March 30, 1971 TAKEHIKO SATO 3,572,999

APPARATUS FOR CRACKING HYDROCARBONS

Filed April 10, 1968

FIG. 1

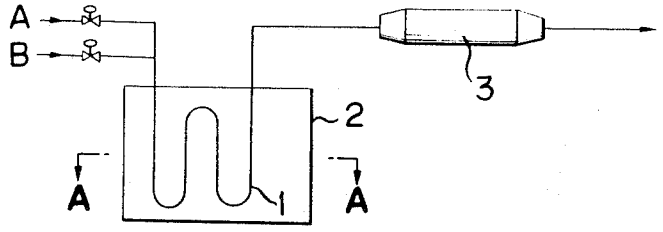



FIG. 2

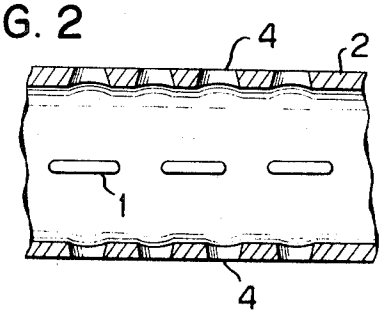



FIG. 3

FIG. 4

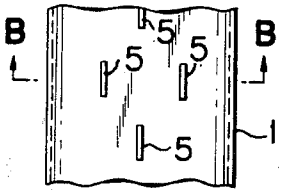



FIG 4a

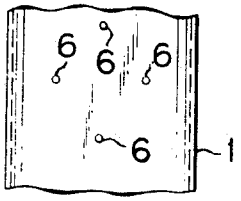
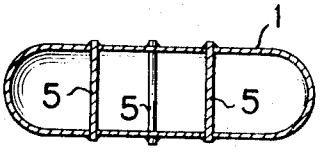



FIG. 5

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# APPARATUS FOR CRACKING HYDROCARBONS

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Int. Cl. F28f 1/02; B01j 1/00
U.S. Cl. 23—277 4 Claims

## ABSTRACT OF THE DISCLOSURE

An external heating type thermal cracking apparatus for thermally cracking hydrocarbons comprising thermal cracking tubes having flattened or compressed round cross-sectional configuration disposed in such a manner that the major axes of said cross-sectional configurations are confronting the heat source.

## BACKGROUND OF THE INVENTION

### (1) Field of the invention

This invention relates to an apparatus for thermally cracking hydrocarbons comprising thermal cracking tubes having flattened or compressed round cross-sections. More particularly, this invention relates to a thermal cracking apparatus comprising thermal cracking tubes having elliptical or oval cross-sections used for thermally cracking normally gaseous or normally liquid hydrocarbons to produce olefins or aromatic hydrocarbons which are useful materials in petrochemical industries.

### (2) Description of the prior art

In producing olefins and aromatic hydrocarbons by the thermal cracking of gaseous or liquid hydrocarbons, normally, a thermal cracking apparatus comprising thermal cracking tubes having round cross-sections has been used heretofore.

Recently, in general, the thermal cracking apparatus is becoming larger and larger mainly due to economical reasons, and it is required to have not only an increased capacity for treating the material for each thermal cracking tube but also an enhanced efficiency in producing valuable olefins.

In addition, in order to meet the fluctuating market demand, the apparatus is further required to have a versatility enabling one to alter the proportion of the desired product to the total products in a wider range. Moreover, in order to enhance the rate of operation, the apparatus is required to cause less coking in the thermal cracking tubes and the appendant rapid cooling device.

Although such measures as enlarging diameter of the thermal cracking tube, increasing flowing amount of the material fed thereto, or, alternatively, shortening the overall length of the tube are admittedly effective for increasing capacity for treating the material per a thermal cracking tube and enhancing efficiency in producing valuable olefins, there are accompanying problems as follows:

That is, in the conventional thermal cracking tube having a round cross-section commonly used heretofore, in order to reduce the reaction time at a given mass velocity of the material gas therein, it is necessary to reduce the total length of the thermal cracking tube and the curtailment thereof inevitably means decrease in the heat transferring area, and it becomes difficult to supply sufficient heat required for thermally cracking the material.

Whereas, if the mass velocity of the material gas is increased in a given length of the tube, the amount of material passing therethrough is increased and there is required an increased amount of heat for thermally cracking the material. However, the maximum amount of heat transferred per unit area of the thermal cracking tube is limited from the standpoint of mechanical strength of the material of which the tube is made.



Hence, in order to give a sufficient amount of heat necessary for thermally cracking the material, it is required to use a thermal cracking tube having a large surface area with respect to the inner capacity, viz a tube having a small diameter. However, the use of thermal cracking tubes having small diameters inevitably decreases the treated amount of the material and causes an economical disadvantage, while the use of tubes having large diameters for increasing the capacity for treating the material leads to decrease in the yield of olefins due to insufficient amount of heat for the thermal cracking.

As described above, it has been difficult to conduct a satisfactory and economical thermal cracking process by using the conventional apparatus comprising thermal cracking tubes having round cross-section employed heretofore.

## SUMMARY OF THE INVENTION

It is, accordingly, an object of this invention to provide a thermal cracking furnace comprising a plurality of thermal cracking tubes of external heating type used for producing useful olefins and other gaseous and liquid products by the thermal cracking of hydrocarbons, capable of not only enhancing the yield of olefins by reducing the reaction time but also decreasing the undesirable formation of secondary by-products, without decreasing the capacity for treating the material.

We have found that the reaction time in the thermal cracking of hydrocarbons may be reduced to a significant extent without decreasing the amount of the treated material by using thermal cracking tubes having flattened or compressed round cross-section, e.g., elliptical or oval cross-sections. That is, we have found that a thermal cracking tube having an elliptical cross-section affords a sufficient amount of heat required for the thermal cracking in a shorter length, since such tube having an elliptical cross-section has a larger surface area as compared with a tube having a round cross-section, when the inner capacity is given.

In accordance with this invention, there is provided a thermal cracking apparatus of external heating type for hydrocarbons which comprises thermal cracking tubes having flattened or compressed round cross-sections, e.g. elliptical or oval cross-sections, arranged in such a manner that the major axes of said elliptical cross-sections are confronting the source of heat.

By the use of the thermal cracking apparatus of this invention, there are brought about advantages in that the reaction time may be shortened by the possible increase in the reaction temperature and the yields of olefins may be enhanced, that the formations of less useful methane and tarry secondary products which give rise to coking may be suppressed and that the yielding ratio of ethylene to propylene or ethylene to butadiene may be altered in a wide range, since the reaction temperature can be controlled in a wider range than in the conventional apparatus known heretofore.

In the apparatus of this invention, the cross-section of the thermal cracking tube need not be an exact geometrical elliptical configuration and the tubes having cross-sections resembling an elliptical configuration may be conveniently employed just as well. For instance, an oblong round cross-sectional configuration is a preferable example.

However, it is an essential requisite in the thermal cracking apparatus of this invention that each individual thermal cracking tube must be disposed in such a manner that the major axis of the oval cross-section of the same is confronting the source of heat. By so doing, the thermal cracking tube receives the radiant heat from the source most effectively.

In the apparatus of this invention, in general, the size of the elliptical or oval-like cross-sectional configuration such as oblong round shape, of the thermal cracking tube has a minor axis of 30–150 mm., preferably 35–100 mm., and a major axis of 100–500 mm., preferably 120–300 mm., the ratio of the minor axis to the major axis being 0.1–0.7, preferably 0.2–0.5.

For example, a thermal cracking tube having a minor axis of 50 mm. and a major axis of 136 mm., viz the ratio of the minor axis to the major axis of 0.368, obtained by flattening a 100 mm. diameter tube having a round cross-section, or, the one having a minor axis of 80 mm. and a major axis 270 mm., viz the ratio of the minor axis to the major axis of 0.296, obtained by flattening a 200 mm. diameter tube having a round cross-section may be suitably used.

If the minor axis is less than 30 mm. in a thermal cracking tube having a flattened or compressed round cross-section, the capacity for treating the material is inevitably decreased even if the major axis is extended as long as 500 mm., and, in addition to that, there is undesirably caused a constructional problem due to sagging of the tube which stems from the excessive flattening of the tube, while, if the minor axis is more than 150 mm., the supply of sufficient amount of heat required for completely cracking the material flowing therethrough is restricted from the strength of the material of which the tube is made, causing undesirable increase in the formation of methane of much less utility and harmful coking, though the capacity for treating the material may naturally be increased.

Similarly, the major axis of less than 100 mm. inevitably decreased the capacity for treating the material, while that exceeding 500 mm. is undesirable since it leads to non-uniform flowing of the material gas passing therethrough which causes coking, and sagging of the tube.

Moreover, if the ratio of the minor axis to the major axis exceeds 0.7, the effect of the present invention may not be fully manifested.

As described above, when thermal cracking tubes having elliptical or oval-like cross-sectional configurations outside the range set forth above are used, there are caused disadvantages in the decrease in the amount of the treated material, increase in the tube pressure loss, nonuniform flowing of the material gas passing therethrough and sagging of the tube.

In the apparatus of this invention, the thermal cracking tube may be provided with suitable reinforcing members therein, if necessary.

## BRIEF DESCRIPTION OF THE DRAWINGS

Now, this invention may be explained more practically by referring to the accompanying drawings in which:

FIG. 1 illustrates a schematic diagram of an embodiment of the thermal cracking apparatus of this invention;

FIG. 2 is a sectional enlarged view of FIG. 1 at line A—A;

FIG. 3 shows cross-sectional views of two forms of the thermal cracking tubes;

FIG. 4 shows plan views of the thermal cracking tubes provided with reinforcing members, and FIG. 5 is a sectional view of FIG. 4 at line B—B.

Referring to FIG. 1 which illustrates an embodiment of the thermal cracking apparatus of this invention, a preheated material A and steam B are introduced to a thermal cracking tube **1** of a thermal cracking apparatus **2** and the cracked products are fed to a waste-heat recovering boiler **3**.



FIG. 2 shows a sectional view of the FIG. 1 at line A—A and a thermal cracking tube **1** is heated by the heat source **4** provided on the walls of the thermal cracking apparatus **2** from both sides thereof. Note that the major axis of the elliptical cross-section of the thermal cracking tube **1** is confronting the heat source **4**.

FIG. 3 illustrates examples of cross-sections of the thermal cracking tube **1** having an elliptical and an oval-like cross-sectional configurations.

FIG. 4 shows the thermal cracking tube **1** of this invention provided with reinforcing plates **5** and reinforcing bars **6**, respectively.

FIG. 5 is a sectional view of the tube shown in FIG. 4 at line B—B, with reinforcing plates **5**. Instead of plates **5** as shown in FIGS. 4 and 5, the tube **1** may be reinforced with rods **6** as shown in FIG. 4*a*.

The thermal cracking of hydrocarbons using the thermal cracking apparatus of this invention may be carried out according to the same operating procedures as in using the conventional thermal cracking apparatus comprising an external heating type thermal cracking tube having a round cross-section.

The materials which may be treated by the apparatus of this invention are normally gaseous and normally liquid hydrocarbons including, for example, ethane, propane, butane, naphtha, kerosene, light gas oil and heavy gas oil.

The reaction time in the apparatus of this invention is generally less than one second and preferably 0.3–0.1 second. The reaction temperature may be adjusted within the range of 750–950° C. depending upon the proportion of the desired products.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following examples will serve to illustrate this invention more fully. It should not be construed, however, that these examples restrict this invention as they are given merely by way of illustration.

Example 1.—Into a thermal cracking tube having a length of 30 m. and an elliptical cross-sectional configuration having a minor axis of 38 mm. and a major axis of 212 mm. were fed 1.89 tons/hr. of naphtha, of which analysis is shown in the following Table 1, in admixture with 1.02 tons/hr. of steam, which were preheated at 600° C., and the thermal cracking reaction was conducted while maintaining the temperature at the exit of the thermal cracking tube at 800° C.

The yields of the products are shown in Table 2:

TABLE 1.—RESULT OF ANALYSIS OF THE STARTING NAPHTHA

| | |
|---|---|
| Specific gravity (API) | 71.1 |
| Initial boiling point (° C.) | 35 |
| 50% boiling point (° C.) | 80 |
| 90% boiling point (° C.) | 132 |
| End point (° C.) | 165 |
| Paraffin (vol. percent) | 73.5 |
| Naphthene (vol. percent) | 18 |
| Aromatics (vol. percent) | 8 |

TABLE 2.—YIELDS OF THE RESULTANT PRODUCTS

| Description: | Yield (wt. percent) |
|---|---|
| Methane | 6.5 |
| Ethylene | 22.5 |
| Propylene | 15.2 |
| 1,3-butadiene | 6.25 |

Example 2.—Example 1 was repeated according to the same procedures as described therein except that the temperature at the exit of the thermal cracking tube was

870° C. The yields of the resultant products are shown in Table 3:

TABLE 3

| Description: | Yield (wt. percent) |
|---|---|
| Methane | 14.7 |
| Ethylene | 32.0 |
| Propylene | 14.6 |
| 1,3-butadiene | 4.0 |

Example 3.—Into a thermal cracking tube having a length of 70 m. and an elliptical cross-sectional configuration having a minor axis of 60 mm. and a major axis of 208 mm. were fed 3.26 tons/hr. of the same naphtha as used in Example 1 in admixture with 1.76 tons/hr. of steam, which were preheated at 600° C., and the thermal cracking reaction was conducted while maintaining the temperature at the exit of the thermal cracking tube at 800 C. The yields of the resultant products are shown in Table 4.

TABLE 4

| Description: | Yield (wt. percent) |
|---|---|
| Methane | 11.4 |
| Ethylene | 23.8 |
| Propylene | 14.8 |
| 1,3-butadiene | 4.8 |

Example 4.—Example 3 was repeated according to the same procedures as described therein except that the temperature at the exit of the thermal cracking tube was 850° C. The yields of the resultant products are shown in Table 5.

TABLE 5

| Description: | Yield (wt. percent) |
|---|---|
| Methane | 16.0 |
| Ethylene | 31.5 |
| Propylene | 14.4 |
| 1,3-butadiene | 3.0 |

I claim:

1. A thermal cracking apparatus comprising heating means and an external heating-type thermal cracking tube vertically disposed in said apparatus, said tube having a flattened or elliptical cross-sectional configuration with a minor axis and a major axis, the ratio of said minor axis to said major axis being 0.1 to 0.7 and said heating means being so disposed as to confront the major axis from each side thereof.

2. A heating apparatus according to claim 1 wherein the tube is provided with reinforcing members transverse of said cross-section and parallel to the minor axis thereof.

3. A heating apparatus according to claim 2 wherein the reinforcing members are plates, the faces of which extend lengthwise of the tube.

4. A heating apparatus according to claim 3 wherein the tube has two faces which are substantially flat and lie in planes parallel to the major axis.


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U.S. Cl. X.R.

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