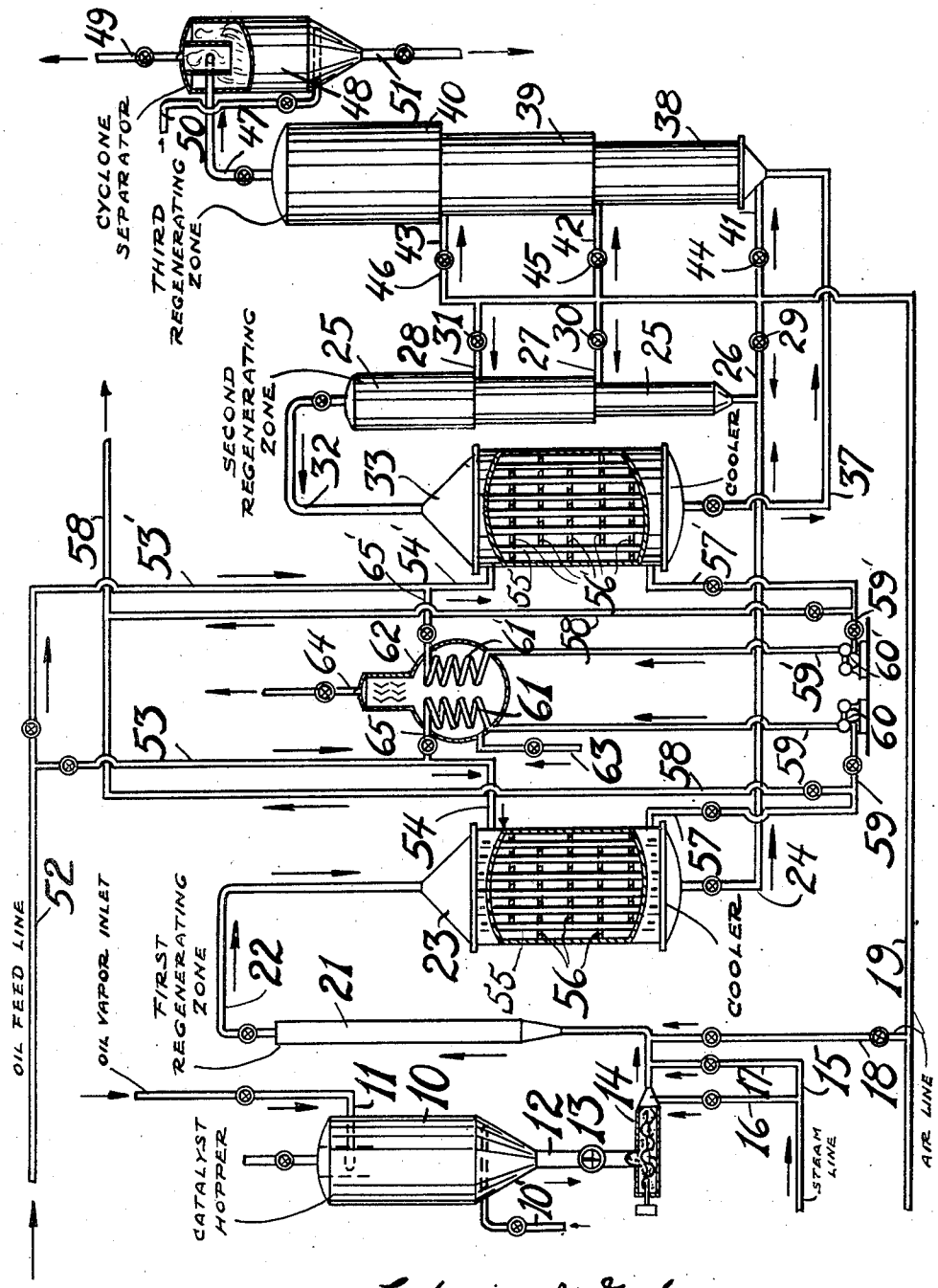
May 25, 1943. E. J. GOHR ET AL 2,320,273

REGENERATION OF SOLID CONTACT MATERIAL

Filed May 16, 1940



Edwin J. Gohr.
Homer F. Martin Inventors
William J. Thompson
By R. H. Young Attorney

Patented May 25, 1943 2,320,273

UNITED STATES PATENT OFFICE

2,320,273

REGENERATION OF SOLID CONTACT MATERIAL

Edwin J. Gohr, Summit, and William I. Thompson and Homer Z. Martin, Elizabeth, N. J., assignors to Standard Oil Development Company, a corporation of Delaware

Application May 16, 1940, Serial No. 335,544

9 Claims. (Cl. 196—52)

This invention is directed to the regeneration of solid contact material containing combustible deposits and pertains more particularly to a method of and apparatus for regenerating finely divided material with an oxidizing gas.

It has heretofore been proposed to carry out various types of organic reactions at elevated temperatures in the presence of a finely divided catalytic material. In many reactions of this character such as in the catalytic cracking, polymerization, hydrogenation, dehydrogenation of hydrocarbon oils and the like and in the purifying and refining of such oil the finely divided material becomes contaminated with combustible deposits which reduces the catalytic efficiency of the material. As a result it becomes necessary to periodically regenerate the catalyst by burning the combustible deposits therefrom to restore the activity of the catalyst. In many cases the activity of the catalyst is permanently impaired if the catalyst is subjected to excessive temperature during the regeneration. Also the ignition temperature of the combustible deposits may approach the maximum permissible temperature which will avoid permanently injuring the catalyst. For example, in the case of activated clays employed in the catalytic cracking of oils the initial or minimum temperature which will burn the combustible deposits at a sufficiently rapid rate may be of the order of 800 to 900° F. whereas the maximum temperature which will not destroy the activity of the clay may be of the order of 1000 to 1200° F. As a result it is necessary to closely control the regenerating temperature between narrow limits.

Furthermore since the time required to regenerate the catalyst is non-productive, it is of advantage to rapidly regenerate the catalyst.

One of the primary objects of the present invention is to provide an improved method for removing combustible deposits from finely divided catalytic or other contact material.

A further object of the present invention is to provide an improved apparatus for removing combustible deposits from finely divided catalytic or other contact material. A further more specific object of the invention is to provide new method of and apparatus for controlling the regenerating temperature. A further specific object of the invention is to provide a rapid method of regenerating finely divided material under closely controlled temperature conditions.

Another more detailed object of the invention is to provide a method of and apparatus for regenerating catalysts wherein the heat liberated during regeneration may be more efficiently utilized.

Other specific objects of the invention will be apparent from the more detailed disclosure hereinafter.

In accordance with the present invention the finely divided catalyst or other contact material to be regenerated is suspended in a stream of gas having an oxygen concentration controlled with respect to the amount of combustible deposits contained on the catalysts and with respect to the specific heat of the resulting suspension to prevent the temperature from exceeding a predetermined maximum. In case the amount of oxygen contained in the gas is not sufficient to remove all of the combustible deposits, the resulting suspension is cooled and a further supply of oxidizing gas is added having an oxygen concentration controlled with respect to the specific heat of the suspension and which will again insure that the resulting products will not exceed the desired permissible temperature. If the amount of oxygen supplied is not sufficient to remove the remaining combustible deposits the resulting suspension may be again cooled and the controlled amount of oxidizing gas again added to the stream and so on.

Expressed in another way the amount of oxygen initially added to the stream is determined by the specific heat of the suspension and is not in excess of that which would raise the temperature of the suspension beyond the desired maximum. The products are then cooled to a minimum ignition temperature and additional oxygen or oxygen containing gas is then added in controlled amounts as before described to prevent the suspension from again exceeding a desired maximum temperature. Thus the required regeneration is accomplished in successive stages with intermediate cooling and controlled amounts of oxygen added during each stage.

With the above objects of general nature in view the invention will now be described in more specific detail as applied to the regeneration of powdered catalyst employed in the cracking of hydrocarbon oils in which the invention finds particular application although in some of its broader phases it will have a wider application as will hereinafter appear. In the detailed description of the invention reference will be made to the accompanying drawing which is partly schematic and partly diagrammatic of an apparatus forming a part of the present invention.

Referring to the drawing the reference char-

acter 10 designates a catalyst hopper containing finely divided catalyst to be regenerated. This catalyst for example may comprise a naturally active or activated clay or it may be any other type of catalytic material the activity of which is affected by excessive temperatures obtained during regeneration. As illustrated the catalyst hopper may contain a cyclone separator in the upper section thereof for removing the catalyst to be regenerated from the reaction products such as for example cracked oil vapors introduced into the top of the hopper through line 11.

The catalysts collected in the hopper 10 after being stripped of oil vapors such as by a stripping gas introduced through line 10' may be discharged therefrom through a conduit 12 having a suitable feeding mechanism such as a star feeder 13 for feeding a controlled amount of catalyst into a suitable conveyor such as a screw conveyor 14 which feeds the catalyst into a stream of regenerating gas.

As a safety precaution to prevent the possibility of oxidizing gas leaking back into the cracking circuit it is usually desirable to first suspend the catalyst in an inert gas such as steam and then introduce the oxidizing gas into the resulting suspension so that an inert gas shield is formed between the cracking circuit and the regenerating circuit.

As shown in the drawing the catalyst is initially suspended in steam introduced through line 15 and branch lines 16 and 17.

Following the introduction of the steam, there is introduced into the suspension of steam and catalyst to be regenerated a controlled amount of oxygen or oxygen containing gas. This gas is introduced through line 18 from the main air line 19. The resulting suspension containing the oxidizing gas then passes through the initial combustion zone 21 in which a predetermined amount of carbonaceous deposits is burned from the catalyst, the amount being limited by the amount of oxygen present in the gas to prevent the temperature within the initial combustion zone from exceeding the desired maximum. In case of activated clays such as acid treated clays it is desirable to prevent the regenerating temperature from exceeding 1200° F. and preferably not in excess of 1050° F. The amount of air introduced into the stream passing to the first combustion zone may be conveniently controlled automatically by the top temperature thereof.

The catalyst to be regenerated, freshly withdrawn from the cracking circuit, may for example be at a temperature of from 800 to 900° F. Assuming that the maximum temperature desirable during regeneration is 1025° F. then the amount of oxygen initially introduced through line 18 is regulated so that the temperature within the initial regenerating zone does not exceed 1025° F.

The product from the first regenerating zone is then passed through line 22 to a cooler 23 in which the suspension is passed in indirect heat exchange with a cooling medium. This cooling medium according to one phase of the invention is fresh oil to be cracked which is preheated by the suspension being cooled. During passage through the cooler 23 the suspension is reduced to a temperature which will enable the combustible deposits remaining on the catalyst to be burned at a satisfactory rate. This temperature may be between 800 and 900° F. such as for example between 825° F. and 850° F.

The cooled suspension then passes through line 24 to a second regenerating zone 25 in which controlled amounts of air or oxygen containing gas are introduced through lines 26, 27 and 28. The diameter of the regenerating chamber is preferably enlarged as illustrated with each addition of air so as to maintain a substantial uniform velocity of suspension through the regenerating zone. The amount of oxygen introduced into the second regenerating zone is again controlled to prevent the temperature from exceeding the desired limit such as for example beyond 1025° F. This may be conveniently accomplished by having the valves 29, 30 and 31 in lines 26, 27 and 28 respectively automatically controlled by the final temperature of the zones defined by the different diameters of the chamber. For example, the amount of oxygen introduced into the initial section of the second regenerating zone through line 26 may be automatically controlled by the top temperature of the smallest diameter section of the chamber, the valve 30 in line 27 may be automatically controlled by the top temperature of the intermediate diameter section of the chamber and the top valve 31 automatically controlled by the top temperature of the largest diameter portion of the regenerating chamber. In the first and smallest diameter section of the second regenerating zone the suspension may be heated from initial temperature to 900° F., in the intermediate section of the second regenerating zone from 900° F. to 975° F. and in the last and largest section of regenerating chamber 25 the suspension may be heated from 975° F. to the final maximum temperature such as 1025° F.

The resulting suspension after passing through the second regenerating zone and after having been again heated to the maximum temperature desirable is then passed through line 32 to a second cooler 33 where the temperature is again reduced the desired amount, preferably by heat exchange with fresh oil.

The products from the second cooler 33 may then be passed through line 37 to a third regenerating chamber having three sections of progressively larger diameters 38, 39 and 40 respectively into which controlled amounts of air or other oxidizing gas are added through line 41, 42 and 43. These lines have valves 44, 45 and 46 respectively for regulating the amount of air introduced at the various points. The amount of air introduced through line 41 is again controlled to prevent the temperature of the suspension passing through the first section of the regenerating chamber 38 from exceeding a desired maximum and the amount of air introduced through line 42 leading to the intermediate section 39 of the regenerating chamber is also controlled to prevent the temperature in the intermediate section from exceeding the desired maximum and the amount of air introduced through line 43 into the final section 40 of the third regenerating zone is sufficient to complete the regeneration.

While three separate regenerating zones have been illustrated it will be understood that more or less may be employed depending upon the amount of combustible deposits necessary to be removed from the catalyst and the maximum temperature permissible within the regenerating zone.

Products from the final regenerating zone may be passed through line 47 to a suitable separator such as a cyclone separator 48 for removing the regenerated catalyst from the gas. The gas is removed through line 49 and may be rejected from the system or further scrubbed to remove

any powdered material remaining therein. The regenerated catalyst is collected in the bottom section of the cyclone separator 49 and may be removed therefrom through line 51 and returned to the cracking circuit by any suitable machanism (not shown).

If desired the catalyst may be stripped of regenerating gases before being returned to the cracking zone such as by introduction of an inert gas into the hopper through line 50.

In accordance with one phase of the invention the cooling of the suspension in the first and second coolers 23 and 33 respectively is accomplished by indirect heat exchange with fresh oil which is to be subjected to the cracking operation as previously described. To this end the cooling oil is introduced into the system through line 52, a portion thereof passing through lines 53 and 54 to the space surrounding the bank of tubes 55 through which the suspension of catalyst and regenerating gases pass. A plurality of horizontal baffles 56 may be provided in the space surrounding the tubes 55 to cause the cooling oil to circulate more rapidly around the tubes. The oil after passing through cooler 23 is withdrawn therefrom through line 57 and a portion thereof is passed through line 58 to the cracking and distilling equipment not shown.

The second heat exchanger 33 is constructed in the same manner as the first heat exchanger 23 and operated in the same way. For sake of brevity corresponding parts of the second heat exchanger 33 have been indicated by prime numbers.

In accordance with a further important phase of the invention the amount of oil circulating through the heat exchangers or coolers 23 and 33 is controlled independently of the amount of fresh oil introduced into the system and the extent to which the oil is preheated in the coolers is controlled independently of the amount of heat extracted from the regenerating stream.

Referring to the drawing, a portion of the oil withdrawn from the coolers 23 and 33 through line 57 and 57' respectively are passed through lines 59 and 59' containing pumps 60 and 60' and are passed through coils 61 and 61' in a common waste heat boiler 62 wherein a portion of the heat extracted from the regenerating stream is removed from the oil stream and recovered in the form of steam. Fresh feed to the waste heat boiler 62 may be supplied thereto through lines 63 and steam liberated in the waste heat boiler may be removed therefrom through line 64. The oil after passing through the coil 61 and 61' in the waste heat boiler 62 is removed therefrom through line 65 and 65' respectively which merge with line 54 and 54' leading to the inlet side of the cooler 23 and 33.

By regulating the amount of oil passing through the waste heat boiler and recycled to the coolers the amount of cooling may be carefully regulated without varying the rate of feed of the oil to the unit and at the same time the oil passing to the cracking unit may be preheated to a uniform temperature. The amount of oil passing through coils 61 and 61' in the waste heat boiler and recycled to the coolers may be automatically controlled by the exit temperature of the regenerating stream.

Having described the preferred embodiment of the invention it will be understood that it embraces such other variations and modifications as come within the spirit and scope of thereof.

What is desired to be protected by Letters Patent is:

1. A method of regenerating finely divided solid contact material containing combustible deposits which comprises passing the contact material through a plurality of regenerating zones separated one from the other, each zone containing an oxidizing atmosphere, controlling the amount of oxygen in each of said regenerating zones to prevent the temperature from exceeding a desired maximum and cooling the contact material between said regenerating zones.

2. A method of regenerating finely divided catalytic material employed in the high temperature conversion of hydrocarbon oils to remove carbonaceous deposits contained thereon which comprises suspending the material to be regenerated while substantially at conversion temperature in a gaseous medium, passing the resulting suspension successively through a plurality of regenerating zones separated one from the other and maintained at a temperature sufficient to ignite said carbonaceous deposits, introducing an oxidizing gas into each of said regenerating zones and controlling the amount of oxidizing gas so introduced to prevent the temperature within said regenerating zones from exceeding a desired maximum and removing heat from the suspension during its passage from one of said regenerating zones to another.

3. A method of regenerating finely divided contact material employed in the high temperature conversion of hydrocarbon oils to remove carbonaceous deposits formed thereon during said conversion treatment in which the conversion temperature is at least equal to the ignition temperature of said carbonaceous deposits which comprises suspending the material to be regenerated while at substantially the conversion temperature in a gaseous medium, passing the resulting suspension successively through a plurality of regenerating zones separated one from the other and maintained at a temperature sufficient to remove carbonaceous deposits therefrom, introducing an oxidizing gas into each of said regenerating zones and controlling the amount of oxidizing gas so introduced to prevent the temperature therein from exceeding a desired maximum and passing said suspension in heat exchange relation with fresh oil to be converted during passage of said suspension from one of said regenerated zones to another.

4. A method of regenerating finely divided catalytic material containing combustible deposits resulting from the high temperature conversion of hydrocarbon oils which comprises suspending said finely divided catalytic material while at substantially conversion temperature in a gaseous medium, passing the resulting suspension successively through a plurality of regenerating zones maintained at a temperature sufficient to burn said carbonaceous deposits, introducing an oxidizing gas into each of said regenerating zones, controlling the amount of oxidizing gas introduced therein to prevent the temperature within said regenerating zones from exceeding a desired maximum, passing the suspension through a cooling zone during passage from one of said regenerating zones to another, circulating oil to be converted in heat exchange relation with said suspension within said cooling zone to thereby preheat said oil and cool said suspension and regulating the amount of oil circulating within said cooling zone to control the temperature of the suspension issuing therefrom.

5. The invention defined in claim 4 wherein at least a portion of the oil after passing through said cooling zone is subjected to further cooling and thereafter recirculated through said first named cooling zone.

6. A method of regenerating finely divided catalytic material containing combustible deposits resulting from the conversion of hydrocarbon oils which comprises suspending the material to be regenerated in a gaseous medium, passing the resulting suspension successively through a plurality of regenerating zones maintained at a temperature sufficient to burn said carbonaceous deposits, introducing an oxidizing gas into each of said regenerating zones, controlling the amount of oxidizing gas introduced therein to prevent the temperature within said regenerating zones from exceeding a desired maximum, passing the suspension through a cooling zone during passage from one of said regenerating zones to another, circulating oil to be converted in heat exchange relation with said suspension within said cooling zone to thereby preheat said oil and cool said suspension, thereafter cooling a portion of the oil after circulating through said cooling zone and recombining the oil so cooled, with the oil to be converted before passing the same in heat exchange relation with said suspension.

7. A method of regenerating finely divided catalytic material containing combustible deposists resulting from the conversion of hydrocarbon oils which comprises suspending the material to be regenerating in a gaseous medium, passing the resulting suspension successively through a plurality of regenerating zones maintained at a temperature sufficient to burn said carbonaceous deposits, introducing an oxidizing gas into each of said regenerating zones, controlling the amount of oxidizing gas introduced therein to prevent the temperature within said regenerating zones from exceeding a desired maximum, passing the suspension through a cooling zone during passage from one of said regenerating zones to another, circulating oil to be converted in heat exchange relation with said suspension within said cooling zone to thereby preheat said oil and cool said suspension, cooling a portion of the oil after circulating through said cooling zone and returning said portion to said first named cooling zone.

8. The invention defined in claim 7 wherein the amount of oil recirculated to said first named cooling zone is regulated to control the temperature therein.

9. A method of regenerating contact material containing carbonaceous deposits which comprises suspending the contact material to be regenerated in a gaseous stream, passing said suspension of contact material and gases through a regenerating zone containing an oxidizing atmosphere maintained at a temperature sufficient to burn carbonaceous deposits from said contact material, continuously removing the suspension of contact material and gaseous medium from said regenerating zone and cooling the contact material so withdrawn and thereafter subjecting said cooled contact material to further regeneration in a second regeneration zone separate and distinct from the first regeneration zone.

WILLIAM I. THOMPSON.
EDWIN J. GOHR.
HOMER Z. MARTIN.