of these feedstocks at reasonable cost suggest that industry will have to turn to crude oil or even heavier materials in their stead. One method for thermal cracking involves introducing liquid feedstocks into a reactor in atomized form together with superheated steam, and/or another hot gas, which supplies the heat necessary for the endothermic cracking reaction. The introduction of the feedstocks and steam is accomplished in such a manner that the components are thoroughly mixed and the high temperature is uniformly and rapidly established throughout the incoming feedstock.

The main drawbacks in present thermal cracking techniques center in the reactors available in that they are not versatile, i.e., these reactors do not accept a variety of liquid feedstocks such as naphtha, gas oils, natural gasolines, raffinates, and their component hydrocarbons, which are being used as feedstocks and will continue to be used for many years, together with crude oil and possibly even heavier materials, which will be used more and more in the future, and present reactors do not have the capability of providing high yields of ethylene, propylene and acetylene regardless of the choice of feedstock. This simply means that because of the transitional nature of the economics affecting feedstocks, highly specialized reactors, which only accept limited kinds of feedstocks are not presently attractive investment-wise. Rather, to be commercially advantageous, a reactor must have sufficient flexibility to accept the feedstocks which are considered to be the most economic at the time whether, e.g., it is naphtha or crude oil, and provide good yields from either.

To date, the provision of high yield reactors for thermally cracking a variety of liquid feedstocks, all at high yields, has proved elusive especially when both naphtha and crude oil must be included in their repertoire.

SUMMARY OF THE INVENTION

An object of this invention, therefore, is to provide a reactor which, using conventional processes, is capable of cracking a variety of hydrocarbon feedstocks, particularly naphtha and crude oil, to ethylene, propylene and acetylene in high yield.

Other objects and advantages will become apparent hereinafter.

According to the present invention, such a reactor has been discovered for the cracking of hydrocarbons with hot gas comprising:

A. a circular convex lens shaped hollow structure having (i) two walls, which are joined at their peripheries to form the structure, at least one of said walls being provided with an orifice disposed substantially centrally therein; and (ii) at least one hollow inlet feed chamber open at both ends passing through a wall of the structure, one end of said feed chamber being disposed in the interior of the structure at about the juncture of the walls in such a manner that vapor, which is passed through said chamber, will flow substantially tangentially to the juncture, provided that the rate of flow is sufficient therefor, creating a vortex-like flow within the structure; and

B. at least one hollow tube open at both ends;

wherein:

a. one end of the tube is connected to the structure at its orifice in substantially concentric alignment therewith and in open communication with the structure;

b. the ratio of the length of the structure measured along a theoretical axis, which joins the center points of the walls, to the diameter of the structure measured across a theoretical plane perpendicular to the theoretical axis and bisecting the structure is about 0.05:1 to about 1:1;

c. the ratio of the equivalent diameter of the orifice of the structure to the equivalent diameter of the tube is about 0.1:1 to about 1:1;

d. the tube has a length to equivalent diameter ratio of about 5:1 to about 200:1; and

e. the ratio of the volume of the structure to the volume of the tube is about 0.01:1 to about 5:1.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic sideview cross section of a reactor embodying the invention.

FIG. 2 is a schematic plan view taken along line 2—2 of FIG. 1.

FIG. 3 is a schematic plan view taken along line 3—3 of FIG. 1.

It should be noted that the relative dimensions of parts of the reactor in FIGS. 1 to 3 do not conform to the ratios prescribed in the specification.

FIG. 4 is a schematic flow diagram illustrating a conventional system in which a reactor embodying the invention can be used.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The reactor can be made from various materials, the preferred material being stainless steel, e.g., AISI type 316 stainless steel. Other representative materials from which the reactor can be made are AISI types 304 and 347 stainless steels; an alloy containing approximately 76 percent nickel, 16 percent chromium, and 6 percent iron; as well as various ceramics with high temperature stability.

The thickness of the reactor walls can be decided upon conventional lines and is not critical to the invention. Temperatures, pressures, longevity, economics,

and available materials should be considered when making the decision.

Referring to the drawing:

It will be apparent from the drawing that the preferred embodiment of the reactor described here can be called a convex lens, or simply, a lens and tube reactor and subsequent references made in the description may refer to the lens portion of the reactor or the tube portion of the reactor.

Atomized liquid feedstock passes through line 1 and joins line 2 through which is flowing a hot gas such as superheated steam. Lines 1 and 2 are conventional parts of the entire cracking system and not essential parts of the reactor. The mixture enters inlet feed chamber 3 and then passes into interior 9 of the lens portion of the reactor where the cracking begins.

Inlet feed chamber (or inlet tube) 3 is disposed in interior 9 at the juncture of walls 4 and 12, which describe a convex lens type structure.

There can be one or more inlets depending on the size of the reactor and the feed input per unit time desired, all placed in a similar manner to chamber 3, preferably at points equally spaced on either side from one another along the juncture at the peripheries of walls 4 and 12. Thus, two inlets can be connected through the juncture at points representing 180° and 360°, respectively; three inlets at points along the juncture representing 120°, 240° and 360°, respectively; and four inlets along the juncture at 90°, 180°, 270°, and 360°, respectively.

The connection of chamber 3, and similar tubes, to the interior of the structure is preferably essentially tangential; however, such disposition is best defined by stating that it be disposed in such a manner that gas flowing from the chamber can flow substantially tangentially to the juncture of walls 4 and 12 creating a vortex-like flow in the lens portion of the reactor. The size and shape of the chamber, the rate of flow of the feedstock/hot gas mixture, and the direction of flow will have to be considered by the technician in achieving tangential and vortex-like flow in the lens. In practice, the inlet chamber is a tube with openings at both ends placed in a fixed position in the lens so that its theoretical axis is tangential to the juncture of the walls, in this case walls 4 and 12, and the rate of flow is controlled to achieve the tangential and vortex-like flow.

Although chamber 3 is preferably disposed through the juncture as shown in the drawing, it can be disposed through wall 4 or wall 12 and still achieve a modicum of tangential flow together with vortex-like flow. Although such a disposition is contemplated, it is not the preferred way of carrying out the invention in view of the irregularities of the flow.

Top wall 4 is a circular structure representing one half of the convex lens type structure and is the same shape as bottom wall 12. It has no openings except at the point where inlet feed chamber 3 is disposed. The arc described by wall 4 can be in the range of about 11° to about 124° and is preferably in the range of about 23° to about 106°. The definition of the arc is not critical because the dimensions of the lens are defined by various ratios mentioned heretofore.

Since symmetry in the lens portion of the reactor is important, bottom wall 12 is the mirror image of top wall 4 except for orifice 6 disposed substantially centrally therein.

The mixture, which now comprises partially cracked feedstock, its cracked derivatives, and steam, and/or other hot gases, passes from the lens portion of the reactor through orifice 6 into interior 11 of the hollow tube portion of the reactor. Wall 5 describes the hollow tube of the tube portion which is open at both ends. The tube is in open communication with the lens through orifice 6. Wall 5 can be connected to wall 12 at the boundaries of orifice 6 or, if the diameter of the tube is greater than the orifice, wall 5 can be connected at other points on wall 12. In any case, the center of the tube is substantially aligned with the center of the orifice.

The cross-section of the hollow tube can be of a variety of shapes, a cylindrical cross-section being preferred. It can, for example, be square, rectangular, triangular, pentagonal, hexagonal, or elliptical, although a mixture of these cross-sections in the same tube is not recommended. The tube can also be a helical coil, which may be of value if the space available will not accommodate a straight tube. The end of the tube opposite to the tube's connection to the disc at orifice 6 is outlet 7 through which the reactor is in open communication with the down-stream portion of the system and, after cracking is essentially completed in the tube portion, the effluent proceeds through this outlet.

Certain ratios concerning dimensions and volumes are critical to the invention. For the purpose of setting out these ratios, the lens portion of the reactor will be referred to as structure A and the tube portion of the reactor as tube B. The important dimensions are as follows:

a = the diameter of structure A measured across a theoretical plane perpendicular to the theoretical axis joining the center points of walls 4 and 12, and bisecting the structure.

b = the length of structure A measured along a theoretical axis, which joins the center points of walls 4 and 12.

c = the equivalent diameter of tube B, the tube portion of the reactor. This dimension can also be referred to insofar as the drawing is concerned to the diameter of the cylindrical tube bounded by wall 5.

d = the length of tube B. This dimension can also be referred to as the height of wall 5.

The dimension of orifice 6 is not shown in the drawing since it coincides with dimension c. This dimension can, however, be different from dimension c and will be referred to hereinafter as the equivalent diameter of the orifice of structure A.

It should be noted that dimensions a, b, and c are outer dimensions which include the thickness of the reactor walls. This was an arbitrary selection, i.e., interior dimensions could have just as well been used.

Equivalent diameter is used to describe dimension c and the dimension of orifice 6 simply because the tube and orifice do not have to be cylindrical cross-sections, but can take on a variety of shapes. Various kinds of shapes were mentioned heretofore for the tube and this is applicable to the orifice also. Equivalent diameter is a convenient way of defining both non-cylindrical cross-sections and cylindrical cross-sections with one term. The mathematical abbreviation for equivalent diameter is D_{eq} and the equation defining this term is as folows:

D_{eq} = (4 × cross-sectional area)/perimeter of cross-sectional area

Where the cross-sectional area of the tube varies along its length an average equivalent diameter can be used, but tubes of varying cross-section are considered impractical and are not recommended. The shape of the orifice can be different from that of the tube, however, without creating any impracticalities.

The critical ratios are as follows:

1. Structure A can have a length *b* to diameter *a* ratio in the range of about 0.05:1 to about 1:1; and such ratio is preferably in the range of about 0.1:1 to about 1:1.

2. The ratio of the equivalent diameter of the orifice of structure A to the equivalent diameter *c* of tube B can be in the range of about 1:1 to about 0.1:1 and is preferably in the range of about 1:1 to about 0.25:1.

3. Tube B can have a length *d* to equivalent diameter *c* ratio in the range of about 5:1 to about 200:1 and such ratio is preferably in the range of about 10:1 to about 100:1.

4. The ratio of the volume of structure A to the volume of tube B can be in the range of about 0.01:1 to about 5:1 and is preferably in the range of about 0.01:1 to about 2.5:1.

Volume of structure A is approximately defined by the following equation:

$$\text{Volume} = 1/24\ (\pi)\ (\text{length})\ [(\text{length})^2 + 3(\text{diameter})^2]$$

Volume of tube B is defined by the following equation:

$$\text{Volume} = (\pi)\ [\text{diameter or equivalent diameter}/2]^2\ (\text{length})$$

The actual dimensions of the reactor vary according to the use to which the reactor is to be put, e.g., laboratory, pilot plant, or commerical use and, even more so, according to the amount of throughput desired. The number of inlet feed chambers, the number of tube portions, i.e., one or two, and the number of reactors along with many auxillary factors such as the particular economics of the situation must all be considered. An illustration of the range of dimensions, which would be desirable for a feedstock throughput of 50 to 100 pounds per hour, using one inlet feed chamber and one tube portion, is as follows:

dimension	value in inches
a	7 to 12
b	2.2 to 3.0
c	1 to 2
d	30 to 70
of orifice	0.5 to 2

As stated heretofore, FIG. **4** is a schematic flow diagram illustrating a conventional system in which a reactor embodying the invention can be used.

Referring to FIG. **4** of the drawing:

Zone **21** represents the source of the feedstock and includes a preheating section where the feed is preheated to a temperature in the range of about 100°C. to about 700°C. and preferably in the range of about 200°C. to about 600°C.

The feedstocks which can be used in the above-described reactor and the system described here can be liquids provided that they are atomized prior to their introduction into the reactor. The feedstocks can also be gaseous. The liquid feedstocks include naphtha, crude oil, gas oil, natural gasoline, various raffinates and the various liquid hydrocarbon components of such feedstocks such as pentanes and hexanes. The preferred feedstocks in this system are naphtha, gas oil, and crude oil, the efficient cracking of which is an object of this invention. Examples of gaseous feedstocks are natural gas, synthetic natural gas and various gaseous hydrocarbon components such as ethane, propane, and butanes.

The most noteworthy characteristic of the instant cracking reactor is its ability to accept and process high boiling fractions, which cannot be vaporized at 500°C. at normal pressures. These fractions are, of course, major constituents of crude oil.

The feed passes along line **22,** which corresponds to line **1** in FIG. **1,** and joins line **23,** which in part corresponds to line **2** in FIG. **1.** Line **23** is carrying a hot gas from zone **24** which represents a hot gas source. The temperature of the hot gas is in the range of about 1,000°C. to about 3,000°C. and is preferably in the range of about 1,200°C. to about 2,500°C. The hot gases which can be used to crack the feedstock are exemplified by superheated steam, which is preferred, or products of combustion of various fuels.

The ratio of hot gas to feedstock lies in the range of about 0.5 parts by weight of hot gas per part by weight of feedstock to about 5 parts by weight of hot gas per part by weight of feedstock and is preferably in the range of about 0.7 parts by weight of hot gas per part by weight of feedstock to about 2.5 parts by weight of hot gas per part by weight of feedstock.

The mixture of preheated feedstock and hot gas proceeds along line **25,** which corresponds to the remaining length of line **2** in FIG. **1,** into the reactor heretofore described.

Cracking is effected in subject reactor under the following conditions:

Temperatures in the lens portion of the reactor are in the range of about 500°C. to about 1,200°C. and are preferably in the range of about 600°C. to about 1,100°C. Temperatures at the outlet of the tube portion of the reactor are in the range of about 450°C. to about 1,150°C. and are preferably in the range of about 550°C. to about 1,050°C.

Pressures are in the range of about 1 atmosphere to about 10 atmospheres and are preferably in the range of about 1 atmosphere to about 5 atmospheres.

Residence time is maintained within the range of about 0.005 seconds to about 0.5 seconds and is preferably in the range of about 0.01 seconds to about 0.2 seconds.

The reactor effluent passes from reactor **26** along line **27** into quench zone **28.** Water or a hydrocarbon stream is used to quench the effluent. Separation of the effluent takes place in this zone with the gas product going overhead along line **29** and the water and liquid product being taken off as bottoms through line **30.** Again, separation, recovery and analysis are conventional.

The prior discussion has considered the use of both liquid and gaseous feedstocks in the above described reactor. Its versatility goes beyond these feedstocks, however, e.g., oxygenated materials such as alcohols and acids, various polymeric materials, and Diels-Alder products can also be effectively cracked therein.

Another embodiment of the described reactor, concerns the use of two tube portions connected to the lens portion in the same manner as the tube portion described above except that, in terms of FIG. **1,** the con-

nection would be to wall **4** at an orifice similar to orifice **6** disposed in that side. All ratios would be the same for this tube portion as for the tube portion heretofore described. The only change would be the step-up in rate of flow of feedstock and hot gas and the preferable use of multiple inlet feed chambers. The outlets of both tube portions can be connected to one downstream system or two of such systems.

The following examples illustrate the invention. Parts and percentages are by weight unless otherwise designated.

EXAMPLE 1

The system and reactor heretofore described are used in this example. More specifically, the procedure followed and the conditions used are as follows:

Initially, a steam generating system is started first by increasing natural gas flow to a furnace and turning on a water pump. A high steam generation rate is used on startup to rapidly heat the associated piping. The water rate is then adjusted to that required to meet test conditions. Approximately 1 hour is required for the steam generation conditions to stabilize after adjustment because of the large volume of the steam generating coils. When the steam generation system is at the desired conditions, steam is turned into the mixing section to preheat the reaction system.

When the burner and reactor are at or above the saturation steam temperature the burner is readied for ignition. Hydrogen is used as fuel for the burner. The burner and reactor are first purged with nitrogen to be sure no combustibles are present. The burner is then ignited. Hydrogen and oxygen flows to the burner are controlled in the proportion for proper combustion, both streams being increased simultaneously to raise the reactor temperature. The function of the burner is to provide a heat source to supply the required sensible heat and heat of reaction.

When the reactor is heated almost to operating temperature, the feed pump is turned on. The hydrocarbon feed is admitted near the outlet of the mixing section where it is mixed with the steam and the mixture passes into what is designated as inlet feed chamber **3** in FIGS. **1** and **2** of the drawing. This inlet feed chamber **3** is attached so that its theoretical axis is tangential to the juncture of the walls of the lens portion of the reactor. Reactor temperature, feed rate, water rate, and combustion rate are controlled to provide tangential flow of the feed/steam mixture and to give the desired residence time.

The reactor effluent is quenched with water to condense residual oils and a major proportion of the steam (about 80 percent by weight). Quench water rate is controlled to maintain the temperature of the stream leaving the quench zone at 70°C.

The gaseous product leaving the quench zone or separator is cooled to ambient temperature in a condenser. Condensed hydrocarbons and water are collected and the make gas is flared.

Analysis of the products is by gas chromatography and Mass Spectrometer gas analysis.

The outer dimensions of the reactor used in this example are as follows:

The lens portion, i.e., structure A, has a length of 2.625 inches and a diameter of 9 inches for a length to diameter ratio of 2.625:9 or 0.29:1.

The tube portion, i.e., tube B, is a helical coil of cylindrical cross-section having a length of 56 inches and a diameter of 1.5 inches for a length to diameter ratio of 56:1.5 or 37:1.

The volume of structure A is $(\pi/24)(2.625)[(2.625)^2+3(9)^2]$or 86 cubic inches.

The volume of tube (B) is $(\pi)(0.75)^2(56)$ or 99 cubic inches.

The ratio of the volume of tube A to the volume of tube B is, therefore, 86:99 or 0.87:1.

The total volume of structure A plus tube B is 185 cubic inches or 3,034 cubic centimeters.

The ratio of the diameter of the orifice of structure A to the diameter of tube B, both of which are circular cross-sections, is 1:1.

The feedstock is designated as "Texaco" naphtha having the following analysis.

Mass Spectrometer Analysis

Normal Paraffins	39.49 percent
Iso Paraffins	38.61 percent
Olefins	1.36 percent
Napthenes	13.39 percent
Aromatics	7.16 percent
ASTM Distillation (ASTM No. D-86)	
Percent overhead	Temperature (°F.)
—	104 (initial boiling point)
10	146
20	167
30	188
40	206
50	226
60	248
70	256
80	287
90	312
End point	370
Recovery:	98.5 percent
residue:	0.5 millimeters
API Gravity:	65.9 at 60°F.
Specific Gravity:	0.717 at 60°F.
Refractive Index:	1.3984 at 25°F.
ppm sulfur:	30
Bromine number:	1.02
H/C, calculated from physical properties:	2.160
Molecular weight via ASTM distillation + API gravity:	99
API =	American Petroleum Institute
ppm =	parts per million
H/C =	hydrogen : carbon mol ratio
Operating Conditions:	
Reactor temperature:	860°C. at outlet of tube portion
Steam dilution ratio (by weight):	2.1 parts of steam per one part of feed
Residence time (seconds):	0.047
rate of hydrocarbon feed:	62.5 pounds per hour
rate of steam feed:	134 pounds per hour
reactor pressure:	10 pounds per square inch gauge
Results:	
Yield in percent by weight	
ethylene	40.2
propylene	11.4
acetylene	2.5
methane	13.6
total gas product	84.2
oil + coke	15.8

EXAMPLE 2

Example 1 is repeated except that the feedstock is changed to that designated as Pennsylvania crude oil having the following analysis:

ASTM Distillation (ASTM No. D-86)

Percent overhead	Temperature (°C.)
—	148
10	230
20	282
30	336
40	398
50	470
60	552
70	596
End point	596
Recovery	71 percent
residue:	29 millimeters
API Gravity:	46.6 at 60°F.
Specific Gravity:	0.795 at 60°F.
Refractive Index:	1.4412 at 20°C.
ppm sulfur:	153
bromine number:	2.14
H/C, calculated from elemental analysis:	2.08
API =	American Petroleum Institute
ppm =	parts per million
H/C =	hydrogen:carbon mol ratio

and various operating conditions are changed as follows:

Reactor temperature:	
disc temperature	875°C.
outlet temperature (tube portion)	857°C.
Residence time (seconds):	0.040
rate of hydrocarbon feed:	74.1 pounds per hour
molecular weight of feed:	180
rate of steam feed:	156 pounds per hour
Results:	
Yield in percent by weight	
ethylene	38.4
propylene	13.2
acetylene	1.8
methane	12.7
total gas product	84.2
oil + coke	15.8

The reactor of this invention is considered especially useful in pollution control particularly in its handling of plastic wastes, which are either in fluid or fluidized form or can be liquefied or fluidized. Polyvinyl chloride, polystyrene and polyethylene scrap are examples of such plastic wastes, e.g., polyethylene scrap can be degraded to a low molecular weight liquid wax-type or heavy oil-type composition, which can be cracked in subject reactor to ethylene yields approaching 60 percent or more.

What is claimed is:

1. A reactor adapted for the cracking of hydrocarbons with hot gas comprising:

A. a circular convex lens shaped hollow structure having (i) two walls, which are joined at their peripheries to form the structure, at least one of said walls being provided with an orifice disposed substantially centrally therein; and (ii) at least one hollow inlet feed chamber open at both ends passing through a wall of the structure, one end of said feed chamber being disposed in the interior of the structure at about the juncture of the walls in such a manner that vapor, which is passed through said chamber, will flow substantially tangentially to the juncture, provided that the rate of flow is sufficient therefor, creating a vortex-like flow within the structure; and

B. at least one hollow tube open at both ends;

wherein:

a. one end of tube (B) is connected to structure (A) at about its orifice in substantially concentric alignment therewith and in open communication with structure (A);

b. the ratio of the length of structure (A) measured along a theoretical axis, which joins the center points of the walls, to the diameter of structure (A) measured across a theoretical plane perpendicular to the theoretical axis and bisecting structure (A) is about 0.05:1 to about 1:1;

c. the ratio of the equivalent diameter of the orifice of structure (A) to the equivalent diameter of tube (B) is about 1:1 to about 0.1:1;

d. tube (B) has a length to the equivalent diameter ratio of about 5:1 to about 200:1; and

e. the ratio of the volume of structure (A) to the volume of tube (B) is about 0.01:1 to about 5:1.

2. The reactor defined in claim **1** wherein one wall is provided with the orifice and there is one tube (B) connected to structure (A) at about said orifice.

3. The reactor defined in claim **1** wherein both walls are provided with an orifice and two tubes (B) are connected to structure (A), one tube (B) at about each orifice.

4. The reactor defined in claim **2** wherein:

b. structure (A) has a length to diameter ratio of about 0.1:1 to about 1:1;

c. the ratio of the equivalent diameter of the orifice of structure (A) to the equivalent diameter of tube (B) is about 1:1 to about 0.25:1;

d. tube (B) has a length to equivalent diameter ratio of about 10:1 to about 100:1; and

e. the ratio of the volume of structure (A) to the volume of tube (B) is about 0.01:1 to about 2.5:1.

5. The reactor defined in claim **3** wherein:

b. structure (A) has a length to diameter ratio of about 0.1:1 to about 1:1;

c. the ratio of the equivalent diameter of the orifice of structure (A) to the equivalent diameter of tube (B) is about 1:1 to about 0.25:1;

d. tube (B) has a length to equivalent diameter ratio of about 10:1 to about 100:1; and

e. the ratio of the volume of structure (A) to the volume of tube (B) is about 0.01:1 to about 2.5:1.

6. The reactor defined in claim **2** wherein the inlet feed chamber is a cylindrical tube, the theoretical axis of which is in essentially tangential alignment with the juncture of the walls of structure (A).

7. The reactor defined in claim **4** wherein the inlet feed chamber is a cylindrical tube, the theoretical axis of which is in essentially tangential alignment with the juncture of the walls of structure (A).

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