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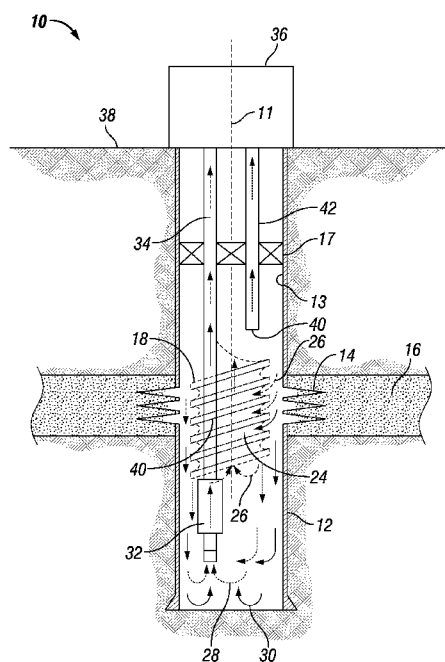


FIG. 1

(57) Abstract: Systems and methods for producing hydrocarbons from a subter-
ranean well include a fluid production tubular and a gas production tubular extend-
ing separately into the well. An electrical submersible pump is in fluid communi-
cation with the fluid production tubular. A cyclone separator is within the well.
The cyclone separator has a rotating screw with thread surfaces open to an inner
diameter surface of the well. The rotating screw is positioned between a lower end
of the gas production tubular and the electrical submersible pump. The thread sur-
faces are angled to direct a liquid stream axially downward and radially outward
towards the inner diameter surface of the well. A central passage extends through
the rotating screw and is oriented to direct a gas stream towards the lower end of
the gas production tubular.

PCT PATENT APPLICATION**DOWNHOLE SEPARATION EFFICIENCY TECHNOLOGY TO PRODUCE
WELLS THROUGH A DUAL COMPLETION****CROSS REFERENCE TO RELATED APPLICATION**

[0001] This application claims priority to and the benefit of co-pending U.S. Provisional Application Serial No. 62/356,968, filed June 30, 2016, titled “Downhole Separation Efficiency Technology To Produce Wells Through A Dual Completion,” the full disclosure of which is hereby incorporated herein by reference in its entirety for all purposes.

BACKGROUND OF THE DISCLOSURE**1. Field of the Disclosure**

[0002] The disclosure relates generally to the development of wells with high gas oil ratio and high water cut, and more specifically to increase the downhole separation efficiency of the gas-liquid phase for producing through an electric submersible pump.

2. Description of the Related Art

[0003] One method of producing hydrocarbon fluid from a well bore that lacks sufficient internal pressure for natural production is to utilize an artificial lift method such as an electrical submersible pump. A string of tubing or pipe known as a production string suspends the submersible pumping device near the bottom of the well bore proximate to the producing formation. The submersible pumping device is operable to retrieve production zone fluid, impart a higher pressure into the fluid and discharge the pressurized production zone fluid into production tubing. Pressurized well bore fluid rises towards the surface motivated by difference in pressure.

[0004] In wells with high gas oil ratio or high water cut or having both high gas oil ratio and high water cut, there can be a decreased efficiency of the production of the hydrocarbons. The accumulation of gas in the electrical submersible pump can decrease the amount of fluids produced and cause gas locking of the pump. Gas locking can require a shutdown of the pump, further harming fluid production of the well.

[0005] In some current systems, the gas phase is re-dissolved into the liquid phase in order to avoid a gas locking effect on the electrical submersible pump. This approach, however, sometimes cannot manage the amount of free gas in order to re-dissolve all of the free gas so the pump experiences a gas lock, reducing the production and increasing the probability of overheating and burning up the motor of the electrical submersible pump.

SUMMARY OF THE DISCLOSURE

[0006] Embodiments disclosed herein provide system and methods for improving the efficiency of the downhole separation of gas and liquids in order to produce hydrocarbons in wells that might not otherwise be able to produce hydrocarbons. Improving the gas-liquid separation in accordance with embodiments of this disclosure can prevent gas lock on the electrical submersible pump and can also reduce liquid loading on the gas string, which is used to produce gas to the surface. Systems and methods disclosed herein can increase the downhole separation efficiency of the gas-liquid phase in order to produce the gas phase through one string and the liquid phase through another string, preventing gas lock on the electrical submersible pump and liquid loading on the gas string. The separation efficiency technology is in the form of a cyclone separator of the embodiments described herein.

[0007] In an embodiment of this disclosure, a system for producing hydrocarbons from a subterranean well includes a fluid production tubular extending into the well and a gas production tubular extending into the well separate from the fluid production tubular. An electrical submersible pump is in fluid communication with the fluid production tubular. A cyclone separator is within the well. The cyclone separator has a rotating screw with thread surfaces open to an inner diameter surface of the well, the rotating screw positioned between a lower end of the gas production tubular and the electrical submersible pump, the thread surfaces angled to direct a liquid stream axially downward and radially outward towards the inner diameter surface of the well. A central passage extends through the rotating screw and is oriented to direct a gas stream towards the lower end of the gas production tubular.

[0008] In alternate embodiments, the thread surfaces of the rotating screw can be angled to direct the gas stream axially downward and radially inward, relative to the liquid stream. A packer can be located within the well downstream of the cyclone separator and the fluid production tubular and the gas production tubular can extend through the packer.

[0009] In other alternate embodiments, the cyclone separator can be located within the well adjacent to perforations into a subterranean formation. The electrical submersible pump can be located axially lower in the well than perforations into a subterranean formation. The lower end of the gas production tubular can be located axially higher in the well than perforations into a subterranean formation.

[0010] In yet other alternate embodiments, the electrical submersible pump can be operable to draw the liquid stream from the inner diameter surface of the well and direct the

liquid stream into the fluid production tubular. The inner diameter surface of the well can be an inner diameter surface of a well casing. The fluid production tubular and the gas production tubular can extend separately to a wellhead assembly.

[0011] In another embodiment of this disclosure, a system for producing hydrocarbons from a subterranean well includes a fluid production tubular extending into the well and through a packer that fluidly seals across a casing of the well. A gas production tubular extends into the well and through the packer. An electrical submersible pump is in fluid communication with the fluid production tubular. A cyclone separator within the well has a rotating screw with thread surfaces open to an inner diameter surface of the casing. The rotating screw is positioned adjacent to perforations through the casing. The thread surfaces are angled to direct a liquid stream radially outward towards the inner diameter surface of the casing and to direct a gas stream radially inward relative to the liquid stream. A central passage extends axially through the rotating screw and is oriented to direct the gas stream towards a lower end of the gas production tubular.

[0012] In alternate embodiments, the electrical submersible pump can be located axially lower in the well than the perforations. The lower end of the gas production tubular can be located axially higher in the well than the perforations. The electrical submersible pump can be operable to draw the liquid stream from the inner diameter surface of the casing and direct the liquid stream into the fluid production tubular. The fluid production tubular and the gas production tubular can extend separately to a wellhead assembly.

[0013] In another alternate embodiment of this disclosure, a method for producing hydrocarbons from a subterranean well includes extending a fluid production tubular into the well. A gas production tubular is extended into the well, the gas production tubular being separate from the fluid production tubular. An electrical submersible pump is provided in fluid communication with the fluid production tubular. A cyclone separator is provided within the well. The cyclone separator has a rotating screw with thread surfaces open to an inner diameter surface of the well. The rotating screw is positioned between a lower end of the gas production tubular and the electrical submersible pump. A central passage extends through the rotating screw. The cyclone separator is operated so that the thread surfaces direct a liquid stream axially downward and radially outward towards the inner diameter surface of the well and the central passage directs a gas stream towards the lower end of the gas production tubular.

[0014] In alternate embodiments the gas stream can be directed axially downward and radially inward relative to the liquid stream with the thread surfaces of the rotating screw. A portion of the well can be sealed with a packer located within the well downstream of the cyclone separator, wherein the fluid production tubular and the gas production tubular extend through the packer.

[0015] In alternate embodiments the cyclone separator can be located adjacent to perforations into a subterranean formation. The electrical submersible pump can be operated to draw the liquid stream from the inner diameter surface of the well and direct the liquid stream into the fluid production tubular. The liquid stream and the gas stream can be produced separately to a wellhead assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] So that the manner in which the above-recited features, aspects and advantages of the embodiments of this disclosure, as well as others that will become apparent, are attained and can be understood in detail, a more particular description of the disclosure briefly summarized above may be had by reference to the embodiments thereof that are illustrated in the drawings that form a part of this specification. It is to be noted, however, that the appended drawings illustrate only preferred embodiments of the disclosure and are, therefore, not to be considered limiting of the disclosure's scope, for the disclosure may admit to other equally effective embodiments.

[0017] Figure 1 is a schematic section view of a system for producing hydrocarbons from a subterranean well, in accordance with an embodiment of this disclosure.

[0018] Figure 2 is a section view of a portion of a cyclone separator in accordance with an embodiment of this disclosure.

[0019] Figure 3 is a graph comparing the GVF of the ESP string from a model operating condition to the GVF in the ESP string that could be obtained using embodiments of the cyclone separator disclosed herein.

[0020] Figure 4 is a graph comparing the tubing flowing bottom hole pressure of the gas string from a model operating condition to the tubing flowing bottom hole pressure in the gas string that could be obtained using embodiments of the cyclone separator disclosed herein.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0021] Embodiments of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings which illustrate embodiments of the disclosure. Systems and methods of this disclosure may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Like numbers refer to like elements throughout, and the prime notation, if used, indicates similar elements in alternative embodiments or positions.

[0022] In the following discussion, numerous specific details are set forth to provide a thorough understanding of the present disclosure. However, it will be obvious to those skilled in the art that embodiments of the present disclosure can be practiced without such specific details. Additionally, for the most part, details concerning well drilling, reservoir testing, well completion and the like have been omitted inasmuch as such details are not considered necessary to obtain a complete understanding of the present disclosure, and are considered to be within the skills of persons skilled in the relevant art.

[0023] Looking at Figure 1, well 10 is a subterranean well used in hydrocarbon production operations. Well 10 can be lined with cement and casing 12 in a manner known in the art. Well 10 can have a central axis 11. Well 10 can be a vertical well, as shown, or can be angled or slanted, horizontal, or can be a multilateral well. Well 10 can have an inner diameter surface 13. Inner diameter surface 13 of well 10 can be the inner diameter surface of casing 12. Perforations 14 can extend through casing 12 and into subterranean formation 16. Formation 16 can contain a combination of liquid and gaseous hydrocarbons and water, which pass through perforations 14 and into well 10 as a multiphase production fluid. Packer 17 can extend across well 10, fluidly sealing across well 10 downstream of perforations 14. Packer 17 fluidly seals a portion of well 10 that includes perforations 14 from a downstream portion of well 10. Where well 10 is a vertical or generally vertical well, packer 17 is axially above perforations 14.

[0024] In certain hydrocarbon developments, there may be a high gas oil ratio, that is, there may be a significant amount of hydrocarbon gasses compared to liquid hydrocarbon. The gas can be dissolved in the liquid hydrocarbon, or oil. The gas oil ratio (GOR) can be known as the volume of gas relative to the volume of crude oil that is produced. Because the

volume of gas will change with a change in temperature or pressure, GOR is given at standard temperature and pressure conditions. Over time as a formation 16 is drained, the GOR can increase until the well can no longer be effectively produced efficiently with some current technology. In the hydrocarbon development, there may additionally or alternately be a high water cut (WCT). Water cut can be known as the ratio of water produced to the volume of total liquid produced.

[0025] In the example embodiment of Figure 1, as the production fluid enters well 10, it is drawn into cyclone separator 18. Cyclone separator 18 is located within well 10 adjacent to perforations 14. Cyclone separator 18 can be located in an annulus between casing 12 and tubular members located within well 10, such as production tubular 34. Cyclone separator 18 will bring the multiphase flow that enters well 10 from formation 16 into rotation where the centrifugal forces will act on the production fluid. Looking at Figures 1-2, cyclone separator 18 includes rotating screw 20 with thread surfaces 22 open to inner diameter surface 13 of well 10. That is, cyclone separator 18 does not have an external shroud or housing but rotating screw 20 is instead located directly in well 10.

[0026] Cyclone separator 18 also has central passage 24 extending through rotating screw 20. Central passage 24 can be generally axial in orientation relative to the rotation of rotating screw 20 or to central axis 11. As rotating screw 20 rotates, centrifugal forces will separate the liquid stream of the production fluid from the gas stream 26 of the production fluid. The liquid stream includes a liquid hydrocarbon such as oil component 28 and a water component 30. In alternate embodiments, central passage 24 is located adjacent to rotating screw 20.

[0027] Thread surfaces 22 are helical shaped protrusion that wind around rotating screw 20. Thread surfaces 22 are oriented such that a liquid stream of the production fluid to move radially outward and axially downward as rotating screw 20 rotates. Thread surfaces 22 are also oriented such that gas stream 26 of the production fluid moves radially inward, relative to the liquid stream, and axially downward as rotating screw 20 rotates.

[0028] The liquid stream in the form of oil component 28 and a water component 30 will travel downward along the helical path of thread surfaces 22, between adjacent thread surfaces 22. As the liquid stream moves axially downward, it will also move radially outward. When sufficient centrifugal force has acted on the liquid stream, the liquid stream will leave rotating screw 20 and move radially outward of rotating screw 20 towards inner diameter surface 13 of well 10. The liquid stream can leave rotating screw 20 at a bottom

end of rotating screw 20 or at another axial location along rotating screw 20. Because rotating screw 20 does not have a shroud or housing, the liquid stream can contact inner diameter surface 13. After the liquid stream has moved radially outward of rotating screw 20, the liquid stream will continue to move axially downward within well 10. In embodiments, the liquid stream will form a film on inner diameter surface 13 of well 10 and move axially downward within well 10 along inner diameter surface 13 of well 10.

[0029] Looking at Figure 1, electrical submersible pump (ESP) 32 is located at an end of fluid production tubular 34 and is in fluid communication with fluid production tubular 34. Fluid production tubular 34 extends into well 10. An upper end of fluid production tubular 34 is associated with wellhead assembly 36. Fluid production tubular 34 extends through packer 17. Rotating screw 20 has an outer diameter that allows for rotating screw 20 to be positioned alongside fluid production tubular 34 within well 10.

[0030] Wellhead assembly 36 can be located at an earth's surface 38 above well 10. ESP 32 is located axially lower in well 10 than perforations 14 into subterranean formation 16 and axially lower in well 10 than cyclone separator 18. Therefore production fluids will pass through cyclone separator 18 before the liquid stream reaches ESP 32 and the portion of production fluids that reaches ESP 32 will have significantly less gas than the production fluids that entered well 10 through perforations 14. This will reduce the risk of gas lock in ESP 32 and increase the efficiency of ESP 32.

[0031] ESP 32 is operable to draw the liquid stream from within well 10, including from inner diameter surface 13 of well 10, and direct the liquid stream into fluid production tubular 34. ESP 32 will provide sufficient lift to the liquid stream to deliver the liquid stream to wellhead assembly 36 through fluid production tubular 34.

[0032] Gas stream 26 can travel axially downward along the helical path of thread surfaces 22, between adjacent thread surfaces 22. When gas stream 26 reaches a bottom end of rotating screw 20, gas stream 26 will enter central passage 24. Central passage 24 is oriented to direct gas stream 26 upwards towards a lower end 40 of gas production tubular 42. Gas production tubular 42 extends into well 10. An upper end of gas production tubular 42 is associated with wellhead assembly 36. Lower end 40 of gas production tubular 42 is axially higher in well 10 than perforations 14. Therefore rotating screw 20 is positioned axially between lower end 40 of gas production tubular 42 and ESP 32. Gas production tubular 42 extends through packer 17 and is separate from fluid production tubular 34.

Production fluids will pass through cyclone separator 18 before gas stream 26 reaches gas production tubular 42 and the portion of production fluids that reaches gas production tubular 42 will have significantly less liquid than the production fluids that entered well 10 through perforations 14.

[0033] In order to confirm the performance of the systems and method described herein, multiphase modeling of various operation conditions were developed. Looking at Table 1, the operations conditions used in the modeling are shown. Table 2 sets for the results of the modeling in terms of the pressures and gas volume fraction obtained for the listed operating conditions. In Tables 1-2, the following data is included:

Rate = flow of production fluids in barrels per day (BPD).

WCT = water cut shown as the ratio of water produced to the volume of total liquid produced.

GOR (and GOR rate) = gas oil ratio shown as the volume of gas in standard cubic feet (SCF) relative to the volume of crude oil in barrels (STB) that is produced.

Qo Rate = flow of oil in barrels per day (BOPD).

Qw Rate = flow of water in barrels per day (BWPD).

WCT Rate = flow of water in barrels per day divided by the sum of the flow of oil in barrels per day plus the flow of water in barrels per day shown as a percentage.

Ql Rate = flow of total liquids in barrels per day (BWPD).

Qg Rate = flow of gas in million standard cubic feet per day (MMSCFD).

Downhole Sep Liq/Gas Phase = the amount of liquid in the gas stream, given as a percentage.

Downhole Sep Gas/Liq Phase = the amount of gas in the liquid stream, given as a percentage.

PIP ESP = pump-intake pressure in pounds per square inch gage (psig).

PDP ESP = pump discharge pressure in pounds per square inch gage (psig).

GVF = the ratio of the gas volumetric flow rate to the total volumetric flow rate, shown as a percentage.

TBG FBHP = tubing flowing bottom hole pressure in pounds per square inch gage (psig).

Holdup = the fraction of liquid present in an interval of the gas string, shown as a percentage of overall fluid in the interval of the gas string.

The ESP string is fluid production tubular 34 and the gas string is gas production tubular 42.

RATE	WCT	GOR	RATES							DOWNHOLE SEP EFF		
			Qo	Qw	WCT	QL	Qg	GOR		Downhole Sep Liq/Gas Phase	Downhole Sep Gas/Liq Phase	Downhole Sep Efficiency
BPD	%	SCF/STB	BOPD	BWPD	%	BWPD	MMSCFD	SCF/STB				
MED	LOW	LOW	2,000	222	10%	2,222	1.41	703		10%	10%	High
			2,000	222	10%	2,222	1.41	703		25%	35%	Medium
			2,000	222	10%	2,222	1.41	703		50%	70%	Low
MED	MED	MED	2,000	667	25%	2,667	3.00	1,500		10%	10%	High
			2,000	667	25%	2,667	3.00	1,500		25%	35%	Medium
			2,000	667	25%	2,667	3.00	1,500		50%	70%	Low
HIGH	MED	MED	4,000	1,333	25%	5,333	6.00	1,500		10%	10%	High
			4,000	1,333	25%	5,333	6.00	1,500		25%	35%	Medium
			4,000	1,333	25%	5,333	6.00	1,500		50%	70%	Low
HIGH	MED	MED	4,000	1,333	25%	5,333	12.00	3,000		10%	10%	High
			4,000	1,333	25%	5,333	12.00	3,000		25%	35%	Medium
			4,000	1,333	25%	5,333	12.00	3,000		50%	70%	Low
HIGH	HIGH	HIGH	4,000	4,000	50%	8,000	12.00	3,000		10%	10%	High
			4,000	4,000	50%	8,000	12.00	3,000		25%	35%	Medium
			4,000	4,000	50%	8,000	12.00	3,000		50%	70%	Low

Table 1: Operation Conditions (rates, downhole efficiency)

RATE BPD	WCT %	GOR SCF/STB	ESP STRING			GAS STRING		
			PIP-ESP PSIG	PDP-ESP PSIG	GVF %	TBG FBHP PSIG	HoldUP %	QG MMSCFD
MED	LOW	LOW	1,753	2,798	1.1%	1,437	0.1%	0.25
			1,763	2,810	2.0%	2,436	52.0%	0.18
			1,704	2,708	5.0%	3,322	99.0%	0.08
	MED	MED	1,837	2,914	2.4%	1,216	13.8%	1.68
			1,705	2,678	11.7%	1,230	14.9%	1.40
HIGH	MED	MED	1,387	2,062	41.5%	1,911	36.9%	0.56
			1,929	3,083	1.5%	1,058	3.8%	3.36
			1,936	2,792	12.5%	1,255	12.4%	2.43
	MED	HIGH	1,752	2,420	32.3%	1,894	34.4%	1.12
			1,912	2,936	7.4%	1,647	0.0%	8.76
			1,816	2,440	36.1%	1,483	2.8%	6.32
	HIGH	HIGH	1,872	2,243	33.9%	1,450	13.3%	2.90
			1,646	3,449	5.9%	1,868	1.8%	8.76
			1,630	3,012	28.1%	1,874	7.0%	6.30
			1,787	2,673	48.6%	2,274	28.4%	2.92

Table 2: Model Results (ESP string and Gas string)

[0034] As can be seen in Table 1 and Table 2, with a low downhole separation efficiency there are instances where the gas string and the ESP string will not be able to produce fluids to the surface. Having tested cyclone separator 18 at the surface, it was found that the efficiency of cyclone separator 18 can be high relative to current technologies, and in the range of 81% to 93%.

[0035] Looking at Figure 3, results of the GVF of the ESP string from Table 2 are compared to the GVF in the ESP string that could be obtained using embodiments of the cyclone separator 18 disclosed herein. With the efficiency of cyclone separator 18, the GVF of the fluids passing through ESP 32 are significantly reduced and ESP 32 can operate without gas lock and more efficiently compared to the example model.

[0036] Looking at Figure 4, results of the tubing flowing bottom hole pressure of the gas string from Table 2 are compared to the tubing flowing bottom hole pressure in the gas string that could be obtained using embodiments of the cyclone separator 18 disclosed herein. With the efficiency of cyclone separator 18, the tubing flowing bottom hole pressure of the fluids passing into lower end 40 of gas production tubular 42 will be significantly lower such that the gas can more easily and efficiently be produced to the surface.

[0037] Therefore, as disclosed herein, embodiments of the systems and methods of this disclosure will increase oil and gas production, maintaining the hydrocarbon supply with a higher production rate per well. Hydrocarbon recovery can be expedited, especially for high GOR wells and wells with high WCT. Using the systems and methods disclosed herein, wells with high surface network backpressure can be produced and the frequency of ESP failures can be reduced.

[0038] Embodiments of the disclosure described herein, therefore, are well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the disclosure has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the present disclosure and the scope of the appended claims.

CLAIMS

What is claimed is:

1. A system for producing hydrocarbons from a subterranean well, the system comprising:

a fluid production tubular extending into the well;

a gas production tubular extending into the well separate from the fluid production tubular;

an electrical submersible pump in fluid communication with the fluid production tubular;

a cyclone separator within the well, the cyclone separator having:

a rotating screw with thread surfaces open to an inner diameter surface of the well, the rotating screw positioned between a lower end of the gas production tubular and the electrical submersible pump, the thread surfaces angled to direct a liquid stream axially downward and radially outward towards the inner diameter surface of the well; and

a central passage extending through the rotating screw and oriented to direct a gas stream towards the lower end of the gas production tubular.

2. The system of claim 1, wherein the thread surfaces of the rotating screw are angled to direct the gas stream axially downward and radially inward, relative to the liquid stream.

3. The system of claim 1 or claim 2, further comprising a packer located within the well downstream of the cyclone separator, wherein the fluid production tubular and the gas production tubular extend through the packer.

4. The system of any of claims 1-3, wherein the cyclone separator is located within the well adjacent to perforations into a subterranean formation.

5. The system of any of claims 1-4, wherein the electrical submersible pump is located axially lower in the well than perforations into a subterranean formation.

6. The system of any of claims 1-5, wherein the lower end of the gas production tubular is located axially higher in the well than perforations into a subterranean formation.

7. The system of any of claims 1-6, wherein the electrical submersible pump is operable to draw the liquid stream from the inner diameter surface of the well and direct the liquid stream into the fluid production tubular.
8. The system of any of claims 1-7, wherein the inner diameter surface of the well is an inner diameter surface of a well casing.
9. The system of any of claims 1-8, wherein the fluid production tubular and the gas production tubular extend separately to a wellhead assembly.
10. A system for producing hydrocarbons from a subterranean well, the system comprising:
 - a fluid production tubular extending into the well and through a packer that fluidly seals across a casing of the well;
 - a gas production tubular extending into the well and through the packer;
 - an electrical submersible pump in fluid communication with the fluid production tubular;
 - a cyclone separator within the well, the cyclone separator having:
 - a rotating screw with thread surfaces open to an inner diameter surface of the casing, the rotating screw positioned adjacent to perforations through the casing, the thread surfaces angled to direct a liquid stream radially outward towards the inner diameter surface of the casing and to direct a gas stream radially inward relative to the liquid stream; and
 - a central passage extending axially through the rotating screw and oriented to direct the gas stream towards a lower end of the gas production tubular.
11. The system of claim 10, wherein the electrical submersible pump is located axially lower in the well than the perforations.
12. The system of claim 10 or claim 11, wherein the lower end of the gas production tubular is located axially higher in the well than the perforations.
13. The system of any of claims 10-12, wherein the electrical submersible pump is operable to draw the liquid stream from the inner diameter surface of the casing and direct the liquid stream into the fluid production tubular.

14. The system of any of claims 10-13, wherein the fluid production tubular and the gas production tubular extend separately to a wellhead assembly.

15. A method for producing hydrocarbons from a subterranean well, the method comprising:

extending a fluid production tubular into the well;

extending a gas production tubular into the well, the gas production tubular being separate from the fluid production tubular;

providing an electrical submersible pump in fluid communication with the fluid production tubular;

providing a cyclone separator within the well, the cyclone separator having:

a rotating screw with thread surfaces open to an inner diameter surface of the well, the rotating screw being positioned between a lower end of the gas production tubular and the electrical submersible pump; and

a central passage extending through the rotating screw; and

operating the cyclone separator so that the thread surfaces direct a liquid stream axially downward and radially outward towards the inner diameter surface of the well and the central passage directs a gas stream towards the lower end of the gas production tubular.

16. The method of claim 15, further comprising directing the gas stream axially downward and radially inward relative to the liquid stream with the thread surfaces of the rotating screw.

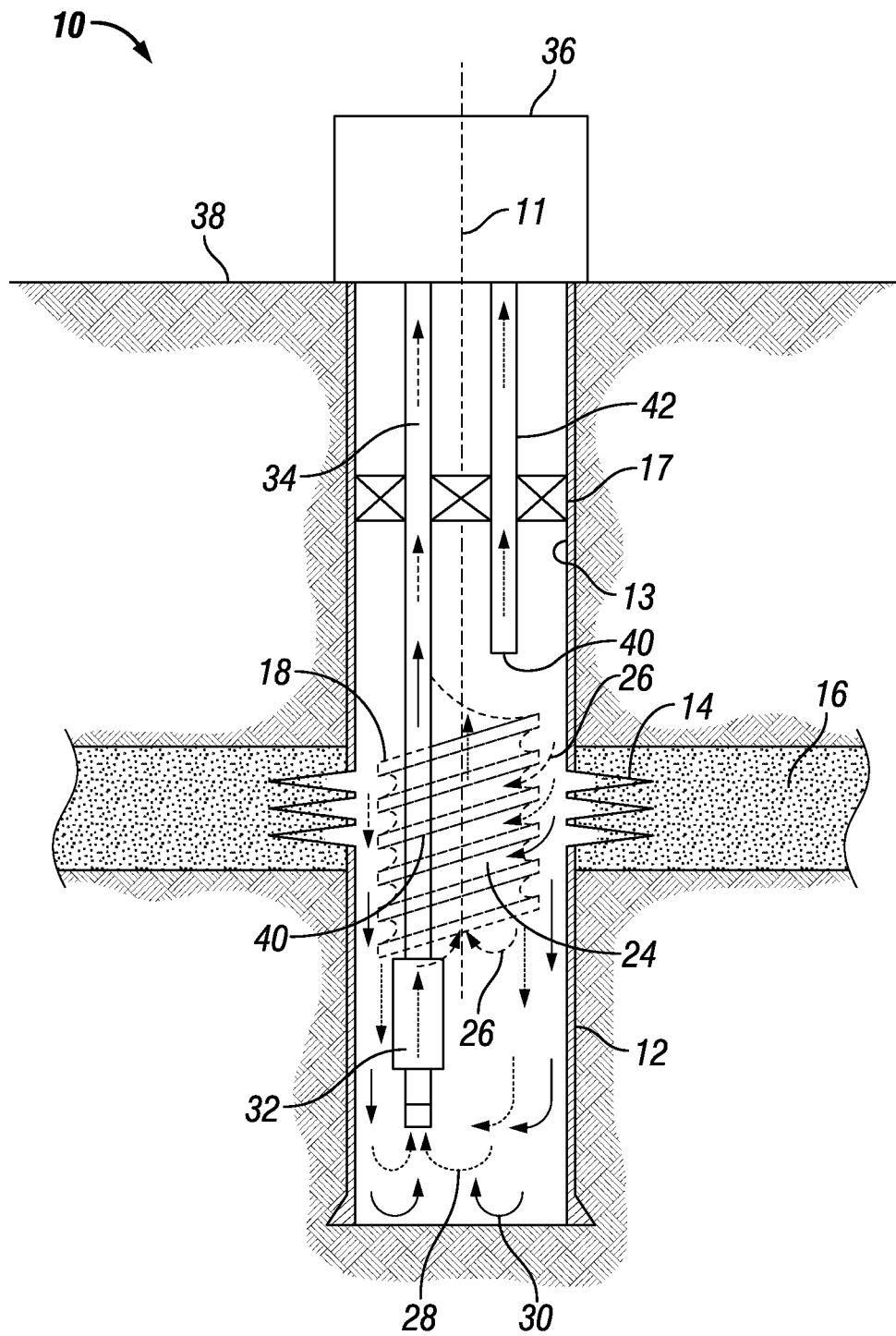
17. The method of claim 15 or claim 16, further comprising sealing a portion of the well with a packer located within the well downstream of the cyclone separator, wherein the fluid production tubular and the gas production tubular extend through the packer.

18. The method of any of claims 15-17, further comprising locating the cyclone separator adjacent to perforations into a subterranean formation.

19. The method of any of claims 15-18, further comprising operating the electrical submersible pump to draw the liquid stream from the inner diameter surface of the well and direct the liquid stream into the fluid production tubular.

20. The method of any of claims 15-19, further comprising producing the liquid stream and the gas stream separately to a wellhead assembly.

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**FIG. 1**

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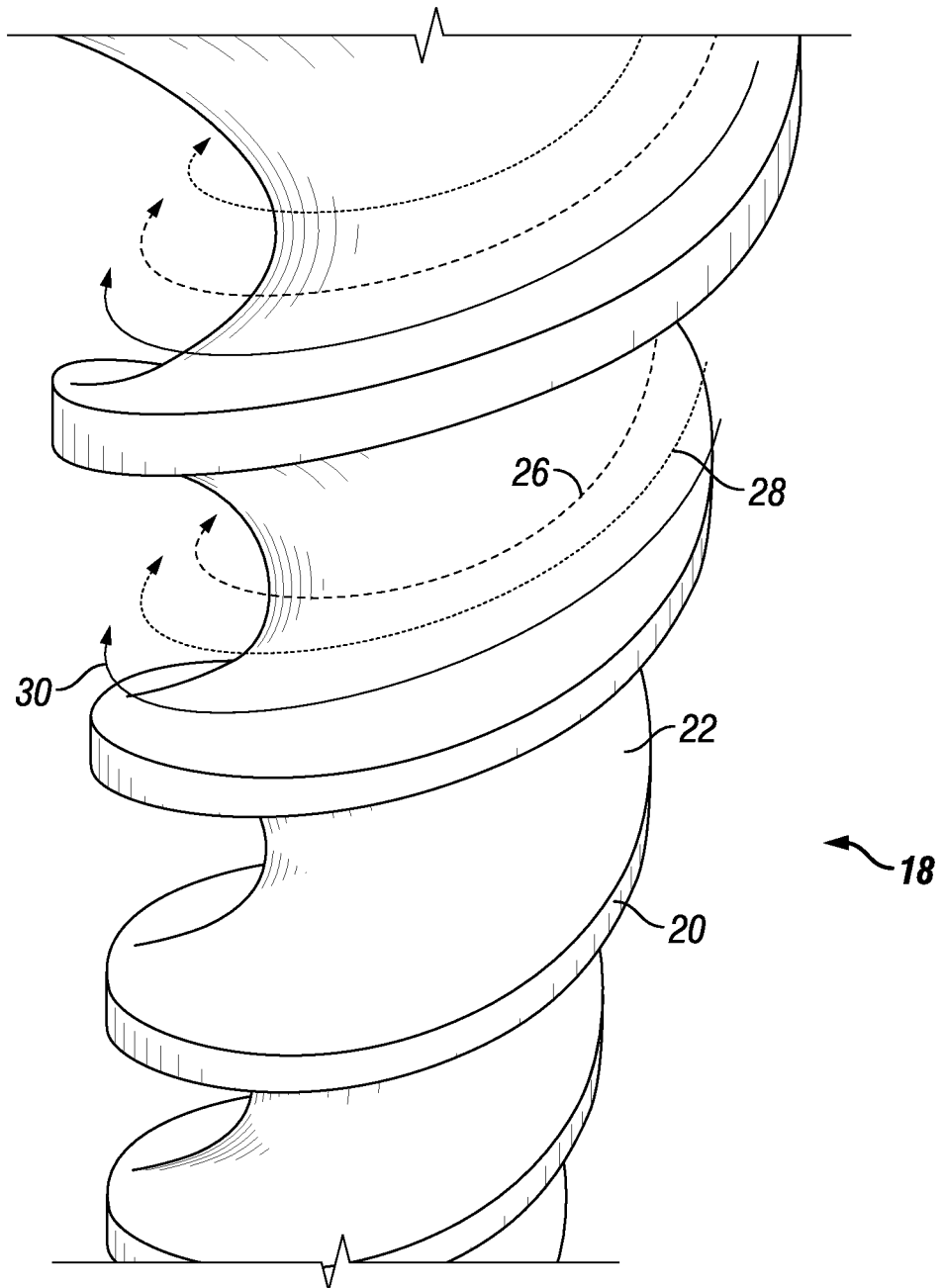


FIG. 2

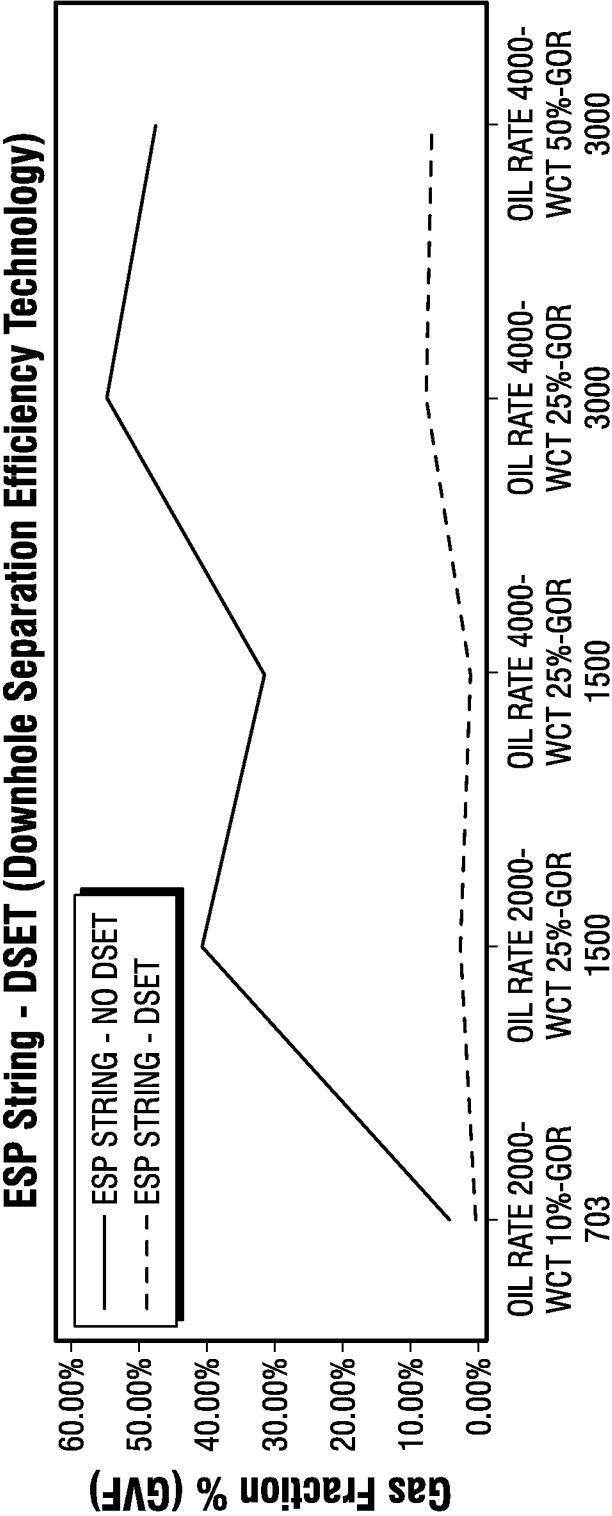


FIG. 3

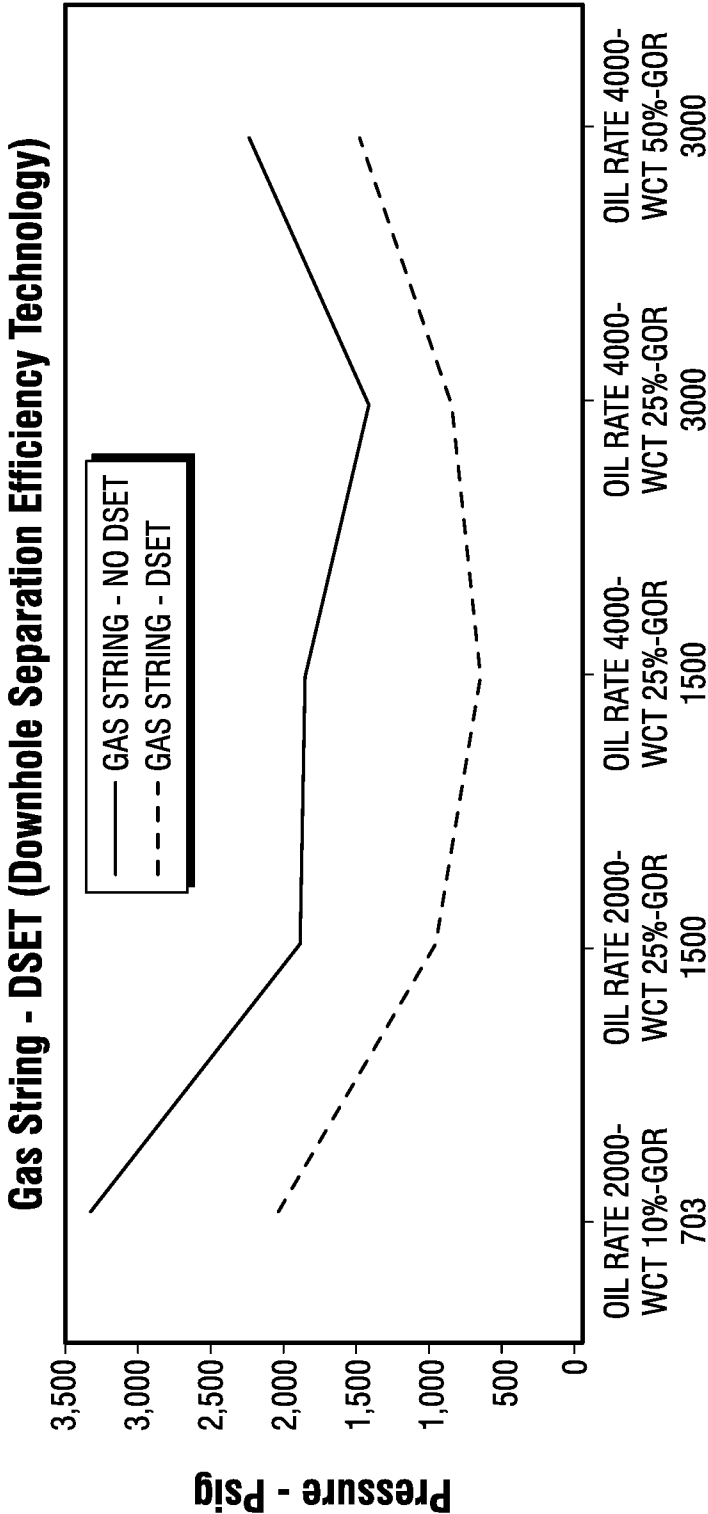


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/040165

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B43/38 E21B43/12
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B F04B F04D F04C B01D B04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2004/031608 A1 (HALL JARED C [US] ET AL) 19 February 2004 (2004-02-19) figures 1-2 paragraphs [0001], [0019], [0022], [0024], [0026], [0028] - [0031], [0040] - [0048], [0051], [0055] the whole document -----	1-20
Y	US 2014/216720 A1 (WANG CHENGBAO [US] ET AL) 7 August 2014 (2014-08-07) figures 1,2,6 paragraphs [0004] - [0006], [0019], [0021], [0022], [0026], [0032], [0034] - [0036] the whole document ----- -/-	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

5 October 2017

Date of mailing of the international search report

16/10/2017

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Pasquini, Matteo

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/040165

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	US 6 167 965 B1 (BEARDEN JOHN L [US] ET AL) 2 January 2001 (2001-01-02) figures 3-L, 3-0 column 1, lines 11-17 column 29, lines 43-47 the whole document -----	1-20

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