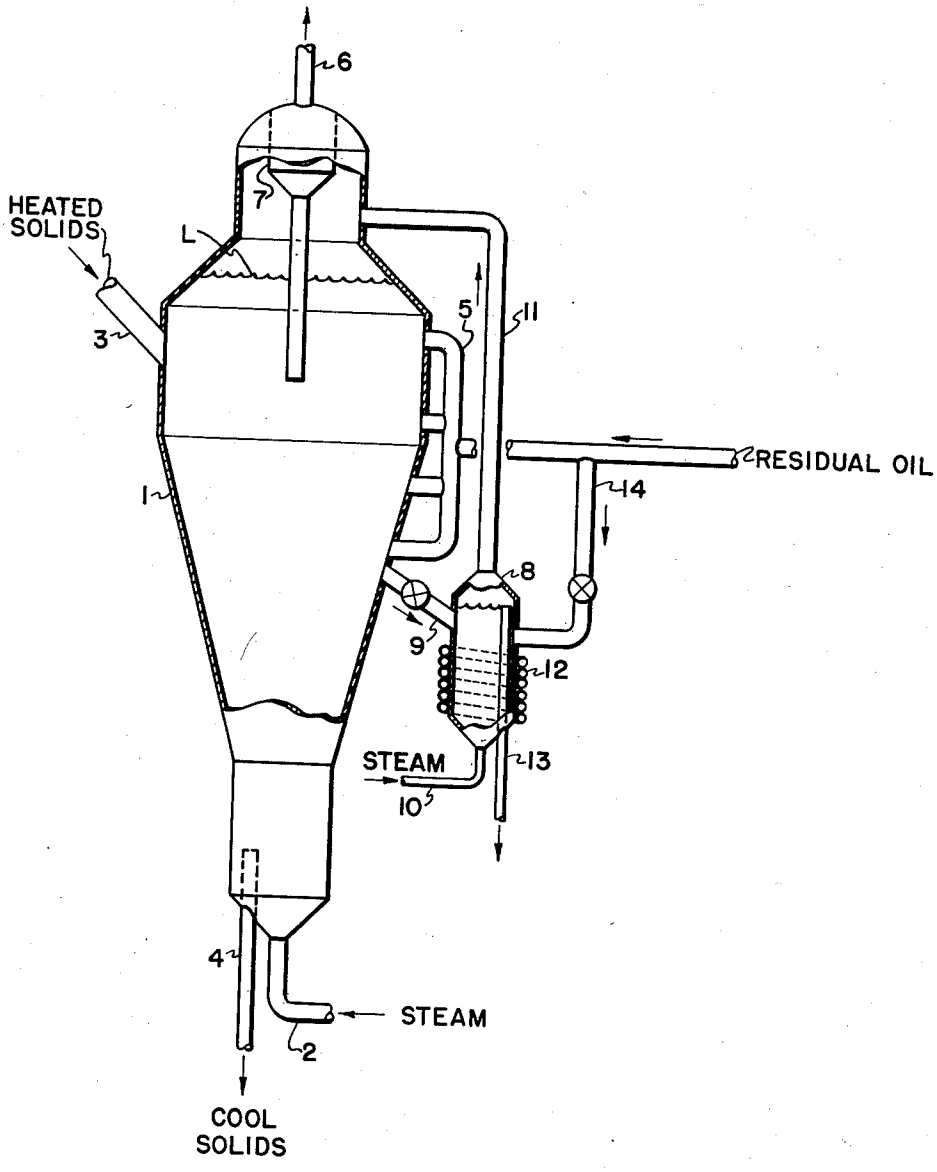
Oct. 1, 1957 J. F. MOSER, JR 2,808,368

PREDICTING BED DEFLUIDIZATION IN FLUID COKERS

Filed April 4, 1955



John F. Moser, Jr. Inventor

By L. Chasan Attorney

United States Patent Office 2,808,368 Patented Oct. 1, 1957

2,808,368

PREDICTING BED DEFLUIDIZATION IN FLUID COKERS

John Frederick Moser, Jr., Baton Rouge, La., assignor to Esso Research and Engineering Company, a corporation of Delaware

Application April 4, 1955, Serial No. 498,967

7 Claims. (Cl. 196—55)

The present invention relates to the coking of heavy oils in a fluidized solids system. It relates particularly to a method for controlling the coking reaction whereby maximum feed rates may be enjoyed while bogging or defluidization of the fluid coking bed is prevented.

In essence, this invention provides a method and apparatus for determining incipient bogging conditions in a coking zone whereby proper adjustment can be made of the operating conditions to circumvent bogging and consequent shutdown of the equipment. This method of determining the onset of bogging comprises operating a relatively small coking or test unit integrally with the main coking unit. A portion of the fluidized bed in the main coker along with adhering liquid residue is transferred to the test coker. A small amount of additional feed is injected into the test coker such that the test coker is operating at an actual higher w./hr./w. than the main coker. Thus, so long as this test coker or "bogging coker" is operable, it is indicative that bogging conditions do not exist in the main coker.

A fluid coking process normally consists of a fluid coking vessel and an external heating vessel, e. g., a fluid bed burner. A fluid bed of solids, preferably coke particles produced by the process, is maintained in the coking zone by a fluidizing gas, e. g., steam. The temperature of the bed is maintained at about 950° F. by circulating solids to the heating vessel and back. The heavy oil to be converted is injected into the bed and upon contact with the hot solids undergoes pyrolysis, evolving lighter hydrocarbon vapors and depositing residue or coke on the solids.

The mixing action of the fluid bed normally results in substantially isothermal conditions in the bed and thorough and rapid distribution of the injected heavy oil. Product vapors, after having entrained solids removed, are removed from the coking vessel and sent to a scrubber or fractionator for cooling and separation.

With the customary feeds to the process, the viscous, near solid components, e. g., asphaltenes, of the feed produce a tacky film on the particles which, until it is coked dry, tends to cause the fluid particles to adhere to each other and to form agglomerates. If the feed rate is too high, or if the coking reaction is too slow, sufficient agglomeration of the particles will occur to cause complete defluidization or bogging of the fluid bed. Bogging of the bed is one of the most serious problems encountered in operating fluid cokers. Thus, it is of vital importance to be able to predict when bogging conditions are being approached in order that suitable adjustments in operating conditions can be made.

It has been the practice to operate a coking process well on the safe side of conditions that cause bogging, i. e., at low feed rates, high temperatures, high solid circulation rates, etc. In this way, all of the feed is promptly evaporated and cracked and the tacky residue is spread over a large amount of the solids so that no substantial agglomeration takes place. Obviously, operating well on

the safe side of bogging conditions severely limits the capacity of the coking system and is highly uneconomical.

If the simple expedient of resorting to higher temperatures is used to avoid bed bogging, then a loss in the quality of products is experienced. It is preferred to coke at temperatures below 1050° F., e. g., at 950° F. At these temperatures, good product yields and distributions are obtained.

This invention provides a means for detecting the onset of bogging of the fluid bed whereby operations at maximum feed rates can be achieved. This invention proposes to operate a small test coker integrally with the main coker, using solids withdrawn from the main coking bed. This test coker is operated at a slightly higher feed rate such that the test coker will be the one first to bog if conditions conducive to bogging are being approached in the main coking bed.

The present invention results in the advantage that the test coker operates on the same coke present in the main coking bed and with the same feed stock being used. It gives, therefore, a true picture of the actual conditions at the moment in the main coker. Equivalent operation of the test coker cannot be obtained by operating on solids from another source, e. g., from the burner. The change in liquid or residue content of the solids supplied to the test coker from the main coker is reflective of a change or upset in the main coker, and is used in this invention to give an accurate picture of conditions in the main coker.

In contrast to previously proposed devices for predicting bogging, the instrument of this invention does not have to be calibrated to perform satisfactorily. With schemes previously proposed, the main coking bed had to be actually subjected to conditions to bogging in order to calibrate the predicting device. This is highly undesirable.

It is to be appreciated that the degree of safety factor desired to anticipate bogging can be readily adjusted by varying the incremental feed rate to the test or "bogging" coker. Alternatively, the test coker can be operated at a slightly lower temperature to achieve a safety factor with less incremental feed. It is obvious that the causing of bogging in the very small coker is not serious as its operability can be readily restored.

When the test coker indicates that conditions of bogging are being approached in the main coking bed, then suitable adjustment can be made in the operating conditions to avoid this difficulty. For example, the feed rate to the coker can be decreased, the coking temperature may be increased, and/or the solids circulation rate may be increased.

Reference to the attached drawing will serve to make this invention clear. The drawing illustrates a preferred modification of this invention and is presented for purposes of illustration only.

Illustrated by the drawing is a fluid coking vessel 1 for pyrolytically converting heavy oils. A fluid bed of solids, e. g., coke of 40 to 800 microns in size, having an upper level L is maintained in the vessel by admitting a fluidizing gas, e. g., steam, to the base of the vessel by line 2 in amounts sufficient to obtain superficial fluidizing gas velocities in the coker in the range of 0.5 to 4 ft./sec. Coke at a temperature 100° to 300° F. above the coking temperature is admitted to the coker by line 3 in amounts sufficient to maintain a coking temperature in the range of 900° to 1200° F. The lower portion of the coker serves as a stripping zone to remove occluded hydrocarbons from the coke. Coke is withdrawn from this stripping zone by line 4 and is circulated to an external heating zone to be reheated.

The feed, e. g., a residual oil, is injected into the

coker via line 5. Vaporous conversion products are removed overhead by line 6 as product after having entrained solids removed by cyclone system 7.

To anticipate the onset of bogging, a small external fluidizing vessel is supplied continuously with a small amount of coke withdrawn from the main coke bed via line 9. This coke has a small amount of yet unconverted tacky material adhering to it. A fluidizing gas, e. g., steam, is admitted at the base of the test coker by line 10 to fluidize the solids therein and to maintain essentially the same gas velocity as that in the main coker. Conversion products and spent fluidizing gas are withdrawn from the top of the test coker by line 11 and may be vented or, more conveniently, be returned to the upper portion of the coker 1 via line 11. Additional amounts of steam may be supplied to line 11 to prevent coking in this line and to aid in regulating the pressure in the test coker.

If it is required, the test coker may be heated as by steam coils 12 or electrical heaters to maintain the coking temperature. With the exception of the feed rate, the conditions in the test coker are maintained substantially equivalent to the conditions in the main coking bed. In general, the capacity of fluid solids of this test coker need not be greater than about 1 cu. ft. to give an accurate picture of the conditions in the main coking bed, although in some cases, somewhat larger volumes may be desirable.

In some applications, the test coker can be run at a lower temperature, preferably 20° to 50° F. below the coking temperature, to give the desired safety factor. There will be, therefore, more of the tacky compounds on the solids in the test coker because of the lower cracking rate. Thus, bogging conditions will be more closely approached in the test coker.

Solids are overflowed from vessel 8 through line 13 to maintain a constant inventory of solids therein. These solids may conveniently be returned to the coking vessel. Other means of withdrawing solids from the test coker will occur to those skilled in the art.

A small amount of the same residual oil feed introduced into the main coking bed, including any recycle streams, is introduced into the test coker by line 14. This feed rate may, for example, be in the range of 0.01 to 0.5 lb./hr./lb. of solids contained in the test coker (w./hr./w.), depending upon the degree of safety factor desired.

By introducing fresh feed into the test coker, the test coker is made to operate at an actually higher w./hr./w. than the main coking bed. Thus, it is more amenable to becoming defluidized or bogged. If the fluid bed in the test coker does bog, then it is indicative that bogging conditions are being approached in the main coking bed.

In some applications, the solids bed in the test coker can be mechanically agitated or stirred as by a vaned impeller or paddle to maintain proper motion of the particles without exceeding fluidization gas limits.

A determination that the bed of the test coker has become defluidized can be made in several ways. If the gases in line 11 start to surge or if the coke ceases to flow through line 13, then bogging has or is about to occur. Alternatively, the bed could be probed with a steel rod to see if compaction or agglomeration is occurring. A rapid decrease in the temperature of the small coking bed is also indicative of bogging.

Example

A fluid coker contains 300 tons of coke of a particle size in a range of 40 to 800 microns, 250 microns median particle size. The bed is maintained at a temperature of 950° F. and steam is admitted to the base of the vessel in amounts sufficient to maintain an average superficial fluidizing gas velocity of 1.5 ft./sec. The pressure above the fluid bed is 6 p. s. i. A heavy oil having an API gravity of 4.2°, a Conradson carbon content of 24 wt. percent, and an initial boiling point of 950° F. is introduced into the fluidized bed at a feed rate of 0.5 w./hr./w. Under these conditions, the coker will bog at a feed rate of about 0.65 w./hr./w. All of the oil is converted under these conditions with recycle operation to products boiling below 1000° F. excluding coke. Twenty pounds of coke are maintained in a fluidized condition in a small test coker having an internal diameter of 6 inches and a bed height of 36 inches. Solids are withdrawn from the main coking bed at a rate of 100 lbs./hr. and are supplied to the test coker through a ½ inch line. Additional feed is introduced into the test coker at a rate of about 0.4 w./hr./w. This amounts to about 3×10^{-3}% of the feed charged to the main coking bed. Under these conditions the test coker is operating at a total effective feed rate of 0.6 w./hr./w., 20% higher than the main coker.

Modifications of this invention will occur to those skilled in the art. For example, other schemes for controlling the coke flow to the test coker can obviously be used. Having described this invention, what is sought to be protected by Letters Patent is succinctly set forth in the following claims.

What is claimed is:

1. In a fluid coking process wherein an oil is pyrolytically converted by contact with a fluidized bed of solids maintained at a coking temperature in a coking zone to vaporous conversion products and residue which is deposited on said solids, a method of determining the onset of bogging of said fluidized bed, which comprises withdrawing a portion of said fluidized bed, introducing said portion into a relatively small coking zone, fluidizing the solids in said small coking zone at a gas velocity substantially equal to that in said fluidized bed, maintaining said small coking zone substantially at said coking temperature, flowing solids from said small coking zone at a rate sufficient to maintain a substantially constant solids holdup therein, removing conversion products overhead from said small coking zone, introducing a small amount of said oil into said small coking zone, and decreasing the liquid content of the solids of said fluidized bed when the solids in said small coking zone begins to bog.

2. The process in claim 1 wherein said decrease in liquid content is achieved by increasing said coking temperature.

3. The process of claim 1 wherein said decrease in liquid content is achieved by decreasing the feed rate of said oil to said coking zone.

4. The process of claim 1 wherein said conversion products are transferred to the upper portion of said coking zone and the solids removed from said small coking zone are returned to said fluidized bed.

5. A process for coking a heavy oil which comprises contacting a heavy oil at a coking temperature with a bed of fluidized solids in a coking zone whereby said heavy oil is converted to vapors and residue which is deposited on said solids, maintaining in a second relatively small coking zone a bed of fluidized solids substantially at the condition of said coking zone, flowing solids coked with adhering liquid residue from said coking zone to said smaller coking zone, removing solids from said second coking zone, introducing a small amount of said heavy oil into said second coking zone, whereby said second zone operates at a higher w./hr./w. than said coking zone, and decreasing the concentration of liquid on the solids in said coking zone when said second coking zone indicates bogging.

6. A method of predicting bogging in a hydrocarbon oil fluid coking process wherein an oil is converted to relatively lighter hydrocarbon vapors in a coking zone by contact at a coking temperature with a bed of fluidized solids, which comprises operating a relatively small fluid bed test coker integrally with said coking zone using solids withdrawn from said coking zone along with adhering liquid residue, and introducing a small amount

of said oil into said test coker whereby said test coker operates at a higher effective feed rate and is more prone to bed bogging than said bed of fluidized solids.

7. The invention of claim 6 wherein said relatively small coker is operated at a temperature 20° to 50° F. lower than said coking temperature.

References Cited in the file of this patent

UNITED STATES PATENTS

2,690,990	Adams et al.	Oct. 5, 1954
2,709,676	Krebs	May 31, 1955
2,735,802	Jahnig	Feb. 21, 1956