PROCESS FOR CRACKING HYDROCARBONS

Filed Dec. 20, 1971 2 Sheets-Sheet 1

FIG. 1

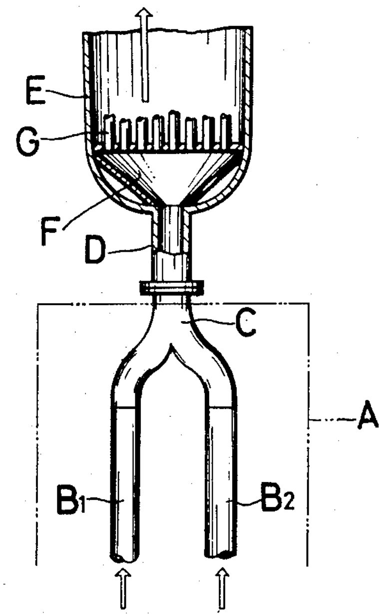


FIG. 2

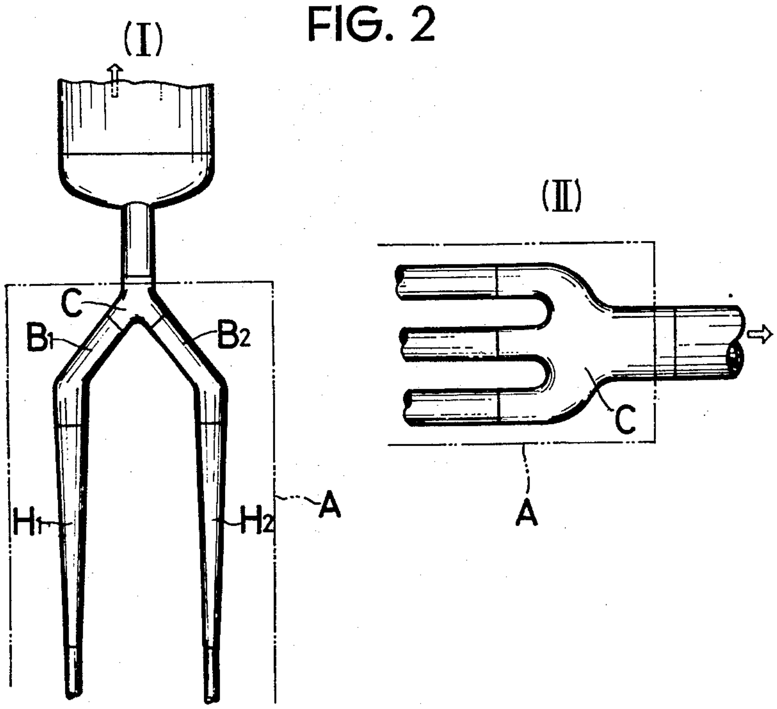


FIG. 3

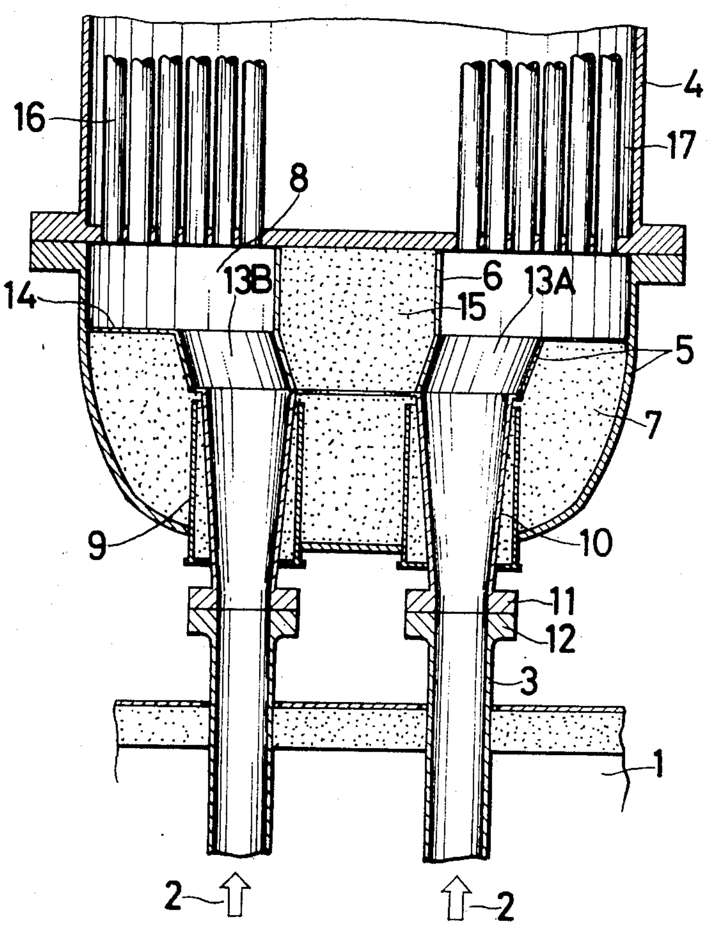
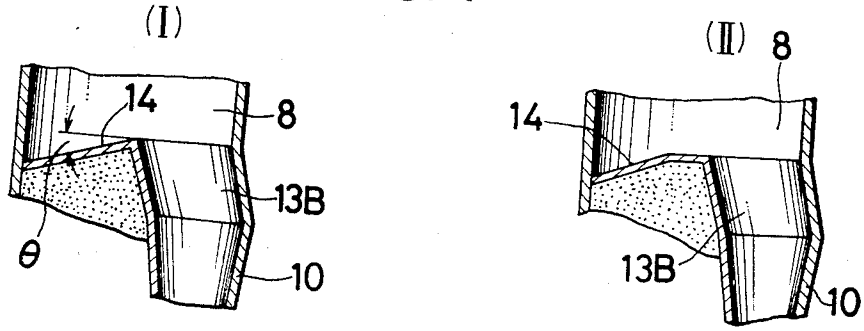

16
8
4
17
13B
6
13A
14
15
5
7
9
10
11
12
3
1
2
2

FIG. 4


(I)
14
8
13B
θ
10
(II)
8
14
13B
10

United States Patent Office

3,763,262
Patented Oct. 2, 1973

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3,763,262

PROCESS FOR CRACKING HYDROCARBONS

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Filed Dec. 20, 1971, Ser. No. 209,730
Claims priority, application Japan, Dec. 29, 1970, 46/128,035
Int. Cl. C07c *3/30;* F28f *9/02*
U.S. Cl. 260—683 R 8 Claims

ABSTRACT OF THE DISCLOSURE

A process for producing useful olefins by thermally cracking hydrocarbons through a plurality of cracking tubes and cooling the resultant cracked gases through a single multitubular indirect cooler of vertical type, characterized by cooling the cracked gases through a cooler having in its lower portion a plurality of tubes gradually increased in diameter upwardly and connected to said cracking tubes and also an inlet gas chamber communicated to the upper ends of said upwardly expanded tubes and formed with a stepped bottom, without causing the streams of the cracked gases to merge through any inverted-Y-shaped tube joint or the like before the entrance of said cooler.

This invention relates to a process for cracking hydrocarbons and an apparatus adapted for practicing the same.

In the process for producing ethylene, propylene and other useful olefins through thermal cracking of hydrocarbons on an externally-heated tubular cracking furnace and a multitubular indirect gas cooler, it is customary practice to combine from two to six hydrocarbon heating tubes (also known as thermal reaction tubes) into a tube of a larger diameter and connect the latter to the single inlet nozzle of the cooler so as to lead the cracked gases into the cooler. Such an arrangement is necessary because the heating tubes have a limited material-processing capacity each, whereas a single cooler can well handle the material being fed in from a few to several heating tubes at a time.

To cite an example of the conventional arrangement as illustrated in FIG. 1 of the accompanying drawings, material gases are thermally decomposed to form cracked gases in two heating tubes B_1, B_2 within a quick heater (cracking furnace) A. The flows of cracked gases are merged into a single flow through an inverted Y-shaped tube joint C, and the combined flow enters an inlet gas chamber F of a cooler E via a straight inlet tube D. From the inlet chamber F the flow of cracked gases is branched off into a plurality of cooling tubes G, wherein the gases are rapidly cooled with a coolant, as water.

The inlet tube and inlet gas chamber of the cooler heretofore employed for the conventional process have been so designed that, as shown in FIG. 1, the inlet tube D is a straight tube having a circular cross section while the inlet gas chamber F has a simple axially-symmetrical shape in the form of an elliptoid of revolution or a cone. Variations of the arrangement just described include a vertical type as shown in FIG. 2(I) in which tubes H_1, H_2 each generally megaphone-shaped with the bore gradually increased toward the front end, are connected to the rear ends of heating tubes B_1, B_2 which in turn are joined together with a two-inlet-port, inverted-Y tube joint C, and a horizontal type as in FIG. 2(II) which uses a three-inlet-port tube joint C within a horizontal heater A.

The conventional process for preparing useful olefins by the equipment of the constructions above described has the

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following disadvantages. The pressure loss of the gas flow in the tube joint C is so great and the internal pressure of the equipment is so high that the yields of useful olefins are low. Extended periods of gas retention in the tube joint C, inlet gas chamber F, etc. lead to excessive cracking and hence reduced yields of objective olefins. Coking due to the flow conditions or thermal conditions in the tube joint C becomes more and more serious and eventually hampers the smooth operation of the apparatus. Since the tube joint C is complicated in construction and large in size, it tends to have a structure with thermally and mechanically insufficient strength. The solid carbides (coke) which flow into the inlet gas chamber F are not accumulated on the bottom of that chamber but deposited on the inner walls of the inlets of cooling tubes G, thus clogging the tubes.

It is therefore a fundamental object of the present invention to provide a process and apparatus free of the foregoing disadvantages.

Under the present invention, the foregoing disadvantages are eliminated because the tube joint C is omitted, the gases from the heating tubes B_1, B_2 are separately led into the inlet gas chamber, upwardly expanded tubes are communicated to the inlet gas chamber, a dead spacer is provided within the gas chamber to eliminate any wasteful swirl, ensure uniform distribution of flow quantities of the gases among the individual cooling tubes, and shorten the retention time of the gases in the gas chamber, a horizontal stepped bottom is provided in the gas chamber (said stepped portion accounting for at least 10 percent, preferably between 30 and 60 percent of the cross-sectional area of the chamber as measured at right angles to the flow direction of the gases) so as to collect and accumulate the coke particles carried away from the heating tubes and thereby avoid any choking of the inlets of the cooling tubes with the coke or any backflow of the coke to the heating tubes. With these features, the apparatus according to the invention makes possible the manufacture of useful olefins in high yields.

These and other objects, features and advantages of the present invention will be better understood by the following description taken in conjunction with the accompanying drawings showing a preferred embodiment thereof. In the drawings:

FIGS. 1 and 2(I), (II) are schematic views of a cooler and connections between the cooler and heating tubes for the conventional process for cracking of hydrocarbons;

FIG. 3 is a sectional view of connections between a cooler and cracking tubes in one embodiment of the present invention; and

FIGS. 4(I), (II) are fragmentary sectional views of different step-like bottoms of a cooler according to the invention.

Referring specifically to FIG. 3, there is shown an arrangement wherein cracked gases **2** heated in a cracking furnace **1** is allowed to flow therefrom into a cooler **4** through heating tubes (which may also be called cracking tubes) **3**.

The cooler **4** has an inlet gas chamber **8** in its lower portion, which chamber is formed by casings **5**, **6**, heat insulation **7**, etc. Into this chamber **8** are communicated tubes **10** which are radually increased in the bore toward the outlets and are separately supported with sleeves **9**. These tubes **10** have flanges **11** at the rear ends for connection with the flanges **12** of the heating tubes **3**. They form two flow passages in the embodiment shown. A space **13** defined between the casings **5**, **6** is an annular space of a concentric circle or ellipse with respect to the center axis of the cooler.

As part of the casing **5** which defines the inlet gas chamber **8**, a horizontal stepped bottom **14** is provided. Also a dead spacer **15** is located in the center of the inlet gas chamber **8**. As already mentioned, the surface area of the stepped bottom **14** accounts for at least 10 percent of the cross-sectional area of the chamber **8** as measured at right angles to the flow direction of the gases.

In the construction above described, cracked gases **2** flow into cooling tubes **16** by way of the upwardly expanded tubes **10**, space **13**, and inlet gas chamber **8**. The gases are then cooled through heat exchange with a fluid coolant in a shell **17**.

While the stepped bottom **14** is shown horizontally in the embodiment of FIG. 3, it is usually possible to adopt a step either horizontal with an angle θ to the horizontal line of approximately zero or outwardly inclined with a negative angle or the both, provided that the step surface permits stable deposition of the solid coke thereon.

Thus, the present invention, which uses the construction above described for the preparation of useful olefins, presents the following advantages.

First, the omission of the merging tube joint which has hitherto been employed eliminates any possibility of a loss of gases pressure due to merging of gas streams, reduces the pressure loss between the outlets of the heating tubes **3** and the cooler **4**, and greatly shortens the distance therebetween and hence the retention time between the two, with the consequence that any undesirable secondary reaction can be avoided.

Second, the pressure loss of the gases before their entry into the inlet gas chamber **8** is remarkably reduced because the flow velocity of the gases drops for the first time in the upwardly expanded tubes **10** in communication with the inlet gas chamber. Although tubes similar to the tubes **10** are employed within the heater A in the conventional apparatus shown in FIG. 2(I), the arrangement is disadvantageous because the gases take much retention time after passage through the megaphone tubes and cannot be cooled rapidly.

Third, the inlet gas chamber according to the present invention is so constructed that the velocity of the cracking gases in the chamber space can be reduced to a suitable level. Moreover, the spacer **15** may take any adequate shape to ensure uniform distribution of the gas flow rates to the individual cooling tubes **16**.

Fourth, the provision of the horizontal stepped bottom **14**, which accounts for at least 10 percent, and preferably between 30 and 60 percent, of the cross-sectional area of the gas chamber **8** as measured at right angles to the flow direction of the gases, enables the coke particles that fly from the heating tubes to drop out of the gas stream and deposit on the sepped portion for subsequent collection, instead of being mixed again into the gas stream. This precludes the usual possibilities that the coke clogs the inlets of many cooling tubes **16** to choke off the gas passage and that the coke drops and flows back into the heating tubes **3**. Said coke is removed at the time of regular checking for the apparatus.

Still another advantage associated with the omission of a tube joint resides in the great mechanical strength that is attained. Ordinarily structures have a number of problems attributable to the thermal conditions for the tube joint. For example, the tube joints of cast metal are easily cracked by thermal strains. The present invention possess no such problem and reduces the manufacturing cost of the apparatus with the omission of such a casting.

Now an example of the present process for the preparation of useful olefins will be described below in comparison with an example of the conventional process, with the results being given in Table 1.

According to the conventional process, as shown in Column A in the table, the yields of cracked gases are adversely affected by the pressure rise in the heating tubes corresponding to a high rate of pressure rise in the outlet of the cracking furnace, or in the inlets of the cooling tubes due to deposition of coke thereon. Furthermore, the decoking intervals are shortened because of the increase of the coking velocity on the heat transfer tubes and therefore the increase of the rate at which the surface temperature of the reaction tubes climbs. On the other hand, as will be obvious from Column B of the same table, the process of the present invention reduces both the rates of increase of the pressure at the outlet of the cracking furnace and the surface temperature of the heating tubes, and extends the decoking intervals to a value more than twice as long as the usual intervals. As regards the yields of valuable olefins, the process makes it possible to increase the yields of C_2H_4, C_3H_6, and 1,3-butadiene by about 15, 8 and 16 percent, respectively. Thus, the process of the invention was confirmed to have very significant advantages over the conventional process.

TABLE 1

Item	Unit	Example A[1]	Example B[2]
Rate of increase of pressure at the outlet of cracking furnace.	Kg./cm.^{2}.day	0.008	0.002
Rate of increase of temperature on the surface of cracking tubes.	° C./day	1.5	0.8
Decoking interval	Days	40	90
Yields of useful olefins:			
(1) CH_4	Weight percent	17.0	15.0
(2) C_2H_4	do	24.0	27.6
(3) C_3H_6	do	14.3	15.5
(4) 1-3 butadiene	do	3.0	3.5
(5) BTX	do	14.0	14.0

[1] A conventional process.
[2] The process of invention.

What is claimed is:

1. A process for producing useful olefins by thermally cracking hydrocarbons through a plurality of cracking tubes and cooling the resulting cracked gas in a single multitubular, vertical type cooler, comprising the steps of passing individual streams of cracked gas from said cracking tubes upwardly into corresponding individually connected tubes of gradually increasing diameter without mixing said streams, causing said gas from said gradually increasing diameter tubes to flow through an inlet chamber connection into an inlet chamber having a stepped bottom extending from said inlet connection, said tubes of gradually increasing diameter and said inlet chamber being located in the lower portion of said cooler, and passing said gas from said inlet chamber to said cooler.

2. A process according to claim **1** wherein said inlet chamber has a greater cross-sectional area than the largest diameter of said gradually increasing diameter tubes, and collecting coke particles on said stepped bottom of said inlet chamber.

3. Apparatus for producing useful olefins, comprising a plurality of thermal cracking tubes, a gradually increasing diameter tube connected to each of said thermal cracking tubes whereby individual streams of gas pass from said thermal cracking tubes to a respective gradually increasing diameter tube without mixing with one another, a multi-tubular, indirect cooler having generally vertically disposed cooling tubes for cooling said cracked gas, and an inlet gas chamber in the lower portion of said cooler communicating with said cooler tubes, said gradually increasing diameter tubes being connected to the bottom of said inlet gas chamber, said bottom of said inlet gas chamber having means defining a step extending from the inlet connection of said gradually increasing diameter tubes.

4. Apparatus according to claim **3** wherein said inlet gas chamber is defined at least in part by an inner wall disposed generally in the center of said inlet gas chamber, said inner wall also defining the outer boundary of a dead space disposed centrally of said inlet gas chamber, said gradually increasing diameter tubes being connected to the bottom of said inlet gas chamber to open into the latter adjacent to said inner wall.

5. Apparatus according to claim 3 wherein said step defining means in the bottom of said inlet gas chamber has a cross-sectional area amounting to at least ten percent of the cross-sectional area of said inlet gas chamber, both of said cross-sectional areas being measured at right angles to the flow direction of the cracked gases.

6. Apparatus according to claim 3 wherein said step defining means on the bottom of said inlet gas chamber is at least partially inclined to form an acute angle relative to horizontal.

7. Apparatus according to claim 3 wherein said step defining means is formed as a ledge disposed beneath said cooler tubes for collecting coke particles carried by said gas.

8. Apparatus according to claim 3 wherein said step defining means is disposed radially outwardly of said gradually increasing diameter tubes.

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U.S. Cl. X.R.

23—277 R; 165—1, 158, 174; 196—138; 208—48 Q