

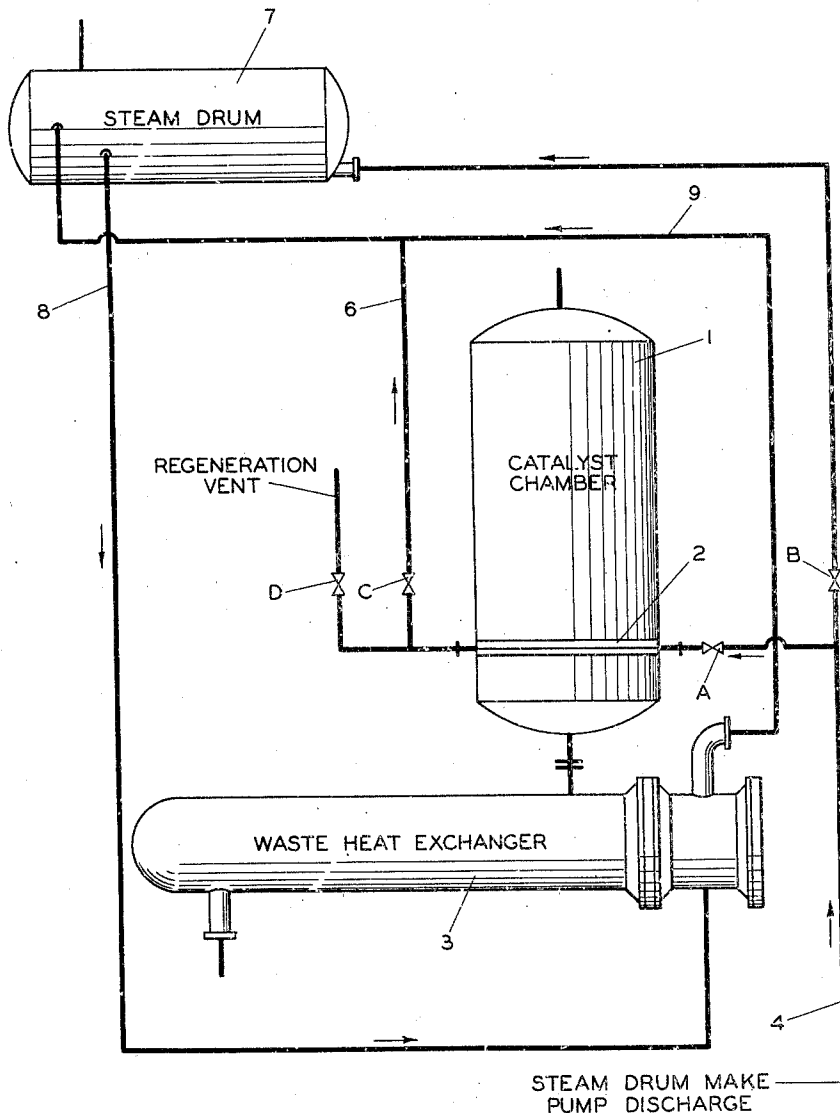
Nov. 8, 1949

H. D. TROTTER
METHOD AND APPARATUS FOR CATALYTIC
CONVERSION OF HYDROCARBONS

2,487,743

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2 Sheets-Sheet 1



STEAM DRUM MAKE
PUMP DISCHARGE

FIG. 1

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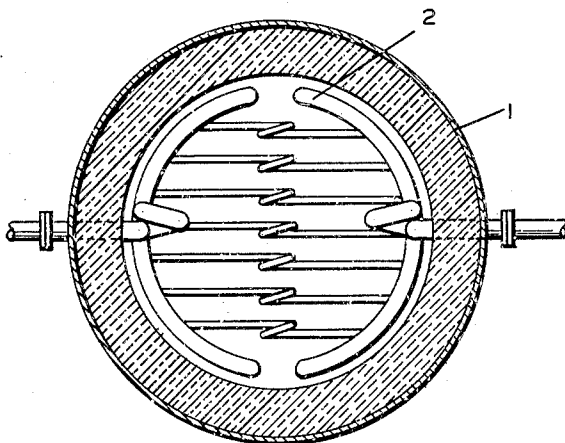


FIG. 3

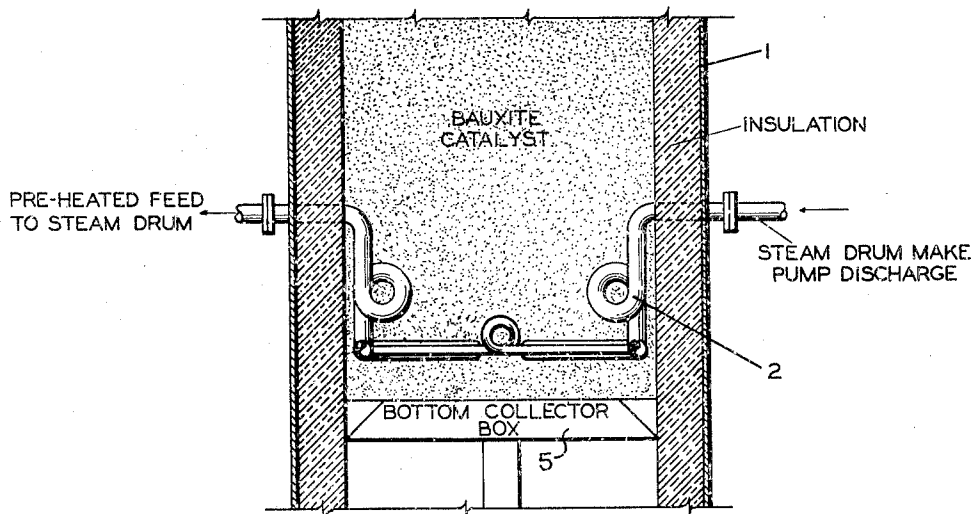


FIG. 2

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR CATALYTIC
CONVERSION OF HYDROCARBONSHarry Darby Trotter, Kansas City, Kans., assignor
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of Delaware

Application August 9, 1946, Serial No. 689,375

3 Claims. (Cl. 196—52)

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This invention relates to the catalytic conversion of hydrocarbons wherein such hydrocarbons are contacted with fixed beds of catalytic material. In a more particular aspect the present invention relates to such a conversion process and apparatus wherein deposition of tar and other high boiling material in equipment associated therewith will be minimized or avoided.

In accordance with existing methods, conversion of hydrocarbons utilizing fixed catalyst beds is carried out by contacting hydrocarbon feed stocks with a suitable catalyst bed or beds, under such conditions that the desired conversion is carried out. Conversion reactions of the type referred to including cracking, polymerization, reforming, aromatization, isomerization, etc. and in particular, reactions in which carbonaceous and heavy molecular weight materials such as tar are formed and carried along with the reaction products. These heavy materials tend to deposit in equipment associated with the conversion system and constitutes an important problem where such deposits tend to restrict flow or affect heat exchange. This problem is particularly acute where the reaction effluents pass through heat exchangers since these deposits may cause plugging of the exchanger tubes, while the deposition on the interior of the tube markedly decreases the efficiency of the exchanger by decreasing the rate of heat transfer.

Applicant has now discovered a method and apparatus in which deposits of the type described above are avoided by causing the heavy materials in question to be deposited within the bed itself and removed during periodic catalyst reactivation. It is therefore an object of the present invention to provide a method and apparatus for the catalytic conversion of hydrocarbons wherein the carrying out of heavy tar-like carbonaceous material with the products of reaction is minimized or avoided. It is a further object of the present invention to provide a method and apparatus for the catalytic conversion of hydrocarbons wherein the deposition of tar-like material in transfer lines or heat exchanger tubes through which reaction effluents flow, is minimized or avoided.

In accordance with the present invention heavy materials of the type described are condensed within the catalyst bed in the portion of the bed adjacent to the outlet. This condensation is effected by introducing in or near the portion of the bed downstream of the inlet and nearest the reaction chamber outlet, means for cooling said outlet portion of the bed. Such means is preferably a cooling coil through which a cooling fluid is circulated and which will serve to reduce the temperature of that portion of the bed which is adjacent thereto to a point sufficiently low to effect substantial condensation of the undesired

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tarry material. The cooling fluid utilized for this purpose may advantageously be one which it is desired to heat for some purpose for use in the reaction and/or reactivation. For example, the cooling fluid may be water or low temperature steam in cases where higher temperature steam is desired for use as a diluent during the conversion reaction or reactivation or both, or for use in purging catalyst before or after reactivation.

The present invention may be described with reference to the attached drawing in which Figure 1 is a flow diagram of a typical fixed bed catalytic cracking system in which superheated steam is formed for use in the process or elsewhere by heat exchange with the effluents of conversion or reactivation in a waste heat exchanger. Figure 2 is a partial vertical cross section of the lower portion of a catalyst chamber showing the cooling coil of the present invention positioned within the bottom portion of the catalyst bed. Figure 3 is a partial horizontal cross section showing the cooling coil disposed in the bottom of the bed. The coil in question is represented only diagrammatically and the length and number of turns thereof will depend entirely on the size of the pipe and the amount of exchange to be effected.

In carrying out the process, oil vapors are passed through a fixed bed catalyst chamber 1 where it is converted by contact at elevated temperatures with a catalyst disposed therein. The products of conversion which contain the undesired tarry material pass through the bottom portion of the catalyst bed before leaving the chamber and since this portion of the bed is cooled by coil 2 the high boiling material is deposited on the catalyst within this portion of the bed and also upon the outside walls of the cooling coil. At the lower extremity of the catalyst bed, the conversion products pass through a bottom collector box 5 which is a catalyst-retaining assembly, conventionally inserted below the catalyst bed to support and retain the catalyst and to collect any catalyst fines which may be present or formed during the use of the catalyst and which tend to be removed with the hydrocarbon products; it is usually covered by screens and generally contains several layers of various sized pellets or lumps of inert material which act as a filtering medium. The products then flow through waste heat exchanger 3. During the conversion reaction, valves B and D are closed and valves A and C are open. Water is introduced via line 4 through valve A into cooling coil 2 and the resultant steam flows into steam drum 7 through valve C and line 6. During the reactivation valves A and C are closed and valves B and D are opened and the coil is vented to the atmosphere. During reactivation the temperature of the catalyst above and below

the coil will be relatively the same. During reactivation water flows into steam drum 7 and thence through line 8 into waste heat exchanger 3 where it is converted to steam by heat exchange, the steam flowing to drum 7 via line 9. During the conversion water flows through heat exchanger 3 via line 8 and serves to quench the reaction products, steam formed going to 7 via line 9. Valve B may be operated by a level-control on steam drum 7 (not shown) to maintain level in the steam drum and to allow a desired amount of water to flow during conversion.

Following the conversion, the catalyst bed is purged of residual hydrocarbon material by introducing a diluent such as steam at the inlet to the catalyst chamber and after a short purging period is ready for reactivation. Carbonaceous material deposited on the catalyst as a result of the conversion is removed by introducing an oxygen-containing gas under combustion conditions at the inlet to the chamber. During the reactivation, a zone of combustion tends to move from the inlet to the outlet of the catalyst chamber and the high molecular hydrocarbons or tars which have been deposited down stream of the chamber are removed from the lower portion of the bed by combustion.

The coil 2 is preferably constructed of an alloy material which will withstand reaction and reactivation temperatures. The coil is designed to give a surface large enough to effect the desired extent of cooling. In general, a decrease in temperature in the bottom catalyst zone, or the hydrocarbon outlet temperature, of from 100-500° F. below the conversion temperature will be sufficient to condense a substantial proportion of hydrocarbons boiling above about 700-900° F. The surface area, and hence the cooling capacity of the coil, is controlled by varying the number of turns and the diameter of the pipe.

Example I

A catalyst chamber has positioned therein a bed of bauxite cracking catalyst 13 ft. high and 10½ ft. in diameter. The bed contains 30 tons of 4-8 mesh bauxite. A cooling coil is positioned in the downstream end of the bed and is located intermediate the lower quarter thereof. The coil is of 3 inch extra strong steel pipe having 1.091 square feet of external surface per linear foot. The total surface area of the coil is 840 square feet. During the process portion of the cycle 250 barrels per hour of 36° A. P. I. virgin gas oil from West Texas crude is charged. The conditions with and without the cooling coil functioning as described above are as follows:

Inlet temperature to bed.....	°F.....	1,020
Outlet temperature (without coil)	°F.....	940
Outlet temperature (with coil)	°F.....	570
Inlet pressure.....	p. s. i. gauge.....	85
Outlet pressure (with or without coils).....	p. s. i. gauge.....	80
Steam diluent.....	lbs./hr.....	8,000
Water into cooling coil.....	gal./hr.....	2,390
Temperature in.....	°F.....	210
Temperature out.....	°F.....	388
Cycle time.....	hours.....	6

Under the foregoing conditions, substantially no condensation of high boiling material took place in the absence of cooling by means of the coil, but with the coil in use approximately 2.5% by weight of charge, of high boiling carbonaceous material boiling over about 900° F., is condensed or deposited in the bed near the chamber outlet.

This deposit is removed when the catalyst is reactivated by combustion with oxygen-containing gas. When the coil was not in use substantial carbonization and coking of the waste heat exchanger tubes was noted with resultant poor flow and heat transfer.

In general, catalytic cracking of gas oil or other petroleum hydrocarbons may be effected in vapor phase at temperatures in the range of 850-1150° F., using bauxite, silica alumina, acid treated clay, or other well known catalysts. Dehydrogenation and other conversion reactions are carried out in the vapor phase under conditions well known to the art, and in each case, deposition of high boiling material in the cooler portion of the catalyst bed will increase efficiency of the heat exchangers or other equipment connected to the reaction chamber outlet. Temperatures in the cool portion of the bed are maintained sufficiently low to insure deposition of a substantial proportion of higher boiling material in the bed.

I claim:

1. In the catalytic conversion of hydrocarbons by contact with a fixed bed of catalyst under conversion conditions wherein high boiling carbonaceous materials are obtained along with other conversion products and wherein such materials tend to deposit externally of the conversion zone, the method which comprises cooling a lowermost portion of the catalyst bed near the conversion zone outlet to a temperature low enough to cause condensation and adsorption of undesired high boiling carbonaceous material on said cooled portion of said catalyst bed, retaining said condensed high boiling material adsorbed on said lowermost portion of the catalyst bed during the conversion of hydrocarbons, and removing said condensed and adsorbed material during subsequent catalyst reactivation.

2. A process for catalytically cracking hydrocarbon oils which comprises flowing said oils in vapor phase through a cracking catalyst disposed in a fixed bed at cracking temperatures, cooling the downstream portion of the bed to a temperature of about 100 to 500° F. below the cracking temperature in the upstream portion of the bed, condensing and adsorbing in said cooled portion of the bed high boiling carbonaceous material, and removing said condensed material by combustion following the cracking step.

3. A process for catalytically cracking hydrocarbon oils which comprises flowing said oils in vapor phase through a cracking catalyst disposed in a fixed bed at cracking temperatures, cooling the downstream portion of the bed to a temperature substantially below the cracking temperature in the upstream portions of the bed, thereby condensing and adsorbing in said cooled portion of the bed high boiling carbonaceous material, retaining said condensed high boiling material adsorbed on said downstream portion of the catalyst bed during the cracking of said oils, and removing said condensed material by combustion following the cracking step.

HARRY DARBY TROTTER

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