United States Patent

Bandyopadhyay

[15] **3,672,450**

[45] **June 27, 1972**

[54] METHOD FOR IN SITU COMBUSTION IGNITION

[72] Inventor: **Pratip Bandyopadhyay**, Tulsa, Okla.

[73] Assignee: **Cities Service Oil Company**, Tulsa, Okla.

[22] Filed: **Jan. 28, 1971**

[21] Appl. No.: **110,492**

[52] **U.S. Cl.** **166/260**

[51] **Int. Cl.** **E21b 43/24**

[58] **Field of Search** 166/260, 261, 262, 251, 302

[56] **References Cited**

UNITED STATES PATENTS

2,871,942	2/1959	Garrison	166/260
2,889,881	6/1959	Trantham	166/260
3,263,750	8/1966	Hardy	166/260
3,217,800	11/1965	Smith	166/260
3,076,505	2/1963	Pryor	166/262

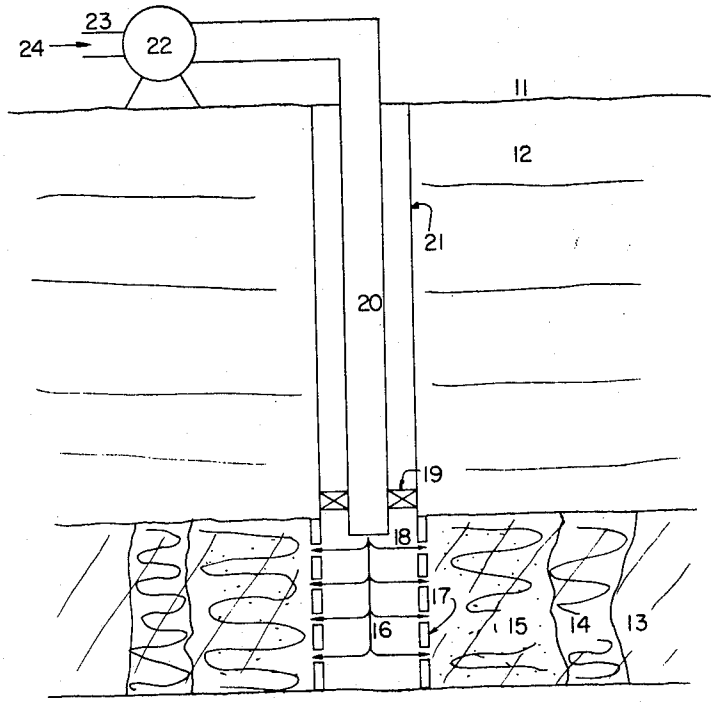
Primary Examiner—Robert L. Wolfe

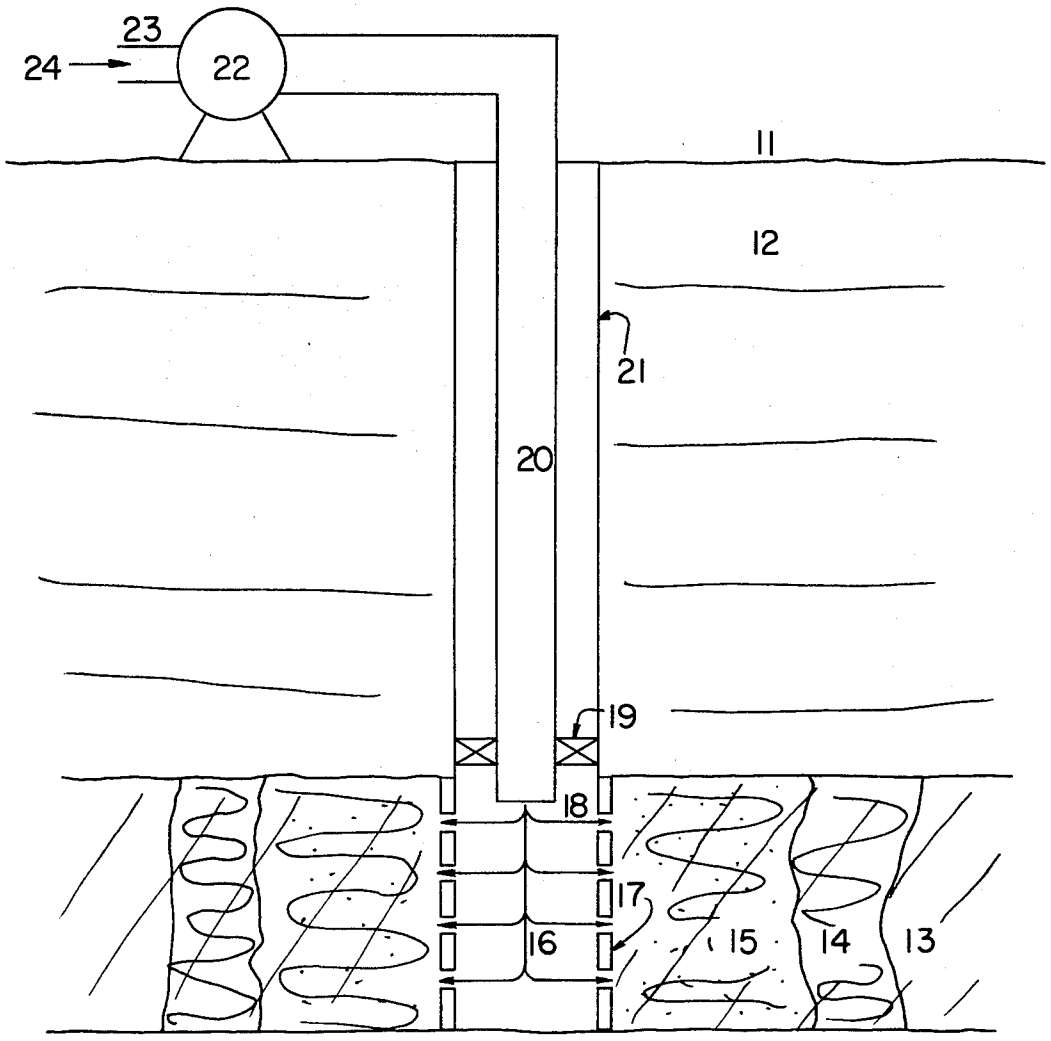
Attorney—J. Richard Geaman

[57] **ABSTRACT**

A slug of material comprising an emulsion of water and carbon black with or without additives is injected into the vicinity about a proposed oxidant injection well in a fireflood pattern. A downhole heater or other suitable ignition means is introduced into the vicinity of the wellbore to be ignited. The initiation of a combustion drive or fireflood is enhanced by the presence of the carbon black material. Through injection of an oxidant, the carbon black ignites, forming an intense heat source about the wellbore from which the formation hydrocarbons are rapidly ignited.

8 Claims, 1 Drawing Figure





PRATIP BANDYOPADHYAY , INVENTOR.
BY J. Richard Geaman
ATTORNEY

METHOD FOR IN SITU COMBUSTION IGNITION

BACKGROUND OF THE INVENTION

The present invention relates to the initiation of fireflooding in oil reservoirs, especially those formations containing a low oil saturation about the oxidant injection well. More particularly, the process of the present invention involves the injection of a water emulsion of carbon black into the formation in the vicinity of the oxidant injection well for the enhanced ignition of the oil contained within the formation.

It is often desirable to heat subterranean oil bearing formations for increased production of oil and/or minerals therefrom. In the initiation of a combustion flood or fireflood, perforations in the injection well are generally located in a position wherein they are adjacent to a sufficient oil saturation such that the formation may be readily ignited and the combustion front sustained through injection of air therein. The hot flue gas from a hydrocarbon burning ignition instrument or an electric heater with subsequent combustion thereabout, forms the heat which permeates into the formation. A gradual temperature buildup within the formation to the ignition temperature of the heavy crude oil occurs. The slow heating incurred with wellbore heaters and simultaneous air injection causes the oil about the wellbore to flow away from the wellbore before it is ignited, thereby reducing the oil saturation in the vicinity of the injection well. This phenomena is particularly significant in instances wherein the oil saturation is marginal for ignition such that the oil saturation near the injection well decreases below the oil saturation required for ignition. As a result of preheating, a significant saturation of fuel does not envelope the wellbore for ignition and initiation of the combustion front.

Conjunctively involved in the process of combustion front ignition are the heat losses in a vertical direction from the wellbore. Formation heating may be slowed and the residual oil thereabout the wellbore afforded more time to backflow away from the wellbore, thereby reducing the required oil saturation for ignition. The probability of ignition being obtained, therefore, decreases. Several methods have been initiated with varying degrees of success for ignition of fuels in a wellbore for combustion sustenance. The methods generally involve the injection of fuel and suspension of an electric heater or hydrocarbon fuel heater, as mentioned above, in the wellbore. These methods are inconvenient in that it is generally necessary for large amounts of fuel to be injected into the wellbore for the initiation of the combustion front and often break down the wellbore completion requiring complete reworking of the injection well and often abandonment of the well.

Chemical ignition has been suggested, for example the injection of a solution, comprising a combustible material, and a volatile solvent, may be displaced down the well and into the formation. After the placement of the combustible material and solvent within the formation, an oxidant is injected into the wellbore to force ignition. Phosphorous and other combustible materials have been utilized for the rapid combustion and temperature increases required for the formation of combustion front. Other chemicals which have been used to enhance the initiation of combustion within the formation include the tri-ethyl borane family of compounds which, when brought into contact with an oxygen containing gas at the location where the ignition is desired, ignite spontaneously. The heat release from the spontaneous combustion of these reactants forms a combustion front which is further initiated through injection of an oxidant, for example air, therein the formation.

None of the above-mentioned methods or procedures have proven to yield more than varying degrees of success for the ignition of fuels in the borehole of a well. Successful ignition is especially acute in those formation from which the oil saturation has been decreased and the oil partially removed from formation in the vicinity of the wellbore so that a marginal saturation remains for the initiation of a combustion front.

Therefore, what is required is a method for the initiation of combustion within a formation through the use of inexpensive and easily positioned materials.

It is an object of the present invention to provide a method for the initiation of a combustion front in oil bearing formations.

It is a further object of the present invention to provide a material for injection therein a formation, in which a combustion drive is desired, for the initiation of a combustion front.

It is still a further object of the present invention to introduce a slug of a water emulsion containing a carbon black material for the deposition of carbon black within the formation which may be ignited to sustain a combustion front for the intiation of a fireflood or combustion drive in a formation for the ultimate recovery of viscous oil therefrom.

With these and other objects in mind, the present invention may be more fully understood through the following drawing and description:

SUMMARY OF THE INVENTION

The objects of the present invention are accomplished through the utilization of a process for the initiation of a combustion drive for the production of viscous crude oil from subterranean formations. The process comprises the introduction of a slug of a water emulsion of carbon black into the subterranean formation. An oxidant is then introduced into the subterranean formation and heating is applied to the carbon black and oxidant to raise them to their ignition temperature. The emulsion may further comprise the addition of a surfactant or other injection inducing chemicals to ease the introduction of the emulsion into the formation and the subsequent ignition thereof.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying FIGURE represents a completed wellbore and wellbore liner having perforations therein through which the process of the present invention is accomplished for the initiation of a combustion drive in, and the subsequent production of viscous crude oil from, a subterranean formation.

DETAILED DESCRIPTION OF THE INVENTION

As disclosed, the present invention is a process for the initiation of a combustion drive for the production of viscous crude oils from subterranean formations. Generally, by viscous crude oil is meant those petroleum oils having a viscosity of 10 centipoise or greater, and which, generally, are not economic or have a short primary production cycle. To produce these viscous crude oils, it is often necessary to add a solvent or heat to the formation such that the viscosity and, therefore, the mobility of the oil is reduced so that it may flow more easily to a wellbore and be produced. It is also generally believed that wells completed into a formation tend to reduce the oil saturation about the wellbore, while leaving a large oil saturation within the formation a considerable distance from the wellbore. This oil may not be productive under the ordinary principle driving forces of primary production. Conventionally, wellbore combustion drive initiation equipment involves the use of a wellbore heater and the injection of chemicals into the formation which are subsequently ignited either spontaneously or by the wellbore heater or a detonation technique. Wellbore heaters are inefficient in initiating a combustion drive in reservoirs containing highly viscous oil as the oil saturation in the region of the wellbore is marginal for ignition while the gravity of the crude is such that the saturation near the injection well decreases below the saturation limit required for ignition. The chemical ignition technique is generally dangerous and costly as it involves exotic chemicals which are not easily handled by surface crews and require exacting introduction into the wellbore and precise control for the ignition thereof. Combined with these problems for the ig-

nition of a combustion drive are the heat losses in the vertical direction within the wellbore in the use of a wellbore heater, and formation heat losses to the overburden and underburden strata which may dilute the heat concentration into the formation, thereby not allowing the greater heating required for the combustion drive ignition.

The process of the present invention, however, utilizes the introduction of a slug of a water emulsion of a carbon black material into the subterranean formation. The slug is displaced into the formation to fill an area with carbon black emulsion from about 0.5 to 25 feet from the wellbore with the ignition fluid. This fluid will preferentially displace the water rather than the highly viscous oil contained in the wellbore in the vicinity about the wellbore and as the formation is heated, the water content of the emulsion will distill off, leaving a deposit of carbon black in the interstices of the formation which insures an adequate fuel concentration for easy ignition and sustenance of a combustion front. The injection process for the emulsion also drives the low oil saturation about the wellbore back from the wellbore to form a bank of oil adjacent to the carbon black material injected. As oxidant is introduced into the formation and heat is applied to the oxidant and carbon black, the flame temperature of the reactants is reached. A sustained combustion begins which ignites the bank of oil adjacent the treated wellbore and begins a sustained combustion front which may be drive through the formation by the further introduction of oxidant.

Generally, the process of the present invention will use a water emulsion of carbon black comprising about 0.01 to about 30 weight percent carbon black. The emulsion consists of an inexpensive water and carbon black emulsion which may be formed simply by introducing the two emulsion materials into a pump. It is preferred that the carbon black be sized from about 0.1 to about 300 microns and, in particular, the micron size utilized in the emulsion be smaller than that of the smallest pore size to be encountered within the formation in the vicinity of the wellbore, so that the carbon black material may be easily injected into the formation and be displaced a considerable distance from the wellbore as required by engineering design. Normally, the oxidant utilized in the process of the present invention will be air, although enriched air and pure oxygen may be utilized. Generally, ignition temperature of from 800° F. to about 1,300° F. are required. Surfactants, wetting agents, and other additives may be included within the emulsion to improve its injectivity and displacement properties. The wetting agent improves the ability of the carbon black to be deposited on the pore sites.

The objects of the present invention may be more fully understood by referral to the accompanying FIGURE in which a well **16** is completed from the earth's surface **11** through overburdened rock **12** into a formation **13** containing a highly viscous crude oil which is to be produced through combustion drive. Well **16** represents an injection well comprising completed casing liner **21** and a tubing string **20** which is hung in the well and isolated from the area of the formation **13** by isolation means, for example hydraulic packer **19**. A pump **21** is connected having an inlet **23** to the injection tubing string **20** through which an oxidant **24** and other solutions utilized herein are introduced into the formation **13**.

The particular method of the present invention for initiation of in situ combustion and ignition thereof is accomplished by the introduction of a water emulsion of a carbon black material injected into inlet **23**, passed through injection tubing **20** and introduced into the formation **13** to form a bank of water and carbon black material which, in turn, drives the residual oil concentration about the wellbore in the formation **13** away from the vicinity of the wellbore to form an oil bank **14** of higher saturation than normally encountered. The water emulsion of carbon black material is introduced into the formation through the slotted liner **17** having perforations **18** therein such that injectivity of the formation **13** is easily accomplished. Subsequent to the introduction of the water emulsion or carbon black material, an oxidant **24** is introduced into the inlet **23** of pump **22**, traverses the injection tubing string **20** and subsequently is introduced into the formation **13**. A wellbore heater, which may be hung downhole through the hydraulic packer **19** or through the tubing string **20**, is positioned so as to produce the heat and oxygen required for the initiation of the combustion front and to raise the temperature of the carbon black and oxygen to the flame temperature for the initiation of combustion. As the formation is heated, water is distilled from the vicinity of the wellbore, leaving a deposit of carbon black which will ensure an adequate fuel concentration for ignition of the combustion front in the formation. As an example of the utilization of the process of the present invention, the following example is illustrated:

EXAMPLE

A wellbore completion into a formation, as depicted in the Figure, is utilized for the initiation of a combustion drive. The formation exhibits a porosity of 30 percent and has an oil saturation of 30 percent which consists of a heavy crude oil having 18° API gravity. There exists the minimum or limit of oil saturation about the vicinity of the wellbore for fireflooding. To insure a rapid formation ignition, a slug of a water emulsion of carbon black is introduced into the formation prior to heating as practiced by the present invention. The concentration of the 10 micron carbon black in the slurry is 0.2 percent by weight. It is assumed that perforations are over a 10 foot interval and a sufficient volume of carbon black is to be injected to flush out 2.5 feet about the 0.5 foot wellbore radius. The pore volume required is obtained through the following formula:

Pore Volume		$= (r_2^2 - r_1^2)\, h\, \phi S_0$
		$= (3.14)(2)(3)(10)(.3)$
		$= 56.6\ ft^3$
wherein π		$= 3.14$
	r_1	= the radius of the wellbore;
	r_2	= radius from the wellbore to which the slug of water emulsion or carbine material is required
	h	= interval of perforations and
	S_o	= the oil saturation
Pore volume water to be injected		$= 0.7\ (56.6) = 40\ ft^3$
		= 7 bbls

Assuming no gas saturation, the water saturation in the interval about the formation is 70 percent such that the pore volume of water injected would equal 40 cubic feet or approximately 7 barrels of water emulsion of carbon black material. Thereby, through use of the formula and engineering practices discussed herein, one may design the amount of pore volume of emulsion required and radial extent from the wellbore to which the emulsion will be introduced to initiation of the fireflood.

Through the utilization of the method for the initiation of an in situ combustion ignition of the present invention, one is provided with a method of forming an intense heat source about a wellbore with which the formation hydrocarbons may be rapidly ignited for the initiation and sustenance of a fireflooding project. The method discloses an easily prepared solution which may be handled by field personnel for the initiation of in situ combustion drive.

The present invention has been described above with particular respect to the embodiments thereof. It will be understood, however, by those skilled in the art, that various changes and modifications may be made without departing from the spirit and scope of the invention as presented.

Therefore, I claim:

1. A process for the initiation of a combustion drive for the production of viscous crude oil from a subterranean formation, which comprises:

a. introducing a slug of a water emulsion of carbon black into the subterranean formation;

b. injecting an oxidant into the subterranean formation; and

c. heating the carbon black and oxidant to their ignition temperature.

2. The process of claim 1 in which the water emulsion of carbon black comprises from about 0.01 to about 30.0 weight percent carbon black.

3. The process of claim 2 in which the carbon black is sized from about 0.1 to about 300 microns.

4. The process of claim 3 in which the heating is supplied by the introduction of a downhole wellbore heater into the wellbore, adjacent the subterranean formation.

5. The process of claim 4 in which the oxidant is air.

6. The process of claim 5 in which the slug size represents a zone from about 0.5 to about 25.0 feet from the wellbore.

7. The process of claim 1 in which the emulsion further comprises a wetting agent.

8. The process of claim 7 in which the wetting agent is present in the emulsion in about 0.001 to about 1.0 weight percent.

* * * * *