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THERMAL CRACKING FURNACE AND PROCESS

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(56) Prior Art Documents
EP 365899
US 4792436
US 4732740

(57) Claim

1. A thermal cracking furnace comprising:

a radiant section;

a convection section offset from the radiant section;

a horizontally disposed breeching section extending between the radiant section and the convection section;

a heating means comprising an array of floor burners in the radiant section; and

a plurality of radiant coils extending through the horizontally disposed breeching section and the radiant section, said radiant coils being comprised of a horizontal radiant coil section extending through the horizontal breeching section and vertical coil sections extending through the radiant section wherein the radiant coils of the horizontal breeching section have an internal cross-sectional diameter smaller than the internal cross-sectional diameter of the coils of the vertical coil sections of the radiant coils and the vertical coil sections of the radiant coils are comprised of an upstream and a downstream section wherein the radiant coils in the upstream section of the vertical coil sections have a larger internal cross-sectional diameter than the coils of the horizontal section of the radiant coils and the radiant coils in

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the downstream section of the vertical sections of the radiant coils have a larger internal cross-sectional diameter than the coils of the upstream section of the vertical section of the radiant coils.

said stopper body is received in said chamber; and

said shield body chamber being configured to receive the outer surface of the area of an evacuated tube adjacent the open end thereof.

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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title: Thermal Cracking Furnace and Process

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

FIELD OF THE INVENTION

This invention relates to furnaces for thermally cracking hydrocarbons. More particularly, the invention relates to a furnace and process for cracking hydrocarbons wherein firing is entirely by floor burners and in which coil fouling due to coke formation is minimized.

BACKGROUND OF THE INVENTION

It has long been known to thermally crack hydrocarbon to produce olefins and other lighter hydrocarbon products.

Typically, a thermal cracking furnace is comprised of a firebox and a plurality of coils that extend through the firebox. A hydrocarbon feedstock is introduced into the cracking furnace and elevated to high temperatures, e.g. 1600°F and quenched to a reaction temperature to provide a yield of cracked products. However, the nature of the thermal cracking process causes coke and tar to form along with the desired products. From the beginning of the practice of thermal cracking, fouling of the coils resulting from coke and tar generation has been a serious problem. When the coils are fouled by coke and tar the furnace must be taken out of service to clean or replace the tubes.

Light hydrocarbons such as ethane are a common and often preferred feedstock. However the high heat of cracking of light hydrocarbon feedstocks poses design constraints and the fouling characteristics of coke from the cracking of the light hydrocarbon feedstocks is particularly troublesome.

Furthermore, as the thermal cracking technology advanced, a trend to high severity cracking occurred to achieve either improved yields or increased selectivity to the desired ultimate product. As a result, thermal cracking furnaces having small diameter, short length coils and a concentration of radiant burners along the furnace walls facing the coils were developed for high severity cracking to attain higher olefin selectivity. Practice has shown that at high severity coking problems become more pronounced.

A further development was the application of floor firing of thermal cracking furnaces. Although many benefits

attend floor firing, experience indicated that deleterious localized coking often resulted from floor firing.

The conventional wisdom now prevailing in thermal cracking is that short residence time, high severity cracking will produce the highest selectivity and olefin yield. However, under high severity cracking conditions, particularly in conjunction with total floor firing, the coking problems increase and the operating run length consequently decreases causing shorter effective operational availability and curtailed equipment life.

SUMMARY OF THE INVENTION

Contrary to the conventional wisdom, it has been found that maximization of olefin output defined as the product of average cracking cycle yield and average furnace availability can be achieved over the long-run by a furnace and process that uses the maximum available radiant heat.

There is disclosed herein a thermal cracking furnace comprising:

a radiant section;

a convection section offset from the radiant section;

a horizontally disposed breeching section extending between the radiant section and the convection section;

a heating means comprising an array of floor burners in the radiant section; and

a plurality of radiant coils extending through the horizontally disposed breeching section and the radiant section, said radiant coils being comprised of a horizontal radiant coil section extending through the horizontal breeching section and vertical coil sections extending through the radiant section wherein the radiant coils of the horizontal breeching section have an internal cross-sectional diameter smaller

than the internal cross-sectional diameter of the coils of the vertical coil sections of the radiant coils and the vertical coil sections of the radiant coils are comprised of an upstream and a downstream section wherein the radiant coils in the upstream section of the vertical coil sections have a larger internal cross-sectional diameter than the coils of the horizontal section of the radiant coils and the radiant coils in the downstream section of the vertical sections of the radiant coils have a larger internal cross-sectional diameter than the coils of the upstream section of the vertical section of the radiant coils.

DESCRIPTION OF THE DRAWINGS

The invention will be better understood when considered with the following drawings wherein:

FIGURE 1 is an elevational view of the furnace of the invention;

FIGURE 2 is a plan view taken through line 2-2 of FIGURE 1;

FIGURE 3 is a perspective view of the furnace coils seen in FIGURE 1; and

FIGURE 4 is a perspective view of a variation of the furnace coils seen in FIGURE 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The furnace of the present invention is a furnace for thermally cracking hydrocarbon feedstock.

The furnace 2 is comprises of a radiant zone 4, a convection zone 6 offset from the radiant zone 4 and a horizontally disposed upper radiant zone or breeching zone 8 connecting the radiant zone 4 with the convection zone 6.

As best seen in FIGURE 1, a plurality of convection coils 10 extend horizontally through the convection zone 6 and terminate in a common manifold 12. Radiant coils 14 comprised of a horizontal section 16 and a connected downstream vertical section 18 extend from the common manifold 12 through the

horizontal breeching zone 8 and the radiant zone 6. The vertical downstream sections 18 of the radiant coils 14 are configured in a U-shape with an upstream section 20, a U-bend 22 and a downstream section 24.

The furnace 2 has sidewalls 26, a roof 28 and a floor 30. The furnace is fired entirely by floor burners 32, best seen in FIGURE 2, that provide radiant heat to the vertically disposed sections 18 of the radiant coils 14 and the horizontally disposed coil section 16 in the breeching zone 8. The flue gases generated by the floor burners 32 provide convection heat for the convection section 6 of the furnace 2 and contribute a modest amount of convection heat to the horizontal radiant coil sections 16 of the radiant coils 14.

Quench exchangers 34 are provided to quench the effluent produced by thermally cracking the hydrocarbon feedstock in the furnace 2. A quench exchanger 34 (individual or common) is located immediately downstream of the outlet 36 of each radiant coil 14.

The radiant coils 14 are comprised of differentially sized tubes. Practice has shown that the furnace 2 will perform well for long periods of time without the need to decoke the tubes when the horizontally disposed section 16 of the radiant coils 14 is of the smallest internal diameter, the upstream vertical coil section 20 is of an intermediate internal diameter and the vertical coil section 24 is of the largest internal diameter. Illustratively, the horizontally disposed sections 16 of the radiant coils 14 are 30 mm to 39 mm internal diameter; the vertical coil sections 20 are 29 mm to 64 mm internal diameter and the vertical coil sections 24 are 50 mm to 76 mm internal diameter.

One embodiment of the radiant coils 14 is seen in FIGURE 3 wherein four horizontally disposed radiant coil sections 16 terminate in a connection fitting 17 and from which a single upstream vertical coil section 20 extends and continues as a single downstream vertical coil section 24.

An alternative embodiment is seen in FIGURE 4 wherein the radiant coils 14 are comprised of two sets of two horizontally disposed radiant

coil sections 16 that terminate in two connection fittings 17 from which two upstream vertical radiant coil sections 20 and 20a respectively extend and terminate in a connection fitting 23. A single downstream vertical radiant coil section 24 extends from the connection fitting 23 to a quench exchange 34.

The process of the present invention proceeds by delivering hydrocarbon feedstock such as ethane, naphtha etc. to the inlet of the convection coils 10. The feedstock is heated to temperatures of 530°C to 700°C in the convection zone 6. After delivering the feedstock from all of the convection coils 10 to the manifold 12 to equalize the temperature and pressure, the hydrocarbon feed is elevated in temperature in the horizontal radiant breeching zone 8 to temperatures of 700°C to 788°C at a residence time of 0.05 sec. to 0.075 sec. Thereafter, the hydrocarbon feedstock is heated to the final cracking temperature of 815°C to 900°C in the vertical section of the radiant coils 18 at a residence time of 0.175 sec. to 0.25 sec.

The heat flux produced in the furnace is 37855 W/m^2 to 110411 W/m^2. Radiant heat of 0.2931 W per coil to 0.3664 W per coil to 0.1512 W per coil in the horizontal radiant breeching zone 8. The combustion gases reach the convection zone 6 at a temperature of 1035°C to 1095°C.

The following table illustrates the projected conditions after forty days of continuous operation of the furnace 2 of the invention wherein dimensions from the coil inlet through the end of the horizontal radiant coil section 18 are 33 mm inside diameter and four coils of thirteen feet length and the dimensions from the connection of the horizontal radiant coil section 18 to the coil inlet 36 are 64 mm inside diameter and one coil of 25 m length.

The operating conditions for the run are 499 kg ethane/Hr. per coil feedstock; 82.7 kPa coil outlet pressure; 0.136 kg steam/kg. hydrocarbon; 65% conversion. The maximum tube metal temperature occurs between points C and D and is 1102°C.

TABLE 1

LOCATION	COIL INLET A	END OF HORIZONTAL SECTION B	BOTTOM OF RETURN BEND C	COIL OUTLET D
Process Temp. °C	705	792	828	876
Tube Metal Temp. (TMT) °C	904	977	1043	1038
Bridge Wall Temp. (BWT) (Flue Gas Temp.) °C	1074	1130	1179	1129

KXW:1836R

The claims defining the invention are as follows:

1. A thermal cracking furnace comprising:

a radiant section;

a convection section offset from the radiant section;

a horizontally disposed breeching section extending between the radiant section and the convection section;

a heating means comprising an array of floor burners in the radiant section; and

a plurality of radiant coils extending through the horizontally disposed breeching section and the radiant section, said radiant coils being comprised of a horizontal radiant coil section extending through the horizontal breeching section and vertical coil sections extending through the radiant section wherein the radiant coils of the horizontal breeching section have an internal cross-sectional diameter smaller than the internal cross-sectional diameter of the coils of the vertical coil sections of the radiant coils and the vertical coil sections of the radiant coils are comprised of an upstream and a downstream section wherein the radiant coils in the upstream section of the vertical coil sections have a larger internal cross-sectional diameter than the coils of the horizontal section of the radiant coils and the radiant coils in the downstream section of the vertical sections of the radiant coils have a larger internal cross-sectional diameter than the coils of the upstream section of the vertical section of the radiant coils.

2. A thermal cracking furnace as in claim 1 wherein the heating means consist essentially of the array of floor burners.

3. A thermal cracking furnace as in claim 1 or claim 2 further comprising a plurality of convection coils in the convection section and a common manifold upstream of the radiant section into which the convection coils extend and wherein the plurality of radiant coils extends from the common manifold.

4. A thermal cracking furnace as in any one of claims 1 to 3 wherein each radiant coil of the plurality of radiant coils terminates in an outlet and further comprising a quench enchanger at the outlet of each radiant coil.

5. A thermal cracking furnace as in any one of claims 1 to 4, wherein the internal cross-sectional diameter of the horizontal section of the radiant coils is 30 mm to 39 mm; the internal cross-sectional diameter of the upstream section of the vertical section of the radiant coils is 39 mm to 64 mm and the internal cross-sectional diameter of the downstream section of the vertical section of the vertical coils is 50 mm to 76 mm.

6. A thermal cracking furnace as in any one of claims 1 to 3 further comprising a connection fitting into which a plurality of the horizontal radiant coils extend and wherein the upstream vertical coil section comprises a single downflow coil extending from the connection fitting.

7. A thermal cracking furnace as in any one of claims 1 to 3 comprising a plurality of horizontal radiant coil section members terminating in connection fittings; a plurality of downflow upstream radiant coil sections extending from a plurality of said connection fittings, a connection fitting into which the plurality of downflow upstream radiant coil sections enter and a single downstream vertical section extending from the connection fitting into which the downflow upstream radiant coil sections extend.

8. A thermal cracking furnace substantially as hereinbefore described with reference to Figures 1 to 4.

DATED this EIGHTEENTH day of JANUARY 1994

Stone & Webster Engineering Corporation

Patent Attorneys for the Applicant
SPRUSON & FERGUSON

ABSTRACT

A thermal cracking furnace (2) comprising a radiant zone (4); a convection zone (6) offset from the radiant zone (4); a horizontally disposed breeching zone (8) extending between the radiant zone (4) and the convection zone (6); an array of floor burners (32) in the radiant zone (4) and a plurality of radiant coils (14) extending through the horizontally disposed breeching zone (8) and the radiant zone (4). The convection zone (6) has a plurality of convection coils (10) which terminate in a common manifold (12). The radiant coils (14) are comprised of a horizontal section (16) and a connected downstream vertical section (18) which has a U-bend (22) and an outlet (36). Quench exchangers (34) quench the effluent produced by thermally cracking the hydrocarbon feedstock.

Figure 1

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FIG. 1

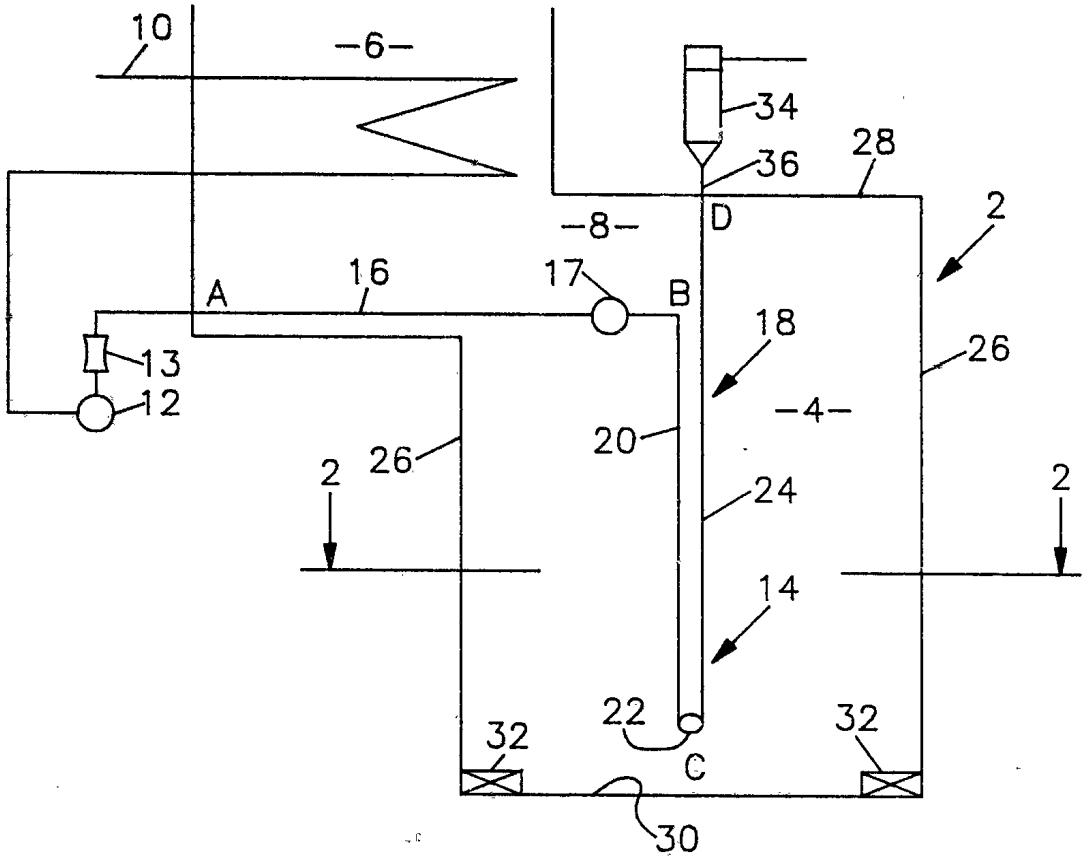

FIG. 2

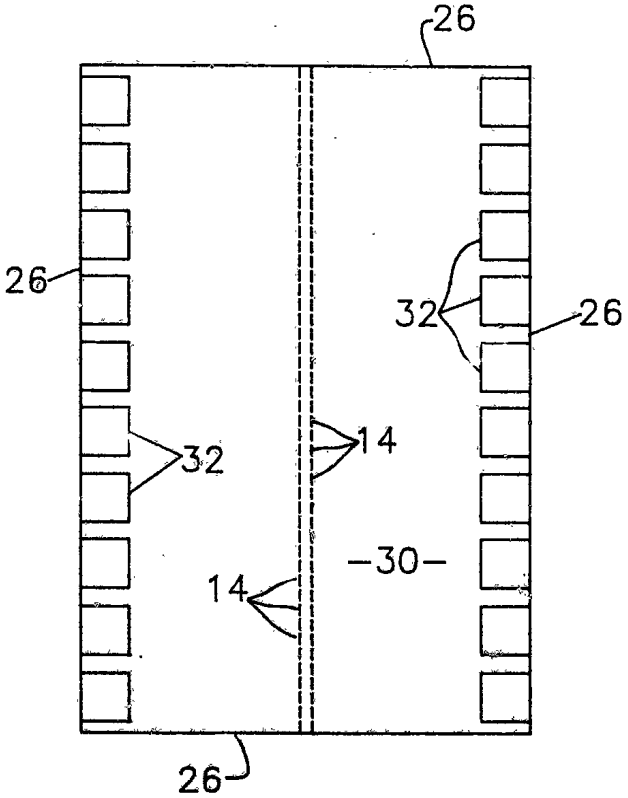

FIG. 3

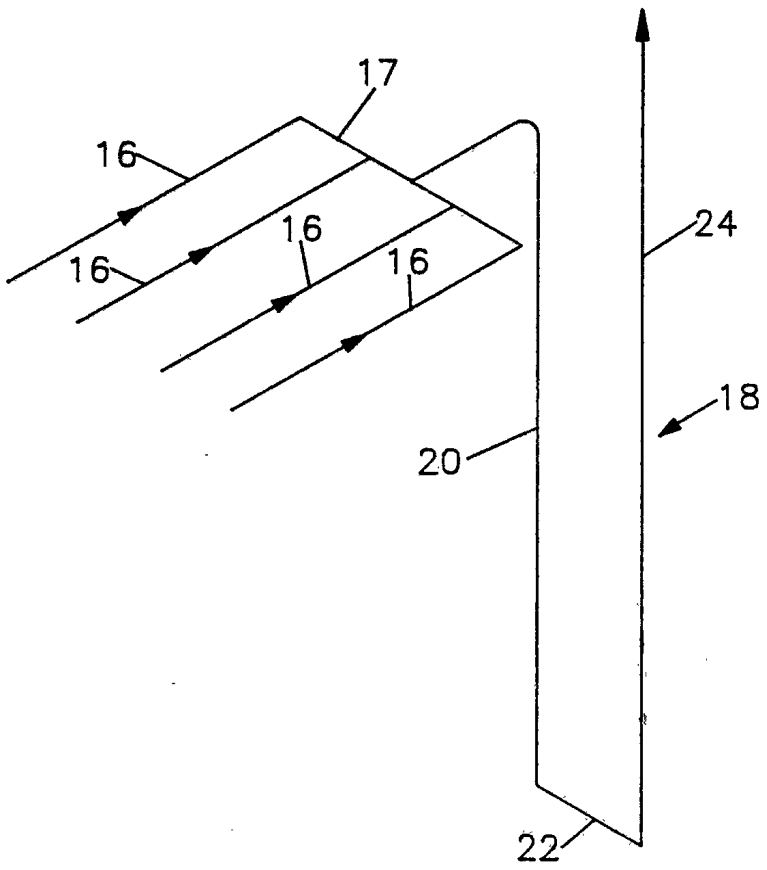

FIG. 4