PRODUCTION OF ETHYLENE BY THERMAL CRACKING OF HYDROCARBONS

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ABSTRACT OF THE DISCLOSURE

A process for the production of ethylene in which hydrocarbons are thermally cracked at temperatures of from 750° to 900° C. in tube furnaces. In the process the hot cracked gas is indirectly cooled by passing the gas through a quench boiler at a mass velocity of at least 50 kg./sq.m./sec., the wall temperatures of the cooling tubes of the quench boiler being kept above 310° C., by maintaining a steam pressure of at least 100 atmospheres on the side of the boiling water. The process has the advantage that deposits of coke and other cracked products are controlled while still making use of the preferred indirect cooling.

This invention relates to a process for the production of ethylene by thermal cracking of hydrocarbons. A special object of the invention is to avoid the deposition of coke and other cracked products as well as high polymers in the cooling tubes of the quench boiler by passing the hot cracked gas through the cooling tubes at a high and specific mass velocity.

It is known that olefins, particularly ethylene, may be produced by cracking gaseous or completely vaporizable liquid hydrocarbons by various prior art methods, for example thermally in metal tubes which are externally heated, in admixture with steam at temperatures of more than 750° C. In the said methods, cracked gases are obtained having a high content of olefinic hydrocarbons, especially ethylene. The byproducts of these processes include propylene, higher olefins and diolefins as well as other cracked products. To avoid secondary reactions the highly reactive gas mixture must be cooled rapidly. This cooling is effected in practice either by directly spraying in coolants, for example liquid hydrocarbons, into the gas mixture, or by indirect cooling in a quench boiler.

Indirect cooling is generally preferred in order to obtain high-pressure steam. A disadvantage of indirect cooling of the cracked gas is that deposits of coke and other cracked products form on the heat-exchanging surfaces and these impair heat transfer and thus lessen the effect of the cooling. Operation thus has to be interrupted at more or less short intervals of time and the quench boiler cleared mechanistically of the coke deposits.

We have now found that the said disadvantages are avoided by passing the hot cracked gas through the cooling tubes of the quench boiler at a mass velocity of at least 50 kg./sq.m./second preferably 60 to 70 kg./sq.m./second.

Examples of suitable hydrocarbons are ethane, propane and butane, if desired, in admixture with olefins, for example 5 to 20% of propylene. In general, liquid hydrocarbons boiling between 35 and 200° C., for example full range naphtha or light naphtha boiling between 35 and 100° C., are used.

Cracking is carried out in the presence of steam with which the feed is mixed prior to introduction into the convection zone of the reactor. In general, 10 to 60 wt. percent of steam is sufficient. When cracking gaseous hydrocarbons, approximately 10 to 20 wt. percent of steam is added and approximately 45 to 60 wt. percent when cracking liquid hydrocarbons.

In carrying out the process according to this invention, gaseous and/or vaporous hydrocarbons are mixed with steam and thermally cracked at temperatures of from 750° to 900° C., preferably more than 800° C., and the hot cracked gas thus formed is cooled in the manner described above in a quench boiler to temperatures of less than 450° C., preferably to temperatures of 340 to 400° C. The temperature during passage through the cooling tubes should not be lower than the dewpoint of the component of the cracked gas having the highest boiling point. It has been found that wall temperatures of the cooling tubes of at least 310° C. or more, e.g., 310 to 330° C., are necessary for this purpose. This wall temperature is achieved under the said conditions when the quench water, if kept at a minimum pressure of 100 atmospheres, preferably at a pressure of 120 to 130 atmospheres.

The use of the process according to this invention is of particular importance for high-severity cracking in which cracking temperatures of 810 to 850° C. and residence times of less than 0.3 second, related to the volume of cracked gas at the heater outlet, are desirable. Further cooling of the cracked gas after it leaves the quench boiler may be carried out in conventional manner by direct cooling, for example by spraying in high boiling point hydrocarbons, or in another quench boiler. Undisturbed operation of the cracking plant is ensured by the process according to this invention and a particularly advantageous recovery of the heat liberated during the cracking is possible because the heat is recovered in the form of high-pressure steam.

Deposition of coke and other cracked products also takes place in the connections between the cracking furnace and the cooling tubes.

We have further found that the risk of coke formation in these connections, i.e., in the inlet cone of the quench boiler, prior to distribution of the hot cracked gas to the individual cooling tubes can be lessened by designing the inlet cone in the manner of a diffuser, turbulence due to sharp deflections of the stream of gas as encountered in conventional equipment thus being prevented. The residence time of the cracked gas in the quench boiler is shortened owing to the incorporation of the connecting member. It is advantageous for the inlet cone to be designed so that the space velocity therein is more than 20 kg. of cracked gas/cu.m./sec., preferably from 20 to 45 kg./cu.m./sec.

An advantageous embodiment of the process and a suitable quench boiler will now be described in the following example with reference to the accompanying drawing.

Example

3700 kg./h. of light naphtha having a boiling range of 35° to 170° C. is premixed with 1850 kg./h. of steam and the mixture heated to 600° C. and thermally cracked at 820° C. in a tube heated externally with gas flames. The residence time of the hot reaction mixture from the beginning of the cracking reaction to the entry of the cracked gas into the cooling tubes of the quench boiler is 0.3 second. Distribution of the hot cracked gas to the cooling tubes of the quench boiler illustrated in the drawing takes place in a connecting member 1 resembling a diffuser which is the inlet cone of the quench boiler. The space velocity in this connecting member is 38 kg./cu.m./sec. 5550 kg./h. of cracked gas flows through the cooling tubes 2 at a mass velocity of 51 kg./sq.m./sec.
and leaves the quench boiler through the gas outlet cone 3 at a temperature of about 350° C. Water as coolant flows from a steam drum at a higher level through downpipes into a water header 4 whence it is supplied by pipes 5 about the cooling tubes. The mixture of steam and water produced is passed through connecting pipes 6 to a header 7 which is connected by risers to the steam drum in which a working pressure of 125 atmospheres is maintained. After a further cooling of the gas to about 200° C. by direct cooling with liquid hydrocarbons having a boiling range of 220° to 250° C. a cracked gas is obtained in trouble-free operation from which 1010 kg./h. of pure ethylene may be recovered by conventional separation methods.

We claim:

1. A process for the production of ethylene by thermal cracking of hydrocarbons at temperatures of from 750 to 900° C. and by indirect cooling of the hot cracked gas in a quench boiler, wherein the hot cracked gas is passed through the cooling tubes of the quench boiler at a mass velocity of at least 50 kg./sq.m./second, the wall temperature of said cooling tubes being maintained at a temperature not lower than the dewpoint of the component of the cracked gas having the highest boiling point.

2. A process as claimed in claim 1, wherein the wall temperature of the cooling tubes is kept at 310 to 330° C. by maintaining a steam pressure of 120 to 130 atmospheres on the side of the boiling water.

3. A process as claimed in claim 1, wherein the cracked gas upon entry into the quench boiler is free from turbulence while being distributed to the cooling tubes and the space velocity of the cracked gas in the inlet cone of the quench boiler is from 20 to 45 kg./cu.m./second.

4. A process for the production of ethylene by thermal cracking of hydrocarbons at temperatures of from 750 to 900° C. and by indirect cooling of the hot cracked gas in a quench boiler wherein the hot cracked gas is passed through the cooling tubes of the quench boiler at a mass velocity of from 60 to 70 kg./sq.m./second and the wall temperature of the cooling tubes is kept at from 310 to 330° C. by maintaining a steam pressure of 120 to 130 atmospheres on the side of the boiling water.

5. A process as claimed in claim 4, wherein the cracked gas upon entry into the quench boiler is free from turbulence while being distributed to the cooling tubes and the space velocity of the cracked gas in the inlet cone of the quench boiler is from 20 to 45 kg./cu.m./second.

6. In a process for the production of ethylene by thermal cracking of hydrocarbons at temperatures of from 750° to 900° C. wherein the hot cracked gas is indirectly cooled in a quench boiler, the improvement which comprises: passing the hot cracked gas through the cooling tubes of the quench boiler at a mass velocity of at least 50 kg./sq.m./second, the wall temperature of the cooling tubes being kept above 310° C. by maintaining a steam pressure of at least 100 atmospheres at the side of the boiling water.

7. A process as claimed in claim 6, wherein the cracked gas upon entry into the quench boiler is free from turbulence while being distributed to the cooling tubes and the space velocity of the cracked gas in the inlet cone of the quench boiler is from 20 to 45 kg./cu.m./second.

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