

UNITED STATES PATENT OFFICE

2,670,047

METHOD OF INITIATING SUBTERRANEAN COMBUSTION

George C. Mayes and Robert L. Koch, Dallas, Tex., assignors, by mesne assignments, to Socony-Vacuum Oil Company, Incorporated, New York, N. Y., a corporation of New York

No Drawing. Application April 22, 1949,
Serial No. 89,154

3 Claims. (Cl. 166—21)

1

This invention relates to secondary recovery of petroleum oil from subterranean reservoirs and relates more particularly to initiation of combustion of petroleum oil remaining in partially depleted subterranean reservoirs to assist in recovery of a portion of such oil.

Petroleum oil is generally recovered from subterranean reservoirs initially as a result of gas pressure, rock pressure, or natural water drive forcing the oil from the oil bearing formation or reservoir through the producing well to the surface. As recovery of oil from the reservoir continues, the reservoir energy gradually decreases and finally becomes insufficient to force the oil to the surface, although a major portion of the original quantity of the oil remains in the reservoir. To increase the ultimate recovery of the oil, pumping is then employed but when the rate of recovery by pumping falls to an uneconomically low level a further increase in the ultimate recovery of the oil may still be economically effected by the employment of secondary recovery methods such as gas drive or water drive. It has recently been proposed to increase the ultimate recovery of the oil by combustion or burning of a part of the oil in place in the reservoir, the combustion being supported by continuous injection of air or other oxidizing medium through an input well or wells, whereby as a result of decreased viscosity and distillation and viscosity breaking, the unburned oil, along with distillation and viscosity breaking products, may be carried to and recovered from an output well or group of output wells.

Combustion of the oil in place in the reservoir has heretofore been initiated by placing charcoal in the input well adjacent to the partially depleted formation, the liner, if the well contains a liner, being perforated where it contacts the partially depleted formation, supplying air or other combustion supporting gas to the formation, and igniting the charcoal. However, difficulty has been encountered in initiating combustion by the use of charcoal and similar types of combustion initiating materials in that the combustion is not uniform and the combustible material shrinks in volume as it is consumed with consequent settling of the unburned material to the bottom of the hole and non-uniform firing of the formation. Additionally, the temperatures attained by burning of the combustion initiating material may be so high in spots as to cause fusion of the formation with resulting hindrance to the flow of air or other combustion supporting gas to the formation. Further, the temperatures attained by burning of the combustion initi-

2

ating material tend to cause collapse or caving of the walls of the well resulting, where the well does not contain a liner, in extinguishment of combustion and the necessity for cleaning or re-boring of the well before further attempts to initiate combustion can be made.

It is an object of this invention to provide a method for initiating combustion in a subterranean petroleum reservoir. It is another object of this invention to obtain uniform firing of a partially depleted petroleum oil bearing formation. It is another object of this invention to prevent collapse of well walls during initiation of combustion in a subterranean petroleum reservoir. It is another object of this invention to provide a dimensionally stable combustion initiating material. It is another object of this invention to prevent fusion of the formation during initiation of combustion. These and other objects of the invention will become apparent from the following description thereof.

In accordance with the invention, the objects are achieved by employing as a combustion initiation material a mixture of a solid combustible material and a granular, refractory material. This mixture is placed in the inlet well adjacent to the partially depleted formation wherein combustion is to be initiated and maintained. Upon ignition, a uniform and substantially complete combustion within the mixture is obtained which, extending to the formation, initiates combustion of the petroleum oil within the formation uniformly along the face of the formation adjacent to the combustion initiation material. The inclusion of the granular, refractory material in the mixture renders the mixture porous, permitting flow of the air or other combustion supporting gas through the mixture and to the formation to support combustion therein after initiation, and provides a heat absorbent preventing attainment of excessively high temperatures conducive to fusion of the formation but maintaining the air or the gas passing through the mixture at a high temperature. Additionally, the granular, porous material provides a rigid, dimensionally stable body of packing within the well preventing collapse of the walls of the well, if a liner has not been provided, and thereby avoiding extinguishment of combustion and the necessity for cleaning or re-boring the well.

For preparing the combustion initiation mixture, various types of solid, combustible material may be used. By solid, combustible material, we mean a combustible material which will be sufficiently non-fluid at the temperatures attained by the mixture during combustion to be substantially

non-flowable or non-separable from the porous, refractory material. The solid, combustible material may contain volatile components, but it is desirable to employ a material which contains a minimum of such components in order to avoid their loss by volatilization prior to burning with consequent reduction in fuel value of the combustible material. It is further desirable that the combustible material have a high heat of combustion. Preferred materials include petroleum coke, coke from coal, and charcoal, although coal, wood, or other solid, combustible carbonaceous material may be used. Generally, the combustible material should have a particle size as small as possible compatible with retention in the mixture under the rates of flow through the mixture of the air or other combustion supporting gas.

The amount of combustible material in the combustion initiation mixture must be such as to raise the temperature of the mixture sufficiently high to initiate combustion of the oil contained in the formation. Generally, the amount of combustible material required will be in excess of 1 percent by weight of the mixture although this amount will vary with the type of combustible material and the type of refractory material. Amounts of combustible material greatly in excess of 1 percent by weight of the mixture may be used although the amount used should be below the amount resulting in the attainment of temperatures of the mixture sufficiently high to result in fusion of the refractory material or the walls of the well. Amounts of combustible material in excess of 15 percent by weight of the mixture should generally be avoided although these larger amounts may be employed where the heat of combustion of the combustible material is low, the heat capacity or fusion temperature of the refractory material is high, or heat losses are high.

The granular, refractory material may be crushed or broken stone, pebbles, sand, crushed or broken fire brick, consolidated particles of clay, etc. The essential characteristics required of these materials are that they be refractory, i. e., do not disintegrate or fuse to any great extent at the temperatures of combustion attained and be granular, i. e., of such size and shape that they will not pack to form a body impermeable to the flow of the air or other gas therethrough for supporting combustion within the oil-containing formation. The average particle size of the refractory, granular material should be preferably about 0.2 inch in effective diameter or smaller, although average sizes small than about .004 inch in effective diameter should be avoided.

The combustion initiating mixture may be prepared by mechanically admixing the desired combustible material and the desired granular, refractory material. However, a preferred type of combustion initiation mixture comprises a carbonaceous material such as petroleum coke deposited on a granular, refractory, surface active material such as fuller's earth (attapulgit), activated clays including the bentonites, synthetic silica-aluminas and activated aluminas. These surface active materials have large surface areas, namely, about 125 to 325 square meters per gram depending upon the material, and therefore are capable of retaining in thin layers large amounts of carbonaceous material. Additionally, the large surface area facilitates combustion in the mixture. Deposition of the carbonaceous material on the surface active material

may be made in any suitable manner as, for example, by contacting the surface active material with a heavy, high boiling petroleum oil such as a petroleum residue, and then heating to a temperature of the order of 800° F. to remove low boiling components.

In initiating combustion in the formation, the mixture is placed in the input well adjacent to the formation from which the oil is to be recovered, the liner, if any, being perforated to permit the spread of combustion and the flow of combustion supporting gas to the formation. Generally, sufficient mixture should be employed to fill the well along the entire depth of the formation in which combustion is to be initiated in order to obtain firing of the formation along the entire face exposed to the well. However, the combustion initiating material may be placed in the well to form a column of any length greater or smaller than the thickness of the formation exposed to the well and it is often advantageous to form a column of combustion initiating material greater than the length of the formation exposed to the well and extending upwardly beyond the formation since thereby the problems of igniting the combustion initiating material, increasing with depth, are minimized.

Ignition of the combustible material in the mixture may be effected in a number of ways. The combustible material in the mixture may be ignited at the surface and the mixture then positioned in the well adjacent to the formation in which combustion is to be initiated, a supply of air or other combustion supporting gas being pumped or otherwise injected into the well to maintain combustion in the mixture and in the formation after combustion is initiated. Preferably, however, the mixture is positioned in the well adjacent to the formation and the combustible material thereafter ignited, the supply of air or other combustible gas being provided to maintain combustion in the mixture and in the formation after ignition. Various methods may be employed to ignite the combustible material after the mixture has been positioned adjacent to the formation. For example, the combustible material in another portion of the mixture may be ignited at the surface and the mixture placed in the well on top of the mixture already in the well. Another method comprises heating the air or other combustion supporting gas injected into the well to a temperature above the ignition temperature of the combustible material in the mixture whereby the combustible material will ignite. Rapid ignition may be obtained by this method where the injected air or other gas is heated to a temperature about 200° F. above the ignition temperature of the combustible material. Ignition may also be effected by placing a charge of black powder or other readily combustible, low brisance material, containing its own combustion supporting medium on top of the combustion initiation material and igniting electrically, by fuse, or otherwise. Other methods of ignition will suggest themselves to those skilled in the art.

Having thus described our invention, it will be understood that such description has been given by way of illustration and example only and not by way of limitation, reference for the latter purpose being had to the appended claims.

We claim:

1. In a method of recovering petroleum from a subterranean formation having an input well and an output well leading from the surface

5

thereto wherein said petroleum is ignited at said input well, a combustion supporting gas is forced through said input well into said formation to maintain combustion of petroleum therein, and petroleum and combustion products migrate to said output well, the improvement in initiating combustion of petroleum contained in said formation comprising placing adjacent to said formation for the entire depth thereof at said input well a mixture comprising a granular, refractory surface active material having a surface area between 125 and 325 square meters per gram and a particle size between .004 and 0.2 inch in effective diameter and having deposited therein petroleum coke in an amount between one percent and fifteen percent by weight of said mixture, and forcing said combustion supporting gas through said input well to said mixture and into said formation and igniting said combustible material in said mixture.

2. In a method of recovering petroleum from a subterranean formation having an input well and an output well leading from the surface thereto wherein said petroleum is ignited at said input well, a combustion supporting gas is forced through said input well into said formation to maintain combustion of petroleum therein, and petroleum and combustion products migrate to said output well, the improvement in initiating combustion of petroleum contained in said formation comprising placing adjacent to said formation for the entire depth thereof at said input well a mixture comprising a granular, refractory surface active material having a surface area between 125 and 325 square meters per gram and a particle size between .004 and 0.2 inch in effective diameter and having deposited therein petroleum coke in an amount between one percent and fifteen percent by weight of said mixture, said mixture having been formed by contacting said surface active material with a high boiling petroleum oil and then heated to a temperature of the order of 800° F., and forcing said combustion supporting gas through said input well to said mixture and into said formation and

6

igniting said combustible material in said mixture.

3. In a method of recovering petroleum from a subterranean formation having an input well and an output well leading from the surface thereto wherein said petroleum is ignited at said input well, a combustion supporting gas is forced through said input well into said formation to maintain combustion of petroleum therein and petroleum and combustion products migrate to said output well, the improvement in initiating combustion of petroleum contained in said formation comprising placing adjacent to said formation for the entire depth thereof at said input well a mixture comprising a granular, refractory surface active material having a surface area between 125 and 325 square meters per gram and a particle size between .004 and 0.2 inch in effective diameter, and having deposited therein petroleum coke in an amount between one percent and fifteen percent by weight of the mixture, said mixture having been formed by contacting said surface active material with a high boiling petroleum oil and then heated to a temperature of the order of 800° F., forcing said combustion supporting gas through said input well to said mixture and into said formation, and igniting said petroleum coke in said mixture by placing black powder on top of said mixture in said input well and igniting said black powder.

GEORGE C. MAYES.
ROBERT L. KOCH.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
797,529	Oliphant	Aug. 15, 1905
1,510,926	DeKaiser et al.	Oct. 7, 1924
2,110,370	Lum	Mar. 8, 1938
2,382,471	Frey	Aug. 14, 1945
2,390,770	Barton et al.	Dec. 11, 1945
2,500,990	Higginbotham et al.	Mar. 21, 1950