

[54] **FLUID CATALYTIC CRACKING PROCESS WITH IMPROVED PROPYLENE RECOVERY**

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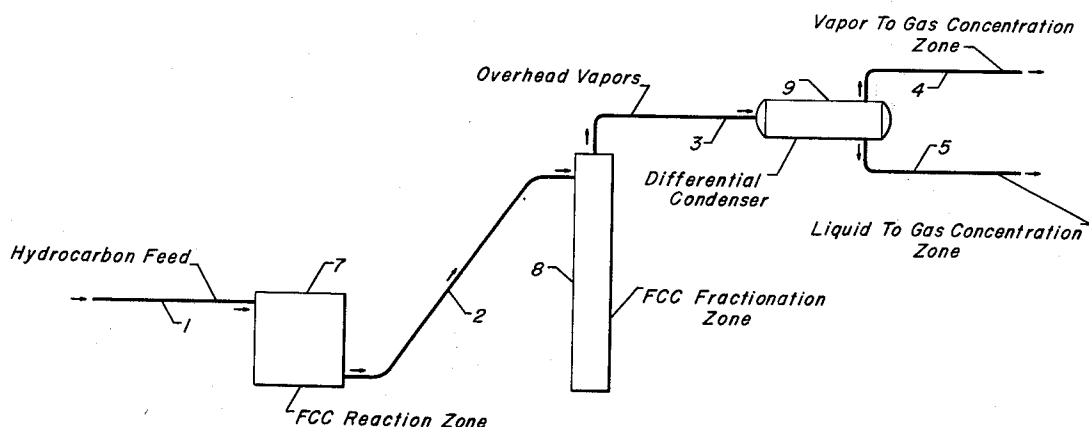
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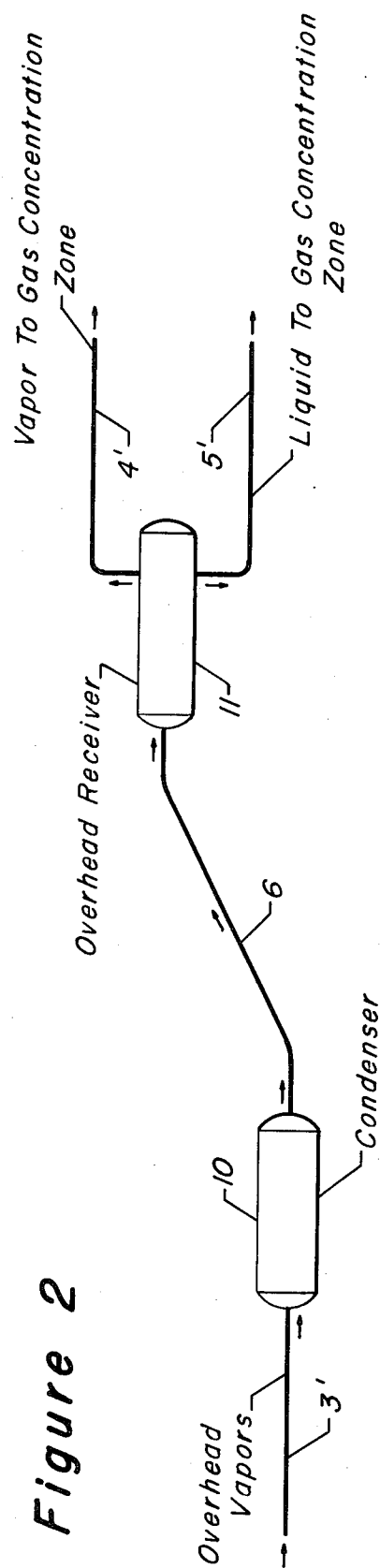
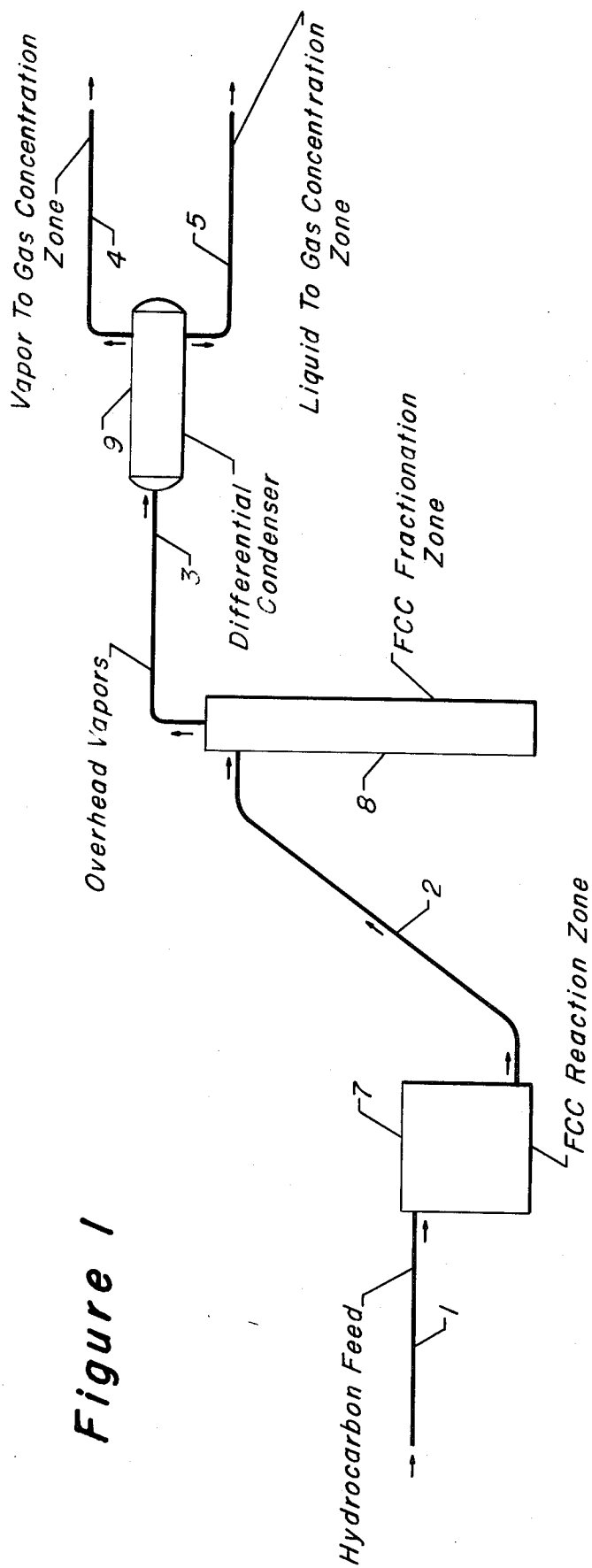
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[57] **ABSTRACT**

In a fluid catalytic cracking process, a method of condensing fractionation zone overhead vapors and separating resultant liquid and vapor phases to improve recovery of a propylene rich product. A differential condenser is employed to withdraw condensed liquid from vapor, as the liquid condenses, in order to limit mixing of the phases. This reduces the amount of propylene passing in the liquid phase to gas concentration facilities, and thereby increases the quantity of propylene recovered.

3 Claims, 2 Drawing Figures





FLUID CATALYTIC CRACKING PROCESS WITH IMPROVED PROPYLENE RECOVERY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The field of art to which this invention pertains is hydrocarbon processing. Specifically, this invention relates to a fluid catalytic cracking process (FCC) in which the recovery of propylene product is improved.

2. Prior Art

The advent of high activity zeolitic catalysts has had a marked effect on operating pressures in FCC units. To maintain the high activity and favorable yield distribution characteristics of zeolitic catalysts, it is necessary to maintain low coke levels. This has been achieved in old and new units by increasing the operating pressure. Higher pressure is conducive to more efficient coke burning in the regenerator and thereby lower coke on catalyst. However, this recent increase in operating pressure has accentuated the traditional problem of imperfect recovery of propylene from reaction products.

In FCC units, propylene is intended to leave the FCC fractionator overhead receiver in the vapor phase, from which it is recovered in downstream gas concentration facilities. Part of the propylene leaving the overhead receiver in the liquid phase is lost to a by-product stream (fuel gas). By virtue of the mixing which takes place between liquid and vapor phases in conventional overhead condensing and receiving steps, the liquid phase leaving the receiver carries with it a considerable amount of propylene which is later lost. Increased loss is experienced when the unit operating pressures are increased in view of the fact that the liquid-vapor equilibrium at higher pressures favors more propylene in the liquid phase.

The present invention reduces the amount of propylene lost in FCC units operating either at lower or higher pressures. In the embodiments of this invention a differential condenser increases the quantity of propylene in the vapor phase stream introduced to gas concentration facilities so that more propylene is recovered as a valuable product.

OBJECTS AND EMBODIMENTS

It is an object of the present invention to provide an improvement to the FCC process whereby recovery of propylene is improved. It is a further object of this invention to increase the value of FCC process products.

In one embodiment our invention affords, in a fluid catalytic cracking process wherein (i) a hydrocarbon feed contacts cracking catalyst at cracking conditions in a reaction zone, (ii) reaction products are withdrawn from the reaction zone and introduced into a fractionation zone, (iii) overhead vapors from the fractionation zone are passed to a condenser, (iv) effluent from the condenser passes in separate conduits to gas concentration facilities, the improvement which comprises; introducing said overhead vapors into a differential condenser and therein separating resultant liquid and vapor phases.

BRIEF SUMMARY OF THE INVENTION

Our invention involves an improvement in the recovery of propylene products from a fluid catalytic cracking process. Condensation of FCC fractionation zone overhead vapors, and separation of resultant liquid and

vapor phases, is accomplished through the use of a differential condenser, rather than the combination of the conventional condenser and overhead receiver. Condensing liquid is removed from the differential condenser as it condenses, while a level of condensed liquid is maintained therein. Conventional operating conditions are employed in the differential condenser.

BRIEF DESCRIPTION OF THE DRAWING

The attached drawing illustrates a particular embodiment of the present invention. Only such details are included as are necessary for a clear understanding of our invention, and no intention is thereby made to unduly limit its scope. Unnecessary items such as certain process streams, valves, pumps, instrumentation and other equipment have been omitted for the sake of simplicity.

FIG. 1 is a schematic representation of an FCC process utilizing the differential condensing technique of our invention.

FIG. 2 shows the conventional FCC process steps which are replaced by the differential condensing step of our invention.

In FIG. 1, hydrocarbon feed entering the FCC reaction zone 7 via line 1 contacts catalyst at reaction conditions. Reaction products plus unconverted feed, if any, pass out of the reaction zone via line 2 and into the FCC fractionation zone 8. In the fractionation zone, gasoline and lighter materials are separated from the mixture of reaction products and unconverted feed and are passed as overhead vapors to differential condenser 9 via line 3. Overhead vapors are differentially condensed in differential condenser 9, and resultant liquid and vapor phases are separated in this same step. Vapor leaves differential condenser 9 via line 4, passing therethrough to the compression section of the downstream gas concentration zone. Liquid from differential condenser 9 leaves via line 5 and passes to the adsorption section of the downstream gas concentration zone.

Referring now to FIG. 2, steps of the FCC process are shown which are replaced by the technique of our invention. Condenser 10 and overhead receiver 11 are replaced by differential condenser 9. Without our invention, overhead vapors from the FCC fractionation zone 8 pass via line 3' to condenser 10. Mixed liquid and vapor phases leave condenser 10 via line 6 and enter overhead receiver 11 where the phases are separated. Vapor from overhead receiver 11 passes via line 4' to the gas concentration zone. Liquid from overhead receiver 11 passes to the gas concentration zone via line 5'.

DETAILED DESCRIPTION OF THE INVENTION

Propylene is a valuable FCC unit product primarily because of its use as a raw material in the production of polypropylene, polymer gasoline (the gasoline produced in a polymerization process unit,) alkylate gasoline and isopropyl alcohol. Some of the propylene produced in the reaction zone of an FCC unit is not recovered in the propylene product stream. It is the primary object of the present invention to improve recovery of propylene, thereby increasing the value of FCC unit products. Those versed in the art are familiar with conventional FCC flow schemes in which reaction products pass from the reaction zone to a fractionation zone where a fraction comprising gasoline and lighter materials (including propylene) is separated from heavier reaction products and unreacted feed. Gasoline

and lighter materials leave the fractionation zone as overhead vapors of a fractionator, and they pass to a condenser and then to an accumulator called an overhead receiver. Here the vapor and liquid phases are separated and pass in separate conduits to different sections of the gas concentration facilities where product and byproduct separations take place. As a result of the configuration of gas concentration facilities, the distribution of propylene in the aforementioned vapor and liquid phases is critical to propylene recovery.

Vapor from the overhead receiver passes through two stages of absorption in series. In the first stage propylene is absorbed and sent with the absorber oil to the fractionation section of gas concentration where the propylene is recovered as a valuable product. propylene-bearing effluent vapor from the first stage is sent to the second stage. In the second stage more propylene is absorbed and returned to the FCC fractionation zone. The balance of the propylene exits the second stage in the by-product stream called fuel gas, thereby assuming a much lower value. Liquid from the overhead receiver enters the first absorption stage near the effluent vapor outlet. This entry point is only a few absorption trays below the absorber oil inlet, so that propylene stripped from this liquid by counter-current vapors within the absorber has little chance to be absorbed by absorber oil in the first stage. The result is that propylene entering with the vapor phase from the overhead receiver traverses both absorption stages which together may contain 48 or more absorption trays, whereas propylene entering with the liquid phase traverses only the second absorption stage and a few trays of the first absorption stage for a total of about 22 to 28 trays. This means that propylene absorption and resultant recovery as a valuable product can be improved by causing more propylene to leave the overhead receiver in the vapor phase and less in the liquid phase.

Loss of propylene due to its leaving the overhead receiver in the liquid phase has recently been made worse by certain FCC processing practices. The recent development of zeolitic catalysts has revitalized innovation in operating techniques. These new catalysts are capable of higher activity and more attractive yield distribution provided that carbon produced in the reaction zone is not allowed to accumulate on the catalyst beyond certain levels. Since raising the operating pressure of an FCC unit results in more efficient carbon removal in the catalyst regenerator section of the reaction zone, the trend has been to increase operating pressure. The preferred pressure range in the past has been from about 10 to 25 psig in regenerators. Pressures in the range of 30 to 40 psig are now quite common. Raising operating pressure results in higher pressure in the fractionation zone, condenser and overhead receiver, and this contributes to lower recovery of propylene. Increased pressure in the condenser and overhead receiver changes the vapor-liquid equilibrium and results in more propylene leaving the receiver in the liquid phase. This presents a situation particularly suited to use of the present invention.

Conventional condensing and overhead receiving steps are characterized by extensive mixing of the liquid and vapor phases during and after condensation takes place. This mixing allows liquid and vapor to substantially reach equilibrium with respect to the distribution of propylene in the two phases. Hence, the liquid

phase will be substantially saturated with propylene. The present invention provides the technique of differential condensing rather than conventional condensing and overhead receiving. Differential condensing, a technique wherein the path of vapor and condensed liquid are differentiated within the condensing means, provides greater enrichment of the vapor phase with respect to propylene.

The term enrichment relates to the increase in concentration of propylene in the vapor phase as overhead vapor passes from the fractionation zone to the gas concentration zone. Enrichment takes place as nonpropylene components condense or are dissolved in the liquid phase and disappear from the vapor phase. Enrichment is thwarted to some extent when vapor phase propylene mixes thoroughly with the liquid phase and is dissolved therein. Our invention effects improved enrichment.

Differential condensing reduces contact between liquid and vapor phases during and after condensation. One embodiment of the differential condensing step of the present invention might be a shell and tube heat exchanger with a receptacle for holding liquid. Coolant passes through the tubes. Baffles in the shell of the heat exchanger are open at their lower extremity such that liquid can flow freely from one end to the other in the shell side. The exchanger is mounted inclined from the horizontal such that gravity flow of liquid in the shell side is effected. The aforementioned receptacle is mounted on the bottom of the lower end of the shell to receive liquid as it exits the shell and to provide a liquid level. Overhead vapors enter the top of the shell at the end of higher elevation. Condensed liquid flows along the bottom of the shell and exits the shell at the lower or outlet end, passing into a receptacle. This allows condensed liquid to be withdrawn from the differential condenser as it condenses, thereby avoiding further contact between liquid and vapor. At the top of the outlet end (lower end) of the shell, a conduit is provided for withdrawal of vapors. Such an arrangement provides for condensation and separation of liquid and vapor phases without undue contact between the phases. An example will serve to show resulting improvement of enrichment over conventional condensing and overhead receiving steps.

For the purpose of giving an example, enrichment will be expressed numerically as the ratio of propylene in the vapor going to gas concentration to propylene in the liquid going to gas concentration. Values of C_3^* in liquid and C_3^* in vapor as shown in the following table are mole fractions. As shown below the use of a differential condensing step in place of condensing and overhead receiving steps results in increase in enrichment from 8.6 to 10.8, a 25% increase.

	Pressure, psig	* C_3^* in vapor	C_3^* in liquid	E**
With Differential Condensing	24	17.3	1.6	10.8
With Con- densing and Overhead Receiving	24	17.1	2.0	8.6

* C_3^* signifies propylene

E** signifies enrichment, as defined above.

The differential condenser is operated at the same conditions as the condenser and overhead receiver that it replaces. These conditions include the range of temperature of condensed liquid of about 80°F to 120°F and the range of pressure of about atmospheric to 40 psig.

We claim as our invention:

1. In a fluid catalytic cracking process wherein (i) a hydrocarbon feed contacts cracking catalyst at cracking conditions in a reaction zone, (ii) reaction products are withdrawn from the reaction zone and introduced into a fractionation zone, (iii) overhead vapors from the fractionation zone are passed to a condenser, and (iv) effluent from the condenser passes in separate conduits to gas concentration facilities, the improvement which comprises: condensing said overhead vapors in a differential condenser and in said differential con-

denser separating the overhead vapor into a gaseous phase containing propylene and a liquid phase comprising hydrocarbon molecules having 4 or more carbon atoms, said separation being effected by withdrawing liquid phase upon condensation to form gaseous and liquid phases containing a non-equilibrium distribution of propylene.

2. The improvement of claim 1 further characterized in that said differential condenser is maintained at a pressure within the range of about atmospheric to 40 psig.

3. The improvement of claim 1 further characterized in that the temperature of said liquid phase withdrawn from said differential condenser is maintained in the range of about 80°F to 120°F.

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