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CATALYST REGENERATION

Charles Wesley Tyson, Summit, and Charles E. Hemminger, Westfield, N. J., assignors to Standard Oil Development Company, a corporation of Delaware

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This invention relates to the regeneration of catalysts and pertains more particularly to a method of controlling the regenerating temperature.

5 While our invention in some of its broader aspects has a more general application, it is particularly adapted for controlling the temperature during the regeneration of clays or other catalysts employed in the cracking, dehydrogenation, 10 purification, and refining of oils in which the regenerating temperature must be controlled to prevent reducing the activity of the catalyst. It has been found to be especially effective for regenerating clays employed in the cracking of 15 hydrocarbon oils.

It has heretofore been proposed to crack oil in the presence of special types of clays to produce gasoline having good anti-knock properties. During the cracking operation the catalyst gradually becomes fouled with coke and tarry deposits which form on the surface and in the pores so that it is necessary to discontinue the cracking operation. To reduce operating costs, it is desirable to regenerate the catalyst by removing 20 these deposits. For economical reasons it is also considered preferable to regenerate the catalyst in situ. To this end, if continuity of operation is desired, the cracking unit is provided with two or more catalyst chambers with the necessary manifold connections so that any one or more of the chambers may be on the cracking cycle while the remainder are on the regenerating cycle.

25 In such a method of operation, it will be evident that the cracking capacity of a unit is limited by the time required for regeneration. It is, therefore, of advantage to reduce the regenerating time as low as possible.

One method of regenerating such catalysts is to burn the solid deposits with an oxidizing gas, such as air or oxygen. These solid carbonaceous deposits burn readily from the surface of the catalyst. After the ignition temperature is 30 reached, combustion proceeds with great rapidity with a resulting rapid rise in temperature of the catalyst bed.

After the carbonaceous material has been burned from the surface of the catalyst, the combustion of carbonaceous materials from the pores proceeds more slowly and the temperature of regeneration during the final regenerating period may be readily controlled.

55 However, it has been found that, unless some provision is made to prevent excessive tempera-

ture during the initial stage of regeneration, the activity of the catalyst is reduced.

One method heretofore proposed for controlling the regenerating temperature has been to dilute the regenerating gas with steam or other non-oxidizing gas, so that the rate of combustion is reduced to a point where the heat capacity of the regenerating gases is sufficient to remove heat from the reaction zone at a rate which will prevent the temperature from exceeding the desired maximum. This method of controlling the temperature has not proven entirely satisfactory. Attempts to control the maximum regenerating temperature in this manner have shown that within the temperature limits of operation dilution of the regenerating gases results in a corresponding increase in the ignition temperature, so that the reduction in temperature rise resulting from dilution is offset by increase in initial ignition temperature. 10 15 20

For example, it has been found that the ignition of carbonaceous deposits on clays used for catalytic cracking when employing a mixture of air and steam having an oxygen concentration of 4 per cent is about 900° F. and the maximum temperature reaches as high as 1400° F. If the oxygen concentration is reduced to 2 per cent, the initial ignition temperature is raised to about 1100°. In either event, it is impossible to maintain the temperature below 1300° F. 25 30

Other methods of controlling the regeneration have been proposed, such as the provision of cooling elements in the catalyst bed, but these methods increase the cost of equipment and have other objections. 35

One of the salient objects of our invention is to provide a simple and effective method of controlling the regenerating temperature during the initial stage of regeneration. Another object of our invention is to provide a method which will 40 reduce the time necessary for regeneration.

Other objects and advantages of our invention will be apparent from the more detailed description hereinafter.

We have found that the regeneration can be 45 effected more rapidly and the regenerating temperature during the initial regenerating stage may be controlled within the desired limits by imposing an elevated pressure on the regenerating gases passing through the catalyst. We have 50 found that, by employing an elevated pressure, the ignition temperature may be lowered, thus creating a wider spread between the ignition temperature and the maximum permissible regenerating temperature. 55

For example, when employing a mixture of steam and air containing about 1½ per cent free oxygen for regenerating clay catalysts employed for cracking gas oils while under a pressure of 4 atmospheres, the ignition temperature may be reduced from about 900° to between 700° and 800°.

It will thus be apparent that our invention makes it possible to provide a wider temperature range between the initial temperature and the final maximum permissible temperature, so that the temperature may be more readily controlled during the initial regenerating stage.

The temperature rise following the initial ignition of the carbonaceous material will depend to a considerable extent upon the concentration of the oxygen contained in the regenerating gases. It is well known that, according to the law of mass action, the rate of any chemical reaction depends upon the molar concentrations of the reacting constituents. By properly correlating the oxygen concentration with the pressure employed during the regeneration, we are able to maintain a careful temperature control and thus prevent the temperature of the catalyst bed from exceeding the desired maximum. The oxygen concentration and the pressure employed will depend upon the type of catalyst used, the character of the deposits contained thereon, the maximum temperature which can be obtained without effecting the activity of the catalyst, and other factors. In general, the lower the oxygen concentration contained in the regenerating gases, the higher the pressure which should be employed. As already mentioned, the pressure employed will determine the initial ignition temperature and the oxygen concentration will determine the extent of temperature rise following the initial ignition.

We have found, for example, that, when regenerating activated clay catalysts used for gas oil cracking, the temperature may be controlled within the desired limits by employing an oxygen concentration ranging from 1 to 10 per cent and a pressure ranging from 2 to 10 atmospheres during the initial regenerating stage. We have further found it to be particularly advantageous to employ an oxygen concentration of from 1 to 4 per cent with a pressure of from 2 to 4 atmospheres.

It will be understood that the above values are illustrative rather than limitative. For example, when extremely rapid regeneration of the catalyst is desired, ordinary air and inert gas having an oxygen concentration of about 6 per cent may be employed, together with a pressure ranging from 250 to 500 or more pounds per square inch. Under these conditions, an ignition temperature of 250° F. may be obtained. As a practical matter, however, it is ordinarily desirable to carry out the regeneration under a pressure somewhat comparable to the pressure employed during the catalyst reaction in order to avoid imposing unnecessary pressure stresses on the equipment in which the reaction is carried out.

As a further alternative, the regenerating temperature may be maintained below the desired maximum, such as for example, below 1100° F., by initially preheating the regenerating gases to a predetermined inlet temperature, such as below 700° F. and the gases subjected to a sufficient pressure to effect the ignition of the carbonaceous deposits at such temperature.

After the surface carbon has been removed,

the burning of the carbon and polymer deposits from the pores of the catalyst proceeds more slowly. The rate of burning and hence the evolution of heat during the final stages is determined by the rate at which the oxygen diffuses into the body of the catalyst. During this stage the oxygen concentration may be increased materially without giving rise to excessive temperatures, since the major part of the oxygen in the regenerating gas is not used up. The oxygen concentration during the final stages of regenerating may be controlled by the temperature it is desired to maintain.

The use of pressure during the final stage of regeneration is also of advantage in that it tends to increase the partial pressure of the oxygen diffused into the body of the catalyst and increases the rate of regeneration during this stage.

It will be understood that the pressure on the regenerating gases is that maintained generally throughout the combustion zone and that the expression "back pressure" means the pressure on the gases leaving the catalyst zone.

The initial stage of regeneration as herein employed is intended to mean the period during which the combustion travels completely through the catalyst zone.

Having described the preferred embodiment and given specific examples thereof, it is understood that our invention embraces such other variations and modifications as come within the spirit and scope thereof.

We claim:

1. A method of regenerating a non-combustible solid catalyst containing carbonaceous deposits having an ignition temperature above 800° F. under a back pressure not greater than atmospheric pressure in an oxidizing atmosphere having an oxygen concentration below 10%, which comprises passing a regenerating gas containing free oxygen in an amount below 10% at a temperature below 800° F. in contact with the catalyst to be regenerated, maintaining during the entire regeneration process sufficient back pressure on the regenerating gas contacting said catalyst to initiate combustion of said carbonaceous deposits at the temperature of said regenerating gases and thereafter regulating the oxygen concentration of said regenerating gas to control the regenerating temperature below a predetermined maximum.

2. A method of regenerating a solid catalyst containing carbonaceous deposits which have an ignition temperature above 800° F. under normal atmospheric back pressure in an oxidizing atmosphere containing not over 10% free oxygen which comprises preheating a regeneration gas containing oxygen, but not over 10% thereof, to a temperature not exceeding 700° F. and thereafter contacting said preheated regeneration gas with said catalyst while maintaining a back pressure on said regeneration gas sufficient to cause ignition of said contaminants at a temperature not exceeding 700° F.

3. The method set forth in claim 2 in which during the regeneration of the catalyst the temperature of the catalyst is maintained below 1100° F. and the regeneration gas is preheated to a temperature within the range of between about 500° F. and 700° F.

4. In the process of regenerating a solid adsorbent contact catalyst containing combustible contaminants, the improvement which comprises forcing an oxygen-containing regeneration gas through the said catalyst at an elevated inlet

temperature which temperature is below the ignition temperature of the contaminants when in contact with said oxygen-containing gas in an operation under back pressure not greater than atmospheric pressure, and maintaining a super-atmospheric backpressure on the gas during the entire regeneration process, said back pressure

being sufficiently high to cause immediate ignition and combustion of the said contaminants at the said inlet temperature of said oxygen-containing regeneration gas.

CHARLES WESLEY TYSON.
CHARLES E. HEMMINGER.