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WELLBORE VISBREAKING OF HEAVY CRUDE OILS

Filed Oct. 11, 1967

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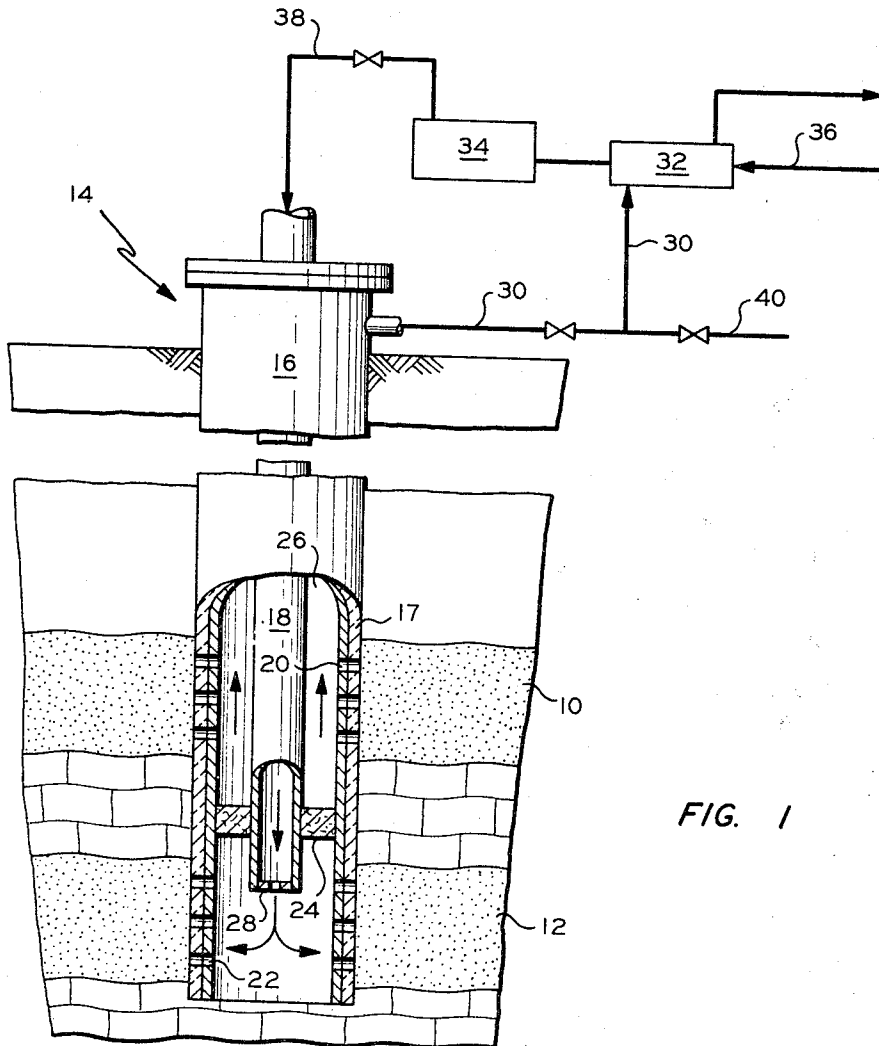


FIG. 1

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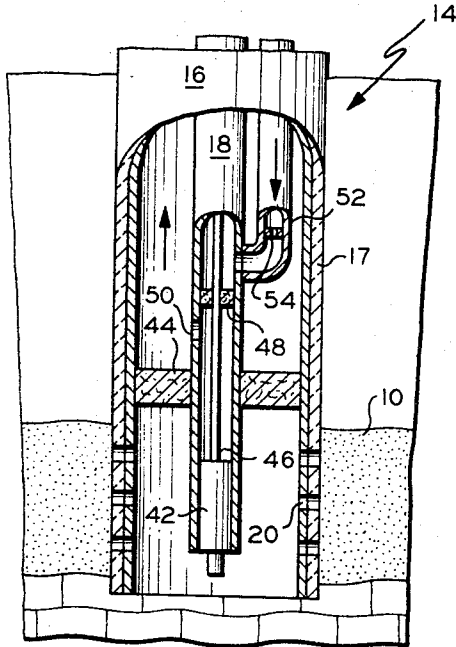


FIG. 2

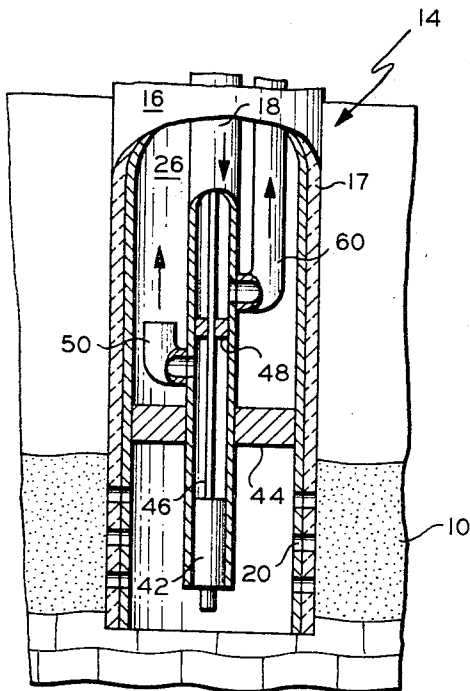


FIG. 4

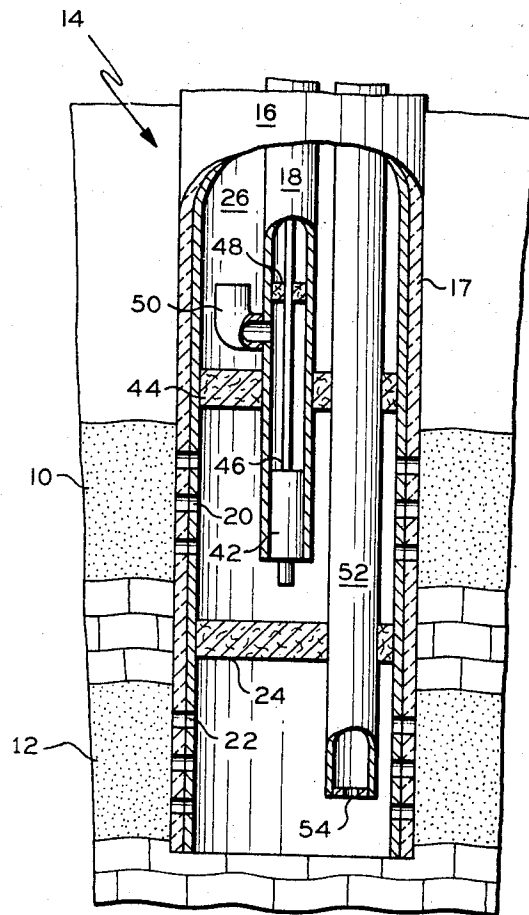


FIG. 3

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WELLBORE VISBREAKING OF HEAVY CRUDE OILS

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9 Claims

ABSTRACT OF THE DISCLOSURE

Heavy crude oil is visbroken and upgraded with substantial reduction in sulfur by heating the oil in the tubing or the tubing-casing annulus at a temperature in the range of 550–700° F. for at least 24 hours as it is being produced, heat being supplied by injected steam at the wellhead thru conduit means extending downhole. The steam and/or condensate is preferably injected into a permeable oil stratum adjacent the producing stratum to drive oil to one or more offset productoin wells.

This invention relates to a method of visbreaking and lowering of the sulphur content of heavy crude oil while the oil is passing thru the borehole.

The desirability of upgrading and reducing the sulphur content of heavy crude oil is well recognized in the art. It has been found that significant visbreaking and sulphur reduction occurs in one-day's time at temperatures of about 650° F.

The principal object of the invnetion is to provide a process for visbreaking and lowering the sulphur content of a heavy crude oil while traveling thru the borehole to ground level. Another object is to provide a process for upgrading a heavy crude oil in the production borehole utilizing steam for the heating medium and making additional use of the steam and hot condensate in auxiliary oil production. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises heating a produced oil steam in the borehole either in the tubing or in the tubing-casing annulus at a temperature in the range of 550 to 700° F., for a period of at least 24 hours and up to several days, or a week, so as to visbreak and lower the sulphur content of the crude oil by passing steam in indirect heat exchange with the produced oil thru the wall of the tubing carrying the steam downhole. It is preferred to produce the oil thru the tubing-casing annulus and inject the steam thru the tubing. The rates of flow of oil and steam are controlled so as to subject the oil to a heat treatment in the range of 600 to 700° F. for at least 24 hours. The casing size and the production rate are selected to provide sufficient residence time for the oil. When utilizing a casing having an I.D. of 11¾ inches and a tubing having an O.D. of 2¾ inches with a well depth of about 4000 feet, the volume of oil in the tubing-casing annulus is about 400 bbl. With this arrangement, any production rate of 400 bbl. or less per day provides a 24-hour period of treating the oil in the annulus. In this type of operation, steam at a pressure of at least 2000 p.s.i.g. and at a temperature of at least 640° F. is injected into the tubing string using a choke on the lower end thereof which facilitates maintaining the pressure in the tubing string. The steam condenses at least partially to hot water due to wellbore heat loss, and finally cools to near the producing zone temperature under the counterflow heat transfer conditions in the well. After passing thru the choke or back-pressure valve at the bottom of the tubing, the condensate and any remaining steam are forced into a sand

below the producing stratum, preferably an oil sand, to effect a hot fluid drive through the oil sand to one or more offset wells.

It is economically desirable to recover heat from the oil which is produced at the wellhead at a temperature of approximately 650° F., utilizing a heat exchanger above-ground. The feed water to the steam generator is passed thru the heat exchanger to pre-heat same before introduction to the steam generator.

Insulated casing may be utilized to reduce wellbore heat loss and increase the overall heat utilization in the process. The process works more economically in wells which produce with a low water cut and/or low gas oil ratio, since water or gas production lowers oil prduction and residence time for given well and given gross fluid production rate.

The invention is readily applicable to a production well leading to a formation or stratum having sufficient pressure to force the oil up the well. It is also applicable to oil production from wells in which pumping is required but specific novel techniques are required in this type of application.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing of which FIGURE 1 is a flow scheme and arrangement of apparatus connected with a well extending to a producing formation; FIGURE 2 is a similar view of a well and downhole equipment for producing by pumping while heating the oil in the well; FIGURE 3 is a similar view to that of FIGURE 2 utilizing a different arrangement; and FIGURE 4 is also similar to FIGURE 2 but showing a different arrangement of apparatus to permit a different technique of operation.

Referring to FIGURE 1, an upper oil sand 10 and a lower oil sand 12 are penetrated by a well 14 provided with a casing 16 covered with insulation 17 and a tubing 18. Casing 16 is perforated at 20 into oil sand 10 and at 22 into oil sand 12. A packer 24 seals off the annulus 26 intermediate the two oil strata. A retrievable choke or back-pressure valve 28 is positioned on the lower end of the tubing for controlling steam pressure within the tubing.

Above ground, an oil production line 30 connects with the annulus at the wellhead and passes thru an indirect heat exchanger 32 for pre-heating water passing to boiler 34 from line 36. The steam from boiler 34 passes via line 38 into tubing 18. Line 40 provides for withdrawal of any or all of the oil produced in line 30 without passing thru the heat exchanger.

Referring to FIGURE 2, well 14 passes thru stratum 10 containing the oil to be produced. Tubing string 18 is provided with a pump downhole and the annulus is sealed by packer 44 postioned above the upper level of stratum 10. Pump rod 46 within tubing 18 operates the pump 42 and passes thru packing material 48 which seals the annulus around the pump rod. Crossover 50 is positioned in the tubing 18 intermediate packer 44 and packing material 48 to provide a flow path for the oil passing up the tubing and into the surrounding annulus thru the crossover. A separate pipe string 52 extends from the wellhead to a level adjacent packing material 48 and is connected thru a side vent with the tubing just above packing material 48. A choke or back-pressure device 54 is positioned in the lower end of pipe string 52.

In the arrangement shown in FIGURE 3, two packers are utilized, packer 24 being positioned intermediate the two oil strata 10 and 12 and packer 44 being positioned above the upper level of the upper stratum. Crossover 50 is positioned above the upper packer so that pump 42 pumps well fluids from oil sand 10 into annulus 26 above the packer as in the structure in FIGURE 2. Steam in-

jection tubing 52 in the arrangement shown passes thru both packers 44 and 24 and is provided with a choke 54 for control of the pressure in the injection tubing.

In FIGURE 4 the arrangement is similar to that in FIGURES 2 and 3 except for the arrangement for injecting steam. Instead of injecting steam thru a separate tubing, steam is injected thru the tubing 18 containing rod 46 and a side vent or choke leads into pipe 60 just above packing material 48, any uncondensed steam and condensate passing to recovery at the wellhead.

The arrangement of FIGURE 1 is applicable to a production well penetrating a stratum under sufficient pressure to force oil up the well to the wellhead. In operation with the arrangement illustrated in FIGURE 1, oil flowing from stratum 10 is forced by stratum pressure upwardly thru annulus 26 to production line 30 at the wellhead from which it flow either thru heat exchanger 32 or thru line 40 to further processing. Water from line 36 is pre-heated in exchanger 32 with the hot produced oil and is then introduced to boiler 34 for conversion to steam at an elevated pressure in the range of about 1000 to 3000 p.s.i.g. or higher. The steam injected from boiler 34 thru line 38 into tubing 18 heats the oil in the sur-

rounding annulus thru the wall of the tubing with adequate back pressure maintained by choke 28 at the lower end of the tubing. Condensate and uncondensed steam egress from the bottom of the tubing and enter oil sand 12 thru perforation 22. The rate of steam injection can be sufficient to effect a hot fluid drive in oil sand 12 to a ring of surrounding production wells. The temperature of the injected steam is sufficiently elevated to heat the oil in the surrounding annulus to a temperature in the range of about 600 to 700° F. The flow of oil thru line 30 is regulated to provide the required heating period of at least 24 hours of the oil ascending well 14.

The arrangements illustrated in FIGURES 2, 3, and 4 are utilized in production wells in which the formation pressure is insufficient to force the oil to the wellhead. In the arrangement of FIGURE 2, oil is pumped by means of pump 42 positioned below packer 44 upwardly thru a short section of tubing to crossover 50 thru which the oil passes into the annulus between the casing and tubing. As the oil ascends the annulus, it is heated by steam injected thru separate tubing 52 and vented into tubing 18 above packing 48 thru choke 54. This arrangement avoids mixing the steam and condensate with the produced oil, the steam and condensate being produced thru the tubing at the wellhead.

With the arrangement illustrated in FIGURE 3, the oil is pumped in the same manner as in FIGURE 2, ascending the annulus 26 around tubing 18 containing the pump rod and also around steam injection tubing 52 which extends thru both packers and delivers the condensate and uncondensed steam to oil sand 20 in which a hot fluid drive is being conducted to surrounding wells.

Operation with the arrangement illustrated in FIGURE 4 is similar to that in FIGURE 2, the difference being in the injection of steam thru tubing 18 carrying the pump rod and recovery of the condensate and uncondensed steam thru a return pipe string 60. It is also feasible to simply vent condensate and any uncondensed steam thru a choke in the wall of tubing 18 above packing 48 and produce these fluids with the produced oil.

In another arrangement not shown, hot oil and condensed water are pumped up the tubing and steam is in-

jected down the annulus using a tubing-casing packer with a choke or back-pressure valve to maintain pressure in the annulus. It is also feasible to inject condensate into a disposal sand above the oil stratum. It is also feasible to control the back pressure on the condensate or steam injected into the lower sand by adding a plugging agent to the injected steam which effects partial plugging of the stratum around the well.

Visbreaking is ordinarily conducted at temperatures above 700° F. and up to 1200° F. with very short contact times. Under these conditions, there is a substantial amount of conversion to coke. The present invention utilizes temperatures which require longer contact times but avoid coke formation.

The following specific example illustrates the invention but is not to be construed as unnecessarily limiting it.

EXAMPLE

Tests were run on Group I and Group III Morichal crude oils in a 600 ml. pressure vessel under selected conditions. Run conditions and data obtained are shown in the table below.

TABLE

Oil used	Reaction conditions			Oil viscosity, cp. at 122° F.		Sulfur content, weight percent	
	Time (hr.)	Temp. (° F.)	Pressure (p.s.i.g.)	Original	Treated	Original	Treated
Group I.....	336	550	1,780	632	360	2.1	1.6
	336	600	2,100	-----	93	-----	1.7
Group II.....	312	600	2,000	8850	273	-----	3.5
	312	600	15	-----	505	-----	3.1
	168	600	15	-----	880	-----	3.7

The vast improvement in viscosity and substantial reduction in sulfur content were produced without any coking of the oil.

In the various arrangements shown in the various figures of the drawings, an expansion joint (not shown) is used between the packer and the tubing extending thru the packer.

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 and visbreaking crude oil from an oil stratum penetrated by a production well provided with a casing and a tubing extending substantially to said stratum which comprises the steps:

- producing liquid crude oil from said stratum thru one of said tubing and the casing-tubing annulus;
- passing steam thru the other of said tubing and said annulus from the wellhead at an elevated temperature and pressure sufficient to heat said oil to a temperature in the range of 550 to 700° F.;
- regulating the flow rate of said oil and said steam so as to hold said oil at said temperature within said well for at least 24 hours to effect substantial visbreaking thereof; and
- recovering the upgraded oil from the preceding steps.

2. The process of claim 1 including the step of:

- passing hot aqueous fluid comprising said steam and water condensed therefrom from the lower end of said well into a second stratum.

3. The process of claim 2 wherein said second stratum is an oil-bearing stratum, and including the steps of:

- driving said aqueous fluid toward an offset well to produce said second stratum oil therein; and
- recovering said second stratum oil from said offset well.

4. The process of claim 1 wherein oil produced thru said annulus in step (a), said annulus is packed off intermediate said stratum and a second lower permeable stratum, and passing from said tubing aqueous fluid com-

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prising said steam and water condensed therefrom into said second stratum.

5. The process of claim 4 wherein said second stratum contains oil and said aqueous fluid from the lower end of said tubing passing into said second stratum drives second stratum oil into an offset well.

6. The process of claim 1 wherein said oil requires pumping, the tubing-casing annulus is packed off adjacent the upper level of said stratum, said tubing is provided with a rod and pump and with a crossover above the packed-off area, and oil is pumped from below said packed-off area thru the lower end of said tubing thru said crossover into and up said annulus, said steam being injected thru a separate tubing to a level adjacent said crossover thence into said first-mentioned tubing above said crossover and passed therethrough to the wellhead.

7. The process of claim 1 wherein said oil requires pumping, the tubing-casing annulus is packed off adjacent the upper level of said stratum and intermediate said stratum and a subjacent permeable stratum, said tubing is provided with pumping means on its lower end intermediate the packed-off areas and with a crossover above the upper packed-off area to pump oil into and thru said annulus to the wellhead, and steam is passed thru a separate tubing extending from the wellhead thru both packed-off areas to said subjacent stratum.

8. The process of claim 1 wherein said oil requires pumping, a packer is set on said tubing above said stratum sealing off the casing-tubing annulus, a crossover is po-

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sitioned in said tubing above said packer, pumping means including a rod and pump are positioned on the lower end of said tubing to pump oil up said tubing thru said crossover and up said annulus to wellhead; rod packing is positioned in said tubing to seal the rod-tubing annulus above said crossover and a side vent and choke are positioned above said packing, steam being passed down said tubing to said side vent and thru said choke for returning to the wellhead thru the tubing-casing annulus in admixture with said produced oil.

9. The process of claim 1 wherein said crude oil contains a substantial concentration of sulfur and said concentration is materially reduced by said process.

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