United States Patent

[11] 3,629,097

[72] Inventor **John H. Smith**
Ponca City, Okla.
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[73] Assignee **Continental Oil Company**
Ponca City, Okla.
Continuation-in-part of application Ser. No. 756,659, Aug. 30, 1968, now Patent No. 3,513,087, which is a continuation-in-part of application Ser. No. 702,047, Jan. 31, 1968, now abandoned. This application Jan. 6, 1970, Ser. No. 1,002

[54] **CONTROL SYSTEM FOR FLUID CATALYTIC CRACKING PROCESS**
4 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** .... **208/159,** 23/288 S, 208/164
[51] **Int. Cl.** **C10g 13/18**
[50] **Field of Search** .... 208/164, 159, DIG. 1; 23/288

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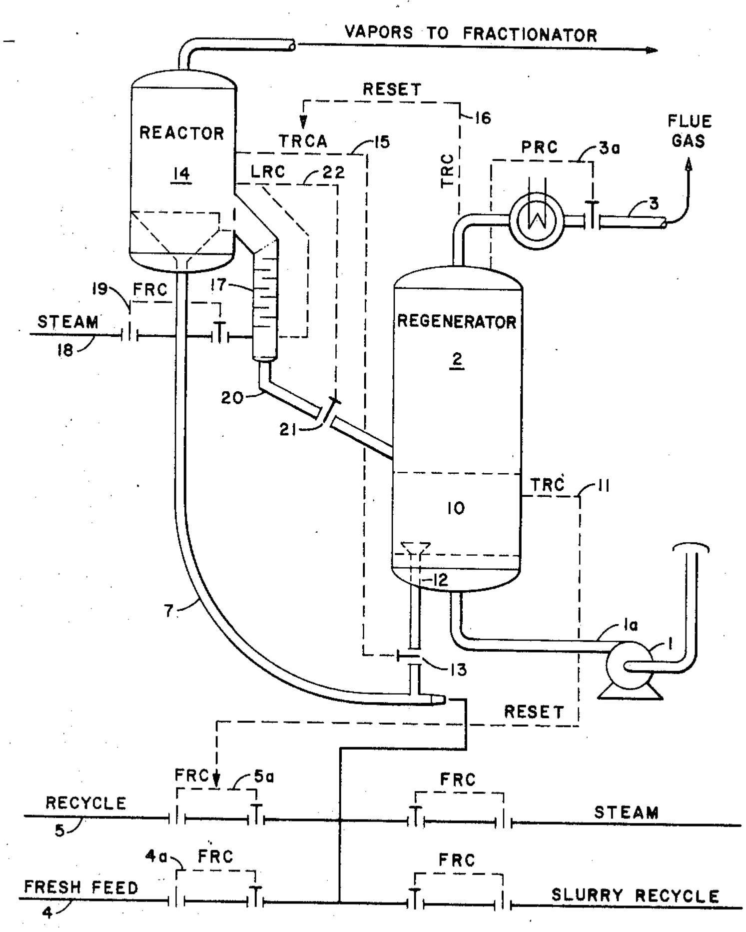
Primary Examiner—Herbert Levine
Attorneys—Joseph C. Kotarski, Henry H. Huth, Robert B. Coleman, Jr., Jerry B. Peterson, Jack N. Shears and Carroll Palmer

ABSTRACT: Coke deposition rate in the reactor of a fluid cat cracker is controlled by varying the severity and conversion level in the reactor, while maintaining maximum air rate to the regenerator. The temperature at the outlet of the regenerator, which is an indication of afterburning and amount of coke buildup, is used to control reactor temperature and catalyst-to-oil ratio in the reactor (by resetting the reactor temperature recorder control, which in turn controls the flow of hot regenerated catalyst from the regenerator to the reactor), thus controlling coke deposition to make it commensurate with air supply by controlling the severity and conversion level in the reactor. The temperature in the regenerator catalyst bed is held constant by varying the recycle feed rate to the reactor in response to variations in such temperature.



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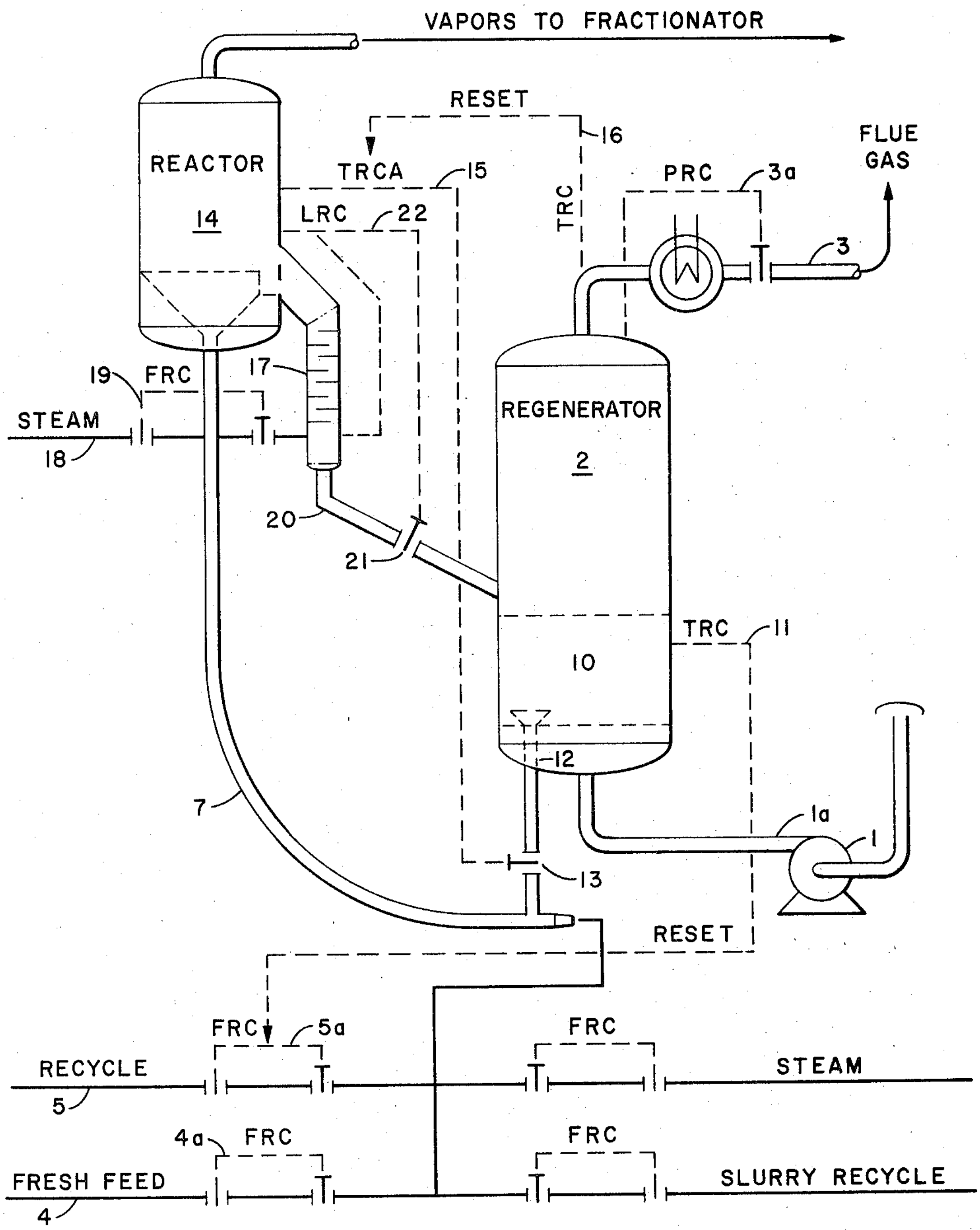

INVENTOR.
JOHN H. SMITH

BY Jerry B. Peterson

ATTORNEY

CONTROL SYSTEM FOR FLUID CATALYTIC CRACKING PROCESS

CROSS-REFERENCES TO RELATED APPLICATIONS

This is continuation-in-part of U.S. Ser. No. 756,659, filed Aug. 30, 1968, now U.S. Pat. No. 3,513,087, which in turn was a continuation-in-part of U.S. Ser. No. 702,047, filed Jan. 31,1968, and now abandoned.

This invention is an improved control system for a conventional fluid catalytic cracker. The improvement consists of a method and apparatus for maximizing the coke burning rate in the regenerator by operating the air compressor at maximum capacity and controlling the coke deposition rate in the reactor by varying the reaction severity in response to variations in air supply from the compressor. More specifically, the improvement consists of method and apparatus for controlling the temperature in the regenerator catalyst bed by varying the recycle feed rate to the reactor.

BACKGROUND

The background of this invention is explained in U.S. Ser. No. 756,659, filed Aug. 30, 1968, which application is hereby incorporated in its entirety into this application.

SUMMARY OF THE INVENTION

This invention is a specific variation in the concept disclosed and claimed in U.S. Ser. No. 756,659 and is directed to a method of maintaining a constant temperature in the regenerator catalyst bed in fluid catalytic cracking units which do not have feed preheating furnaces. In U.S. Ser. No. 756,659 the unit included feed preheating furnace **6**, and the temperature in the regenerator catalyst bed **10** was maintained constant by means of TRC **11** which automatically reset TRCA **8** to control the fuel to furnace **6**. In this invention the unit does not contain a furnace **6** and the regenerator catalyst bed temperature is held constant by regulating or varying the recycle feed rate in response to variations in the regenerator catalyst bed temperature. In other respects the concept and method and apparatus for operating the unit is the same as that of U.S. Ser. No. 756,659.

DESCRIPTION OF THE DRAWING

The FIGURE is a simplified flow diagram of a fluid catalytic cracking unit embodying my invention.

DETAILED DESCRIPTION

Referring to the drawing, compressor **1** runs at maximum speed on governor control, delivering all the air it can compress into regenerator **2** in which the pressure is held constant (preferably at about 10–30 p.s.i.g.) by a pressure recorder controller (PRC) **3***a* operating a back pressure valve in the flue gas exit line **3**. Fresh feed and recycle gas oil streams **4** and **5** each on flow rate control (FRC) **4***a* and **5***a*, join and pass into the reactor feed riser **7**. The temperature in the dense phase **10** of the regenerator is held constant by a temperature recorder controller (TRC) **11** which resets the control point of FRC **5***a*, which in turn controls the recycle feed rate.

Steam and slurry recycle from the fractionator (not shown) may also be charged to the reactor feed riser at constant rates as indicated. Regenerated catalyst from the dense phase in regenerator **2** flows via a standpipe **12** and slide valve **13** into the lower end of the reactor feed riser **7** where it mixes thoroughly with the steam and fresh feed and recycle feed streams. By virtue of its higher temperature (about 1,220° F.), the regenerated catalyst surrenders heat to the combined oil feed stream, bringing it to the desired temperature to effect vaporization and cracking of the latter. The resultant vapors and steam flow up through the reactor feed riser into reactor **14**, entraining the catalyst therewith. The temperature within the reactor is controlled to maintain a reactor temperature preferably within the range of about 890°–960° F., by a temperature recorder controller alarm (TRCA) **15** which regulates the position of the slide valve **13** in the regenerated catalyst standpipe **12**.

The amount of afterburning which occurs in regenerator **2** is controlled by controlling its flue gas exit temperature with a temperature recorder controller (TRC) **16** which resets the control point on TRCA **15** which directly controls the reactor temperature.

Spent catalyst from reactor **14** gravitates through stripper **17** wherein it is countercurrently swept with steam fed to the base of the stripper via line **18** controlled by a flow recorder control (FRC) **19**. This steam stripping removes adsorbed and entrapped oil vapors from the spent catalyst and returns them to the reactor from whence they ultimately flow to the fractionator.

Stripped spent catalyst gravitates from the base of stripper **17** into regenerator **2** via spent catalyst standpipe **20** and slide valve **21**. The position of slide valve **21** is regulated by a level recorder controller **22** to maintain a constant head of catalyst above the base of stripper. The catalyst level may extend up into the reactor if desired.

Except for very short term deviations, the heat input to a catalytic cracker must equal the heat output; otherwise system temperatures might rise or fall to damaging levels. The sum total heat input via combustion within the regenerator **2** must equal the sum of the radiation losses, the sensible heat surrendered to the flue gas leaving the regenerator, and the sensible, latent, and reaction heats surrendered to the product vapors from the reactor **14**.

If, at any time, the temperature of the dense phase **10** in the regenerator should tend to drop, it would signify that the rate of heat removal from the system temporarily exceeded the rate of heat input; the regenerator TRC **11** would react by decreasing the control setting of FRC **5***a*. This in turn would decrease the recycle feed rate (line **5**) to riser **7**, thereby reducing the rate of heat withdrawal from the system and thus bringing heat input and output back into balance and returning the regenerator temperature to its control point. It is readily apparent that by reacting in opposite fashion, the control system just described will limit the degree to which the regenerator temperature can climb above the control point.

A typical unit operates at or near the following conditions:

Recycle gravity	25° API
Recycle temperature	540° F.
Mean reactor temperature	930° F.
Regenerator bed temperature	1,225° F.
Regenerator flue gas temperature	1,275° F.
Air to regenerator	200° F.
Coke compositions	CnHn
CO_2/CO ratio in flue gas	1.0
Net heat of combustion	12,300 B.t.u./No. coke
Heat loss to flue gas	3,100 B.t.u./No. coke
Heat to process	9,200 B.t.u./No. coke
Air required	140 s.c.f./No. coke
Heat to process	66 B.t.u./s.c.f. air
Heat to recycle	100,000 B.t.u./bbl.

From the above it can be seen that the recycle rate must be changed by 950 barrels a day to compensate for a change in air rate of 1,000 cubic foot per minute.

The control temperature setting on the TRC **16** must be somewhat higher than that on TRC **11** to insure controlled afterburning. This difference should be at least 5° F. to ensure reasonable controllability but should not be so high as to be wasteful of air that might be better used for burning additional coke which would result from raising conversion. In some instances it might be desirable to operate with a flue gas exit temperature 50° F. or more above the regenerator dense phase temperature to maintain a high mean oxygen concentration in the gases rising through the dense phase to reduce the residual coke content on regenerated catalyst to a lower level than would otherwise be achieved. For this control scheme to function properly, it is obviously necessary that the controlled temperature level in the regenerator dense phase exceed the ignition temperature of carbon monoxide. The preferred temperature is about 1,200° to 1,225° F.

If, at any time, the temperature of the flue gas exiting from the top of regenerator should tend to fall below the control point, it would signify that there was a reduction in afterburning because of a drop in oxygen content of the flue gases rising from the dense phase. This in turn would signify that the means concentration of coke on catalyst in the regenerator was rising which would means that coke was being deposited at a faster rate than it was being burned. The flue gas TRC **16** would immediately lower the control setting on the TRCA **15** which would, in turn, reposition (reduce the opening of) the slide valve **13** in the regenerated catalyst standpipe **12**. The combination of lower reaction temperature and lower catalyst-to-oil ratio would reduce coke deposition rate by reducing conversion level until coke deposition rate again became commensurate with regeneration air rate (line **1***a*). It is readily apparent that if the flue gas exiting temperature should tend to rise, it would signify that coke was being deposited at a lesser rate than it was being burned and that the automatic control action would be the exact opposite of that just described to increase conversion rate until the coke deposition and burning rates again became equal. A change in reactor temperature of about 0.5° to 1.0° F. will compensate for a change of one percent in air rate or coke yield tendency of the feed stock.

In actual operation, the system may be simplified further by substituting potentiometers or other temperature sensing means for TRC **16** and allowing the operator to manually reset TRCA **15**.

The reactor temperature control **15** includes high- and low-temperature alarms which alert the operator if the temperature reaches either alarm setting. The operator then takes appropriate action to bring the reactor temperature back within the prescribed range. For example, if the high-temperature alarm should sound, he would take some action to increase the severity of some reaction control variable other than temperature. This might be an increase in reactor catalyst level, catalyst activity, or slurry recycle rate, or a reduction in dilution steam rate to the riser or regenerator dense phase temperature. If the low temperature alarm should sound, the operator would take some action opposite to those just described. Alternatively, the reactor temperature control might be equipped with one or more reset mechanisms to automatically effect one or more of the changes indicated.

Although the control system could be made more complex as indicated in the last paragraph, I prefer the simple version as described and depicted in the drawing, relying upon the operator to take appropriate action to keep the reactor temperature within the alarm settings.

This plan of control will improve the results obtainable with any feedstock otherwise suitable for catalytic cracking and will be especially beneficial for any feedstock that varies in quality during operations.

Suitable catalysts are conventional fluid catalytic cracking catalysts, which are well known in the art.

What is considered new and inventive in this present invention is defined in the hereunto appended claims, it being understood, of course, that equivalents known to those skilled in the art are to be construed as within the scope and purview of the claims.

I claim:

1. In the continuous process of cracking a hydrocarbon feedstock in the presence of subdivided catalyst particles, wherein the hydrocarbon stream effects a fluidized contacting of the particles in a reactor, conversion products are separated from the contacted particles, separated catalyst particles containing coke deposited hereon effect fluidized contacting of air in a separate regenerator, said air being supplied by an air compressor, combustion gas products are separated from regenerated catalyst particles and such regenerated catalyst particles with a reduced coke content are returned to the reactor for contact with hydrocarbon feedstock, the air compressor operated at maximum capacity with all of the air output going into the regenerator, the coke deposition rate in the reactor is controlled by varying the reaction severity in the reactor in response to variations in the air supply from the compressor, the reaction severity in the reactor is controlled by varying the temperature and the catalyst-to-feedstock ratio in the reactor in response to the temperature at the outlet of the regenerator while the temperature in the regenerator catalyst bed is held constant; the improvement which comprises holding said regenerator catalyst bed temperature constant by varying the recycle feed rate in response to variations in said regenerator catalyst bed temperature.

2. The process of claim **1** in which the temperature and the catalyst-to-feedstock ratio in the reactor are varied by varying the flow of hot regenerated catalyst from the regenerator to the reactor.

3. In a catalytic cracking unit consisting essentially of:

a. A reactor having a first conduit attached to the upper portion thereof, a stripper attached to lower portion thereof, and a temperature recorder controller alarm attached to said reactor;

b. a regenerator having attached to the upper portion thereof a second conduit and means to control the pressure in the regenerator, and having attached to the lower portion thereof a third conduit, equipped with a valve, said third conduit extending up into the lower portion of the regenerator, and a fourth conduit connected to the lower portion of the regenerator, said fourth conduit having an air compressor connected thereto;

c. means for controlling the operation of said valve in response to temperature variations in the reactor;

d. a fifth conduit connecting the lower portion of the reactor with the bottom end of said third conduit and extending beyond said connection to connect with a sixth conduit for fresh feed and a seventh conduit for recycle feed;

e. flow rate control means in each of said sixth and seventh conduits;

f. temperature-sensing means connected to the upper portion of the regenerator, said temperature-sensing means being operatively connected to said means (*c*);

The improvement which comprises:

g. Temperature-sensing means connected to the lower portion of the regenerator, said temperature-sensing means being operatively connected to said flow rate control means in said seventh conduit.

4. The combination of claim **3** wherein said temperature sensing means (*g*) comprises temperature control means for changing the control setting of said flow rate control means in response to temperature variations in the lower portion of the regenerator.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,629,097 Dated December 21, 1971

Inventor(s) John H. Smith

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, after the first paragraph, should be the heading --Disclosure--.
Col. 2, line 20, after "controller" should be --(LRC)--.

Col. 3, line 8, "means" should be --mean--.
Col. 3, line 11, after "the" should be --reactor--.
Col. 4, line 12, after "sor" should be --is--.

*Symbol for pounds.

Signed and sealed this 4th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,629,097 Dated December 21, 1971

Inventor(s) John H. Smith

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 54, "No." should appear -- lbs. --; line 55, "No." should appear -- lbs. --; line 56, "No." should appear -- lbs. --; line 57, "No." should appear -- lbs. --.

Signed and sealed this 12th day of December 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents