

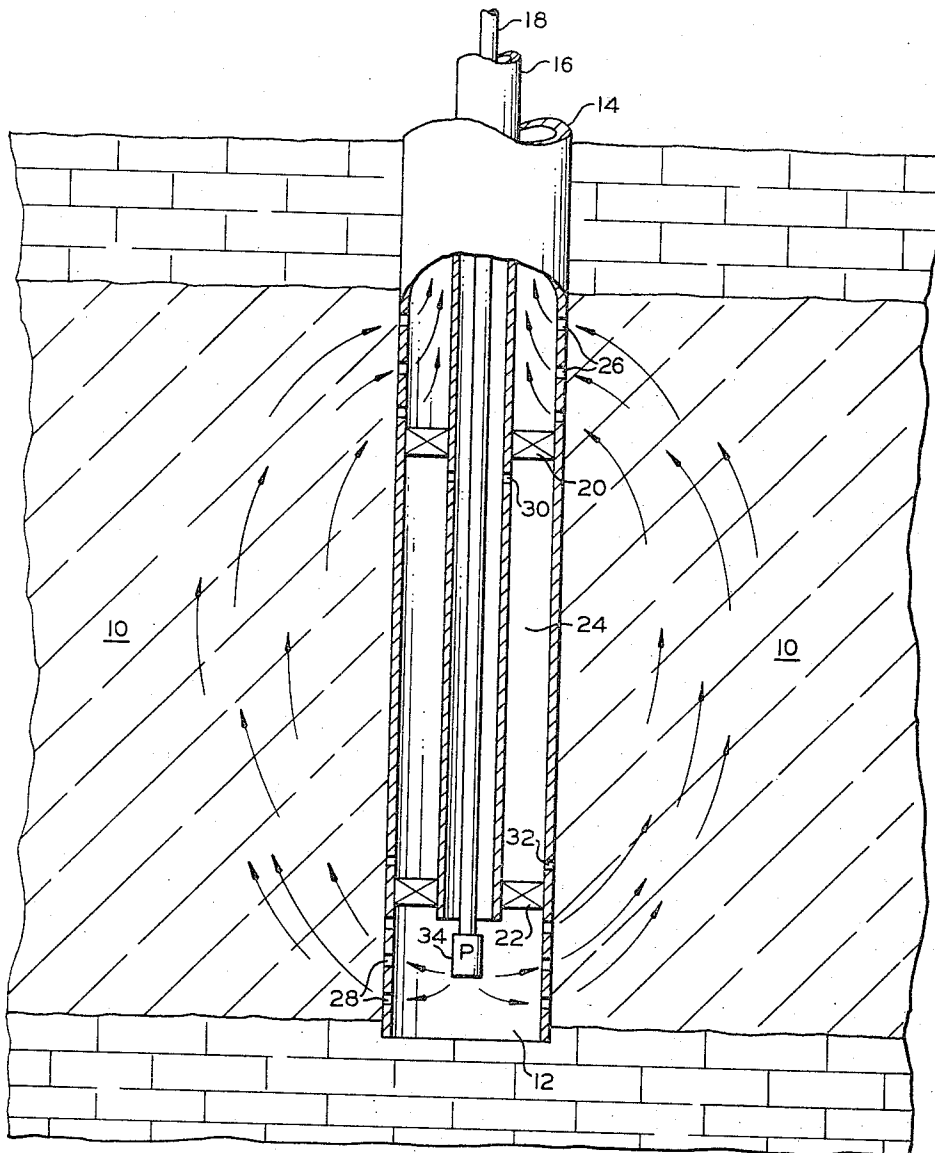
April 23, 1968

M. SANTOURIAN

3,379,247

OIL RECOVERY PROCESS USING HOT FLUIDS

Filed Nov. 8, 1965



INVENTOR

BY MELCON SANTOURIAN

Young & Quigg
ATTORNEYS

1

3,379,247

OIL RECOVERY PROCESS USING HOT FLUIDS
Melcon Santourian, Meshed, Iran, assignor to Phillips
Petroleum Company, a corporation of Delaware
 Filed Nov. 8, 1965, Ser. No. 506,676
 11 Claims. (Cl. 166-11)

ABSTRACT OF THE DISCLOSURE

Heavy oil is produced from a stratum containing the same and penetrated by a production well provided with a casing and tubing string by isolating a section of the annulus intermediate the upper and lower boundaries of the stratum, passing hot fluid (such as steam) from the well into the stratum below the isolated section to heat the stratum surrounding said section, the oil being fluidized and collected in the well from which it is recovered by pumping or gas lift. Heating fluid is also circulated thru the isolated section of annulus to aid in heating adjacent stratum. Eventually, fluids including oil are produced in the annulus above the isolated section and thereafter heating fluid is forced thru the stratum to one or more offset wells, preferably, after producing oil around the offset well in the foregoing manner.

This invention relates to a process for producing oil from strata containing heavy crude oils and tars which are too viscous to flow like most crude oils under normal reservoir conditions.

Certain oil deposits contain highly viscous fluid to semi-solid hydrocarbon material which is not recoverable by ordinary methods. Examples of fields containing such deposits are the Athabaska tar sands of Canada and the Morichal field in Venezuela containing extremely viscous crude oil both of which do not flow under ordinary reservoir conditions. The problem of producing oil from such deposits has been attacked but without outstanding success.

This invention is concerned with a method of producing oil from such strata by the use of hot non-oxidizing fluid.

Accordingly, it is an object of the invention to provide an improved process for producing highly viscous hydrocarbon material in the form of oil from strata containing such material. Another object is to provide a process for producing oil from a stratum containing viscous oil-bearing material by utilizing a hot fluid such as steam or water to render the hydrocarbon material sufficiently fluid to flow into a production well. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

In accordance with the invention, a well is drilled thru the stratum to be produced and is provided with a casing extending substantially thru the stratum, a tubing extending to a lower section of the stratum, packers between the tubing and casing, one just below the top of the stratum and one just above the bottom of the stratum, and a producing string within the tubing extending to the bottom of the well. The casing is perforated above the upper packer into the stratum and also below the lower packer into the stratum. Production is effected by injecting hot fluid under substantial pressure thru the tubing and the lower perforations into the stratum where the heating effect of the fluid renders the heavy hydrocarbon material in the stratum less viscous by heating same so that the more fluid oil resulting from the heating gravitates into the well thru the lower perforations. The injection of the hot fluid is continued until a sufficient body of oil accumulates in the bottom of the well to warrant

2

production thereof and this body of oil is produced thru the production string either by conventional pumping or by hot fluid pressure supplied thru the tubing. This aspect of the invention comprises continuously injecting hot fluid so as to heat up the hydrocarbon material in the surrounding stratum, with resultant production of oil in the well, and intermittent opening of the production string at the wellhead to allow fluid pressure in the well to lift the oil to the wellhead.

Steam is the preferred injection fluid but hot water or other hot non-oxidizing fluid may be utilized with less desirable results. Hot hydrocarbons from normally gaseous to liquid and ranging in weight up to gas oil may be utilized as the heating and fluidizing material. The subsequent discussion of the invention will be directed to the use of steam as the heating and producing fluid but it is to be understood that the invention is not limited thereto.

The injection of hot fluid or steam at the top of a massive formation, especially one containing a highly viscous oil, leads to the formation of a bank of practically impermeable oil which prevents the condensed hot water and solubilized oil from migrating thru the formation to the bottom of the well to be produced therefrom. This procedure also tends to form a water block since the condensed water has no way of settling out of the zone being treated.

To overcome some of the difficulties referred to in reducing oil viscosity and in establishing zones of communication, the steam injection process of the invention is set up substantially as illustrated in the drawing, which is a schematic elevation in partial section thru a stratum containing a low gravity, highly viscous oil.

Referring to the drawing, a stratum 10 is penetrated by a well 12 which is provided with a casing 14, a tubing 16 and a production string 18. A first packer 20 is set on the tubing 16 just below the upper level of the stratum, thereby packing off a section of annulus 24 between the packers. Perforations 26 above packer 20 provide for passage of fluid into the annulus above the packer; and perforations 28 in casing 14 below packer 22 provide passages into the stratum for injected fluid. Alternatively, perforations 30 at the upper end of annulus 24 and perforations 32 at the lower end of this annulus may be provided so as to pass heating fluid thru the annulus to assist in heating the surrounding stratum during the production phase of the operation.

Pump 34 is positioned on the lower end of production string 18 in the event production by gas lift is not to be used.

In operation, steam is injected thru tubing 16 from a steam generator (not shown) thru the wellhead and into the bottom of the well below packer 22 from which the steam enters the formation via perforations 28. Initially, the stratum has low permeability and passage of injected steam or condensed water thru the stratum to perforations 26 is not immediately attained. However, the heavy crude oil is heated some distance from the well by the invading steam so as to reduce the viscosity of the oil and render same readily flowable. The heat of the steam is moved radially and vertically upward around the well as the steam condenses to form water. The steam tends to move upward to reach the perforations 26 above packer 20 and enter the annulus which is opened at the well head to flow.

The heated lower zone immediately surrounding perforations 28 contains a mixture of steam, water, and solubilized oil which is lighter than the viscous crude. There is a turbulence boundary effect created in which the lighter components tend to rise and the more viscous portions tend to settle downward, being in turn heated and solubilized in their gradual downward movement. Occasionally, in particularly low permeability strata containing very viscous oil, an oil bank forms. In this operation,

however, the condensed water, containing solubilized oil, gravitates to the lower perforations 28. It is preferred to periodically suspend steam injection so as to facilitate or hasten the drainage by gravity of the more fluid materials (oil and water) from the heated zone into the bottom of the well thru perforations 28. Production is effected either at this time by conventional pumping or immediately after re-establishing steam injection pressure by opening production string 18 at the wellhead and utilizing gas lift to produce the accumulated oil and water. This operation is not a "huff and puff" operation but merely a cleaning out phase to rid the well bottom of accumulated fluids and to allow the injected steam to impinge directly on the oil bank to restart oil flow.

The periodic production and cleaning procedure is repeated until substantial production is noted thru the upper perforations 26 during the steam injection period. After reaching this phase of the operation, oil is produced from the top of the formation only, thru perforations 26. Steam injection and production from the annulus above packer 20 are continued as long as production is economical. By the time this phase of the operation is reached, the produced zone is usually extended at least 20' radially into the stratum and it is feasible to close the annulus at the wellhead while continuing the injection of steam so as to force steam and produced fluid to one or more offset production wells. This is rendered more effective by similarly producing around the offset production wells before attempting to effect the direct steam drive between well 12 and the offset production wells.

The principal advantage of the foregoing process is in the absence of formation blocking which takes place in prior art methods of producing low gravity viscous oil, particularly, when injecting steam in an upper section of the formation and attempting to produce from a lower section thereof. The process also takes advantage of gravity drainage forces which prevents the accumulation of condensed water in the stratum.

After opening up the stratum around several wells in a production pattern by the procedure described herein, it is feasible to utilize an in situ combustion drive between the wells to complete the production of the intervening stratum. The in situ combustion phase of the process is effected in conventional manner by igniting the residual oil adjacent one of the wells to form a combustion zone and feeding air to the combustion zone thru one of said wells. Either direct or inverse drive of the combustion zone may be used.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for producing oil from a stratum containing a hydrocarbon material too viscous to flow under normal conditions, said stratum being penetrated by a well, which comprises the steps of:

- (1) providing said well with a casing extending substantially thru said stratum, a tubing extending to a lower level of said stratum, a first packer packing off the annulus between said tubing and said casing at an upper level of said stratum, a second packer packing off said annulus at a lower level of said stratum, first perforations in said casing into said stratum above said first packer, and second perforations in said casing into said stratum below said second packer;
- (2) injecting hot non-oxidizing fluid into said stratum thru said tubing and said second perforations and also circulating said fluid thru the packed-off section of annulus formed in Step 1 so as to heat said hydrocarbon material in the area surrounding said second perforations and said annulus, thereby converting same to fluid oil and causing said oil to flow by gravity into said well; and

(3) recovering as oil the fluid hydrocarbon material resulting from Step 2 from said well.

2. The process of claim 1 wherein said fluid is steam.

3. The process of claim 1 wherein said fluid is hot water.

4. The process of claim 1 wherein said fluid is steam and injection of steam in Step 2 is alternated with recovery in Step 3.

5. The process of claim 1 wherein the injection and production steps are continued so as to provide a flow path for hot fluid from said second perforations thru said stratum and said first perforations into said annulus above said first packer, thereafter injection of fluid is continued so as to produce fluid oil in last said annulus, and oil is recovered therefrom.

6. The process of claim 1 wherein the hot fluid is steam and a first steam passageway is provided thru said tubing into the upper section of said packed-off annulus and a second steam passageway is provided from a lower section of said packed-off annulus thru said casing into said stratum for said circulating of said fluid.

7. The process of claim 1 wherein a production string is provided inside of said tubing and said string is opened to flow, periodically, so that fluid pressure in said tubing lifts produced fluids thru said production string to ground level.

8. A process for producing oil from a stratum containing a hydrocarbon material too viscous to flow under normal reservoir conditions, said stratum being penetrated by a well, which comprises the steps of:

(1) providing said well with a casing extending substantially thru said stratum, a tubing extending to a lower level of said stratum, a first packer packing off the annulus between said tubing and said casing at an upper level of said stratum, a second packer packing off said annulus at a lower level of said stratum, first perforations in said casing into said stratum above said first packer, and second perforations in said casing into said stratum below said second packer;

(2) injecting hot non-oxidizing fluid into said stratum thru said tubing and said second perforations so as to heat said hydrocarbon material in the area surrounding said second perforations, converting same to fluid oil and causing said oil to flow by gravity into said well;

(3) recovering as oil the fluid hydrocarbon material resulting from Step 2 from said well;

(4) alternately repeating Steps 2 and 3 until injected fluid along with displaced oil passes thru said stratum and said first perforations into the annulus above said first packer;

(5) thereafter, producing displaced oil from said annulus;

(6) continuing the injection of hot fluid until an area around said well extending radially therefrom at least about 20 feet is substantially produced and rendered highly permeable;

(7) thereafter, closing said well to production and continuing hot fluid injection so as to force said fluid and displaced oil into at least one offset production well.

9. The process of claim 8 wherein production around said offset production well is effected by Steps 1 thru 6 prior to Step 7.

10. A process for producing oil from a stratum containing a hydrocarbon material too viscous to flow under normal reservoir conditions, said stratum being penetrated by a well, which comprises the steps of:

(1) providing said well with a casing extending substantially thru said stratum, a tubing extending to a lower level of said stratum, a first packer packing off the annulus between said tubing and said casing at an upper level of said stratum, a second packer packing off said annulus at a lower level of said stratum, first perforations in said casing into said stratum

5

- above said first packer, and second perforations in said casing into said stratum below said second packer;
- (2) injecting hot non-oxidizing fluid into said stratum thru said tubing and said second perforations so as to heat said hydrocarbon material in the area surrounding said second perforations, converting same to fluid oil and causing said oil to flow by gravity into said well;
- (3) recovering as oil the fluid hydrocarbon material resulting from Step 2 from said well;
- (4) alternately repeating Steps 2 and 3 until injected fluid along with displaced oil passes thru said stratum and said first perforations into the annulus above said first packer;
- (5) thereafter, producing displaced oil from said annulus;
- (6) continuing the injection of hot fluid until an area around said well extending radially therefrom at least about 20 feet is substantially produced and rendered highly permeable;
- (7) producing oil from said stratum around at least one offset production well by Steps 1 thru 6;
- (8) thereafter, igniting residual oil in said stratum adjacent one of said wells to form a combustion zone; and
- (9) moving said combustion zone toward the other of said wells by feeding air to said zone thru one of said wells to produce additional oil from said stratum.

6

11. A process for producing oil from a stratum containing a hydrocarbon material too viscous to flow under normal reservoir conditions, said stratum being penetrated by a well, which comprises the steps of:

- (1) providing a tubing string in said well extending from above the well head to a lower level of said stratum forming an annulus with the well bore;
- (2) sealing off a section of said annulus intermediate the upper and lower boundaries of said stratum;
- (3) injecting hot non-oxidizing fluid thru said tubing string into said stratum below the sealed off section of annulus of Step 2 and circulating hot fluid thru said section of annulus, thereby heating and converting the in-place hydrocarbon material to fluid oil and causing same to flow by gravity into said well; and
- (4) recovering as oil the fluid hydrocarbon material resulting from Step 3 from said well.

References Cited

UNITED STATES PATENTS

2,946,382	7/1960	Tek et al.	166—11
3,040,809	6/1962	Pelzer	166—11 X
3,126,951	3/1964	Santourian	166—42 X
3,136,359	6/1964	Graham	166—40 X
3,155,160	11/1964	Craig et al.	166—40
3,259,186	7/1966	Dietz	166—40 X
3,312,281	4/1967	Belknap	166—40

STEPHEN J. NOVOSAD, *Primary Examiner*.

30