



(43) International Publication Date
21 September 2017 (21.09.2017)

- (51) International Patent Classification:
E21B 43/12 (2006.01)
- (21) International Application Number:
PCT/EP2017/056158
- (22) International Filing Date:
15 March 2017 (15.03.2017)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
62/308,593 15 March 2016 (15.03.2016) US
- (71) Applicant: STATOIL PETROLEUM AS [NO/NO]; For-
usbeen 50, 4035 Stavanger (NO).
- (72) Inventors: JENSEN, Tord; Kattedbakken 12, 9411 Harstad
(NO). LARSEN, Ivar Øystein; c/o Statoil ASA, 4035
Stavanger (NO). VALLE, Arne; Fogtegeta 25, N-3936
Porsgrunn (NO). FEVANG, Øivind; c/o Statoil ASA,
4035 Stavanger (NO).
- (74) Agent: BRANDERHORST, Matthijs; Marks & Clerk
LLP, Fletcher House (2nd Floor), Heatley Road, Oxford
Science Park, Oxford Oxfordshire OX4 4GE (GB).

- (81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN,
KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA,
MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG,
NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS,
RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY,
TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: ARTIFICIAL LIFT METHOD

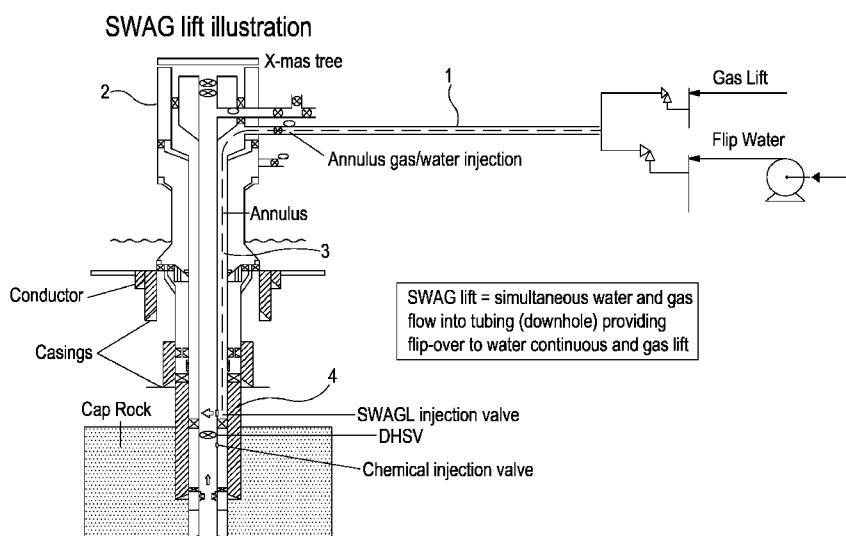


Fig. 1

(57) Abstract: An artificial lift method is provided which is suitable for use in heavy oil reservoirs. The method comprises injecting a combination of water and gas into a well to create artificial lift.

Artificial lift method

Production wells are used to produce fluid from reservoirs in the geological subsurface. In particular, fluids in the form of oil and gas are produced through wells, as is routinely the case in the oil and gas industry. The production fluid is typically received in the well from the subsurface reservoir due to the natural pressure conditions, and then flows out of the well inside a dedicated production tubing disposed in the well. The flow of gas and liquids in a production well takes place as a result of pressure in the reservoir. The naturally occurring pressure may be sufficient to lift the fluids to the surface. In addition to the natural flow of fluids, an artificial pressure may be added to increase the flow, or create a flow if the naturally occurring pressure is not sufficient to lift the fluids to the surface. The artificial pressure is also referred to as artificial lift. An electric submersible pump (ESP) is a downhole pump which can be used to create artificial lift. A system of multiple ESP lifted wells may be used, wherein the wells are connected to a common manifold. The production fluid from the well is then transported along pipelines to a downstream facility, for example a floating production platform (in the case of an offshore well) where the fluid may be processed further. Additional booster pumps may be provided in the production system at the surface, for example on the seabed, to help pump the production fluid from the well along the pipeline to the downstream facility at a suitable rate.

Existing methods for creating artificial lift for a high production rate, for example over 1000 standard cubic metre per day, are: gas lift for conventional oil wells, ESP mainly for heavy oils, HSP (hydraulic submersible pumps) mainly for heavy oils, rod pumps and hydraulic jet pumps.

The main problems with the current technology ESP are: a limited life time (0.5-1.5 years) before they have to be changed; high cost of changing the ESP (need a drilling rig to change the pump); loss of production when the ESP is down; higher well cost due to down hole equipment (in addition to the ESP itself); high OPEX of the ESP pump; cost, weight and space of the topside equipment to control the pump (mainly VSD); down hole diluent may be required to reduce the viscosity of the fluid in the well. The diluent is expensive and uses some of the available surface process capacity

The invention provides a method and system as defined in the accompanying claims.

Some embodiments of the invention will now be described by way of example only and with reference to the accompanying drawing, in which:

5

Fig.1 illustrates schematically a system;

Fig.2 illustrates a method.

The method described herein may be used as an artificial lift method for heavy oil reservoirs where gas-lift cannot be applied due to high viscosity of the reservoir oil.

10

The method described herein provides for a method of injecting a combination of water and gas into a well. This method may be used to create artificial lift. The water and gas may be injected simultaneously into the well.

15

The water and gas may be injected into the well through holes in the production tubing, optionally as deep as possible such that injection takes place close to a lower completion section. The holes in the production tubing may be provided with valves to control the inflow of water and gas.

20

The water and gas may be transported down in the annular space between the tubing and the smallest casing. Alternatively, the water and gas may be transported down in a single shared tubing which is provided inside or outside the production tubing. Alternatively, the water and gas may be transported down in separate tubing inside or outside the production tubing, wherein a first tube is provided for the water and a second tubing for the gas. With separate tubing, water can be provided at any position upstream the gas injection. Water can also be provided by extending the well or a well branch into an aquifer.

25

An advantage of adding or injecting water to the produced reservoir fluid is to generate a flow regime inside the production tubing with a low apparent viscosity, when compared to reservoir fluid without water, to reduce the frictional pressure loss. An advantage of adding or injecting gas to the produced reservoir fluid is to generate a fluid mixture in the tubing with low apparent density, when compared to reservoir fluid without gas.

35

Consequently, by adding, injecting and/or mixing water and gas down hole in the well with the produced reservoir fluid, the fluid mixture in the tubing will have both low viscosity and low density, thereby combining the advantages of water and gas.

5

The amount of water and gas injected into the production tubing down hole can be regulated continuously to maximize the production of reservoir fluid. The amount of water and gas injected into the well may be varied depending on the composition of the produced fluid, such as water cut and gas liquid ratio of the produced reservoir fluid.

10 Addition of water with continuous flow conditions can be one solution to secure low apparent viscosity of the fluid in the production tubing.

Injection of both water and gas simultaneously reduces pressure losses both due to friction and gravity. Without adding further pressure, the well pressure itself may be sufficient to transport the production fluids to the surface in combination with the reduction of pressure losses after injection of water and gas.

15

The added water to reduce friction pressure loss may also be used in connection with transportation of heavy oil outside the well, such as in pipeline transportation of oil.

20

Further advantages of the method disclosed herein are: reduction of cost (CAPEX and OPEX), improved well regularity (avoid replacement of ESP's, expensive rig time), reduced weight (mainly VSD's), improvement of the utilization of the surface processing capacity (avoid injection of diluent before it is needed in the surface process). An ESP is sensitive to gas, and the use an ESP will influence the position of the wells in a reservoir with a gas cap. Using gas lift can increase the flexibility of where to position the well path, thereby enhancing the production from the field. An ESP limits the well paths (e.g. maximum dog leg), while the present method does not put any restrictions on the well path which may allow for a more optimum placement of wells with respect to recovery and production rate. Addition of water will influence the amount of water which generates water continuous conditions, which improves oil/water and gas/liquid separation downstream of the wellhead.

25

30

Figure 1 illustrates a specific implementation for SWAGL (simultaneous water and gas injection lift). The gas and water are mixed above the sea bed and combined in a

35

single tube (1). The tube extends through the Christmas tree (2) into an annulus (3), which is provided outside the innermost tubular extending towards the bottom of the well. The tube terminates at a valve (4) provided at an opening in the tubular. The opening is provided below the water, below the seafloor and below the cap rock. Other
5 alternatives are injection of water and gas in single or separate tubings inside or outside the production tubing, or controlled water production from the aquifer combined with conventional gas lift.

Figure 2 illustrates a method of combining gas and water (S1), and injecting the
10 combination of water and gas into a well to create artificial lift (S2).

Although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only and that the claims are not limited to those embodiments. Those skilled in the art will be
15 able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims. Each feature disclosed or illustrated in the present specification may be incorporated in the invention, whether alone or in any appropriate combination with any other feature disclosed or illustrated herein.

20

Claims

1. An artificial lift method suitable for use in heavy oil reservoirs; the method comprising:
5 injecting a combination of water and gas into a well to create artificial lift.
2. The method of claim 1, wherein the water and gas are injected simultaneously into the well.
- 10 3. The method of claim 1 or 2, wherein the water and gas are injected into the well through one or more openings in the production tubing,
4. The method of any preceding claim, wherein the water and gas are injected deep in the well such that injection takes place close to a lower completion section.
15
5. The method of claim 3, wherein the one or more openings in the production tubing are provided with valves to control the inflow of water and gas.
6. The method of any preceding claim, wherein the water and gas are transported
20 downhole in an annular space between the tubing and the casing.
7. The method of any one of claims 1 to 5, wherein the water and gas are transported downhole in a single shared tubing which is provided inside or outside the production tubing.
25
8. The method of any one preceding claim, wherein the water and gas are transported down in separate tubing inside or outside the production tubing, wherein a first tube is provided for the water and a second tubing for the gas.
- 30 9. The method of claim 8, wherein water is provided at a position upstream the gas injection.
10. The method of any preceding claim, wherein water is provided by extending the well or a well branch into an aquifer.
35

6

11. A system for providing artificial lift suitable for use in heavy oil reservoirs; the system comprising:

5 a combined tube extending through a Christmas tree into an annulus of the well and terminating at a valve provided at an opening in a tubular, wherein the tube is arranged to provide a combination of gas and water at the opening in the tubular.

12. The system of claim 11, wherein the opening is provided below the water, below the seafloor and below the cap rock.

10

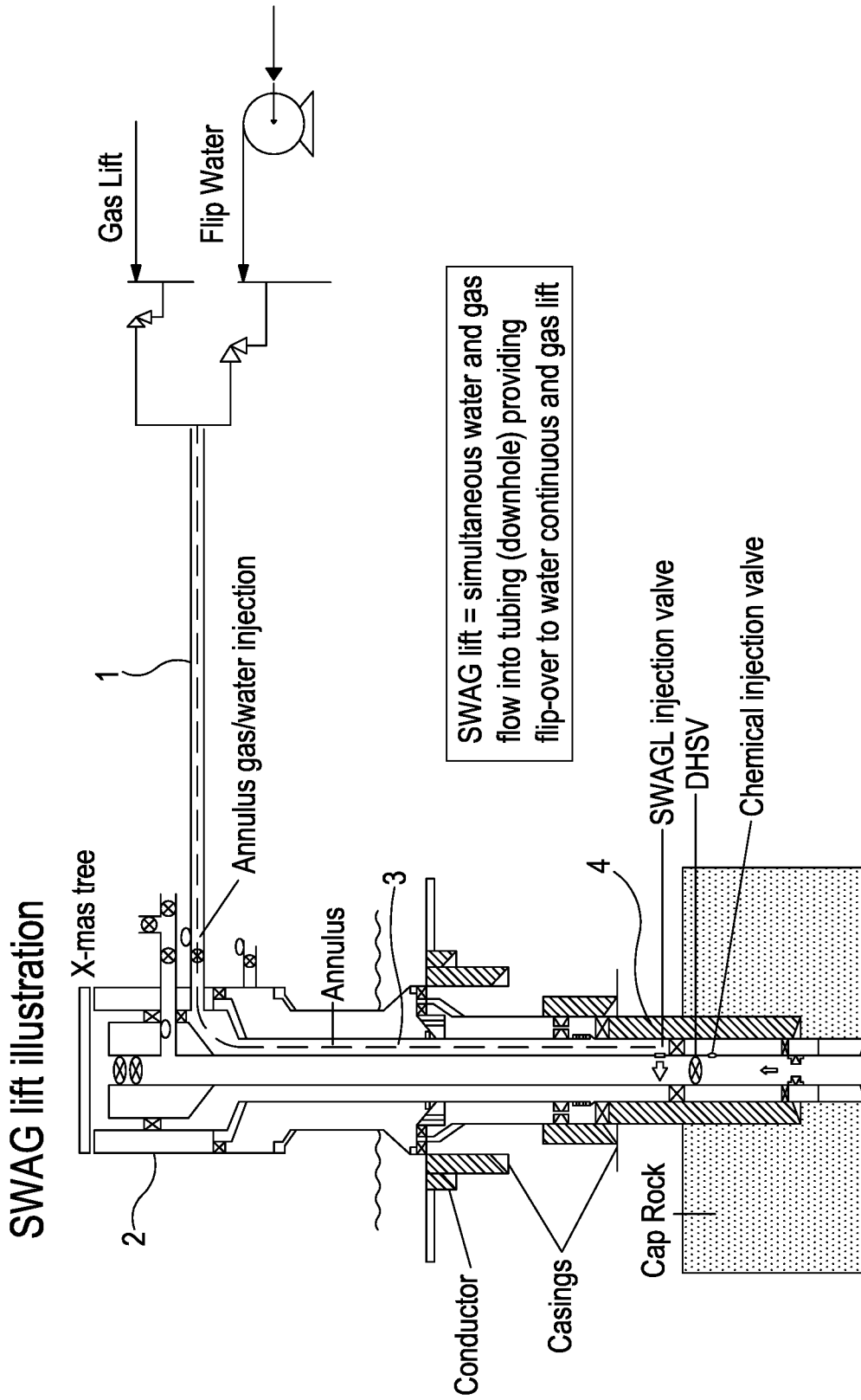


Fig. 1

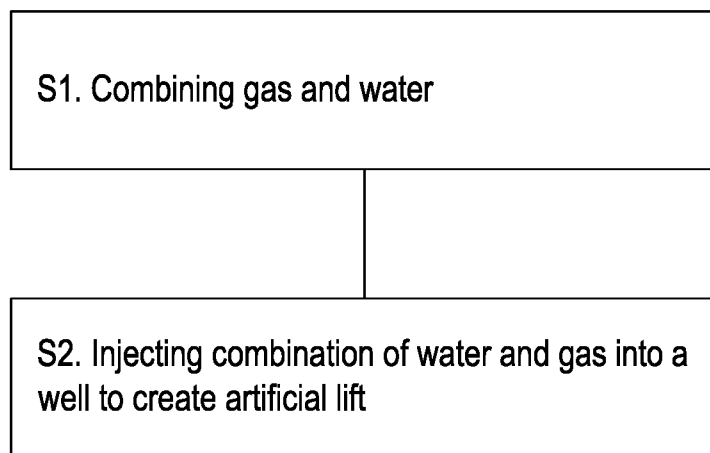


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/056158

A. CLASSIFICATION OF SUBJECT MATTER
INV. 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

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011/278015 A1 (MAZZANTI DARYL V [US]) 17 November 2011 (2011-11-17) paragraph [0049] -----	1-12
Y	US 5 421 408 A (STOISITS RICHARD F [US] ET AL) 6 June 1995 (1995-06-06) page 2, lines 16-37 -----	1-12
Y	US 2013/312980 A1 (STOISITS RICHARD F [US] ET AL) 28 November 2013 (2013-11-28) the whole document -----	1-12
Y	WO 2015/197422 A2 (MAERSK OLIE & GAS [DK]) 30 December 2015 (2015-12-30) paragraph [0052] -----	1-12

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search 9 May 2017	Date of mailing of the international search report 22/05/2017
---	--

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Manolache, Iustin
--	---

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/056158

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011278015	A1	17-11-2011	AR 087313 A1 12-03-2014
			AU 2012287267 A1 30-01-2014
			BR 112014001670 A2 21-02-2017
			CA 2842045 A1 31-01-2013
			CN 104024564 A 03-09-2014
			CO 6950450 A2 20-05-2014
			EA 201490310 A1 28-11-2014
			EP 2737166 A2 04-06-2014
			JP 2014523989 A 18-09-2014
			PE 10572014 A1 21-09-2014
			US 2011278015 A1 17-11-2011
			US 2015247390 A1 03-09-2015
			US 2016108709 A1 21-04-2016
			WO 2013015826 A1 31-01-2013
			WO 2013016097 A2 31-01-2013

US 5421408	A	06-06-1995	NONE

US 2013312980	A1	28-11-2013	NONE

WO 2015197422	A2	30-12-2015	DK 201671046 A1 27-02-2017
			EP 3161248 A2 03-05-2017
			WO 2015197422 A2 30-12-2015
