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Production of a dead oil well by a progressive cavity pump and its optimization

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Abstract

In the context of oil and gas extraction, a dead well refers to a well that has ceased to produce hydrocarbons. The major problems that account for this are: the reservoir has been depleted, the pressure has dropped too low to allow for extraction, or there are technical issues such as blockages or equipment failure. The main objective of this paper is to analyze the performance of a dead well called K88 (for confidential reasons) activated by the progressive cavity pump (PCP) in order to improve and maximize the oil flow rate produced. The completion, reservoir, production pressure, volume, and temperature (PVT) data are processed under Excel and Prosper software by using nodal analysis, sensitive analysis, economic analysis, and decline curve methods to obtain the results. The results showed that well K88 activated by the PCP has an oil flow rate of 1600.9 STB/day. The optimization makes it possible to obtain a net oil flow rate of 2005 STB/day associated with a head pressure of 45 psig. According to the economic calculation results, a gain in production is noticed during 10 years of production and a return on investment at the latest 39 days of production.

Keywords: Dead well; progressive cavity pump; nodal analysis; optimization; prosper software; return on investment.

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1- Introduction

The natural exploitation of oil deposits, known as primary exploitation, involves the energy stored in the reservoir in the form of pressure in the rock and in the compressed fluid [1-3]. As production progresses, reservoirs begin to deplete, and the production capacity of wells declines [4-6]. This decline is caused by a decrease in the reservoir's ability to deliver fluid to the well (a drop in blowout energy) and in some cases is caused by increased pressure losses in the production column [7-10]. When this energy fails to meet production constraints despite large reserves in place, artificial lift, and secondary recovery techniques are introduced to improve potential and increase production [11-13]. Well, activation techniques used in the literature include gas lift, progressive cavity pump, hydraulic pump, and rod pump [14-17].

Progressive cavity pump technology has evolved considerably over the last few decades, offering a multitude of solutions and options to overcome the problems and constraints that previously limited the use of this technique [1, 18]. These are being introduced with a view to improving potential and increasing production [19, 20]. The choice of lifting system depends on well and reservoir characteristics, financial considerations, and well location. It is with a view to adapting a sophisticated method in the field called K (for reasons of confidentiality) that the choice of study in this paper focuses on "bringing a dead oil well into production by a progressive cavity pump and its optimization". The K field formation is unconsolidated Greccia and the gas-oil ratio (GOR) is low, so the activation mode is one of the main production systems on these fields for Upper Cretaceous wells. Production from the K field has fallen considerably (2.5 m^3 to 0.8 m^3/h) due to the drop in formation pressure. It is therefore necessary to use a more suitable lifting system to promote more profitable extraction.

The main objective of this work is to analyze the performance of PCP activation well K88 in order to improve and maximize the oil flow rate produced. The specific objectives that contribute to this overall objective are as follows: Model the production system using PROSPER software, analyze the sensitivity of well performance to various parameters, and carry out an economic evaluation. To address the above concerns, the paper will be divided as follows: Section 1 presents the

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introduction. Section 2 presents the data and results. Section 3 presents the conclusion.

2- Data and results

To obtain the various results, several data presented in Table 1 were made available, namely: Reservoir data, well data, PVT data, and production data.

Table 1. Data used

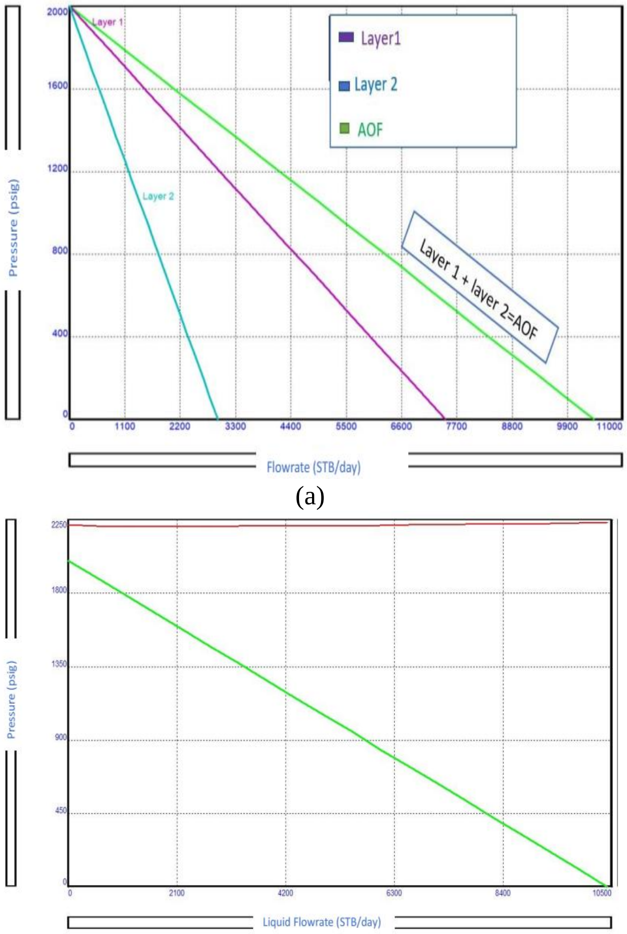
Reservoir data		
Parameters	**Values**	**Units**
Reservoir Pressure	2000	Psi
Reservoir Temperature	137.5	°F
Solution GOR	20	Sm^3/Sm^3
Parameters of K88 well		
Parameters	**Values**	**Units**
Depth	5270.1	Feet
OD casing diameter	6.05	Inch
ID casing diameter	4.95	Inch
Elevation of drilling platform	1 301.00	Feet
Completion rig elevation	1 291.00	Feet
Perforation interval (R1)	79.00	Feet
Perforation interval (R2)	45.00	Feet
Planned gravel packer depth	4 760.37	Feet
Depth of sump packer	5 158.00	Feet
PVT Data		
Parameters	**Values**	**Units**
Solution GOR	20	Sm^3/Sm^3
Oil gravity	19	API
Gas gravity	0.8	sp. gravity
Water salinity	50000	ppm
Mole percent of H_2S	0	percent
Mole percent of CO_2	0	percent
Mole percent N_2	0	percent
Production data for well K88		
Year	**Oil production (Kbarrel/day)**	**Water production (Kbarrel/day)**
2004	158.7	82
2005	174.7	165
2006	127.7	325
2007	110.8	415
2008	109.8	500

Well K88 is a vertical well drilled in 2004 and completed in oil production on the two reservoirs respectively (R1 and R2). The depth of the well K88 is 5270.1 ft. Production casing diameter is 6.05" OD. Internal casing diameter is 4.95".

2.1. Results for well K88 activated by a progressive cavity pump

The IPR curves for layers 1 and 2 and the IPR/VLP curves for well K88 in its initial state are shown in Fig. 1.

Under normal conditions, the reservoir can produce 10429.1 STB/day (maximum flow rate), i.e. 7478.2 STB/day for layer 1 and 2956.2 STB/Day for layer 2, but under the negative effect of pressure, well K88 is not responding to production, as shown in Fig. 1 a. Fig. 1 b shows that the IPR and VLP curves do not cross, so well K88 in its initial state is no longer producing, and is therefore being considered for production by PCP. The profile and operating point of the PCP-activated well K88 is shown in Fig. 2.



(a)

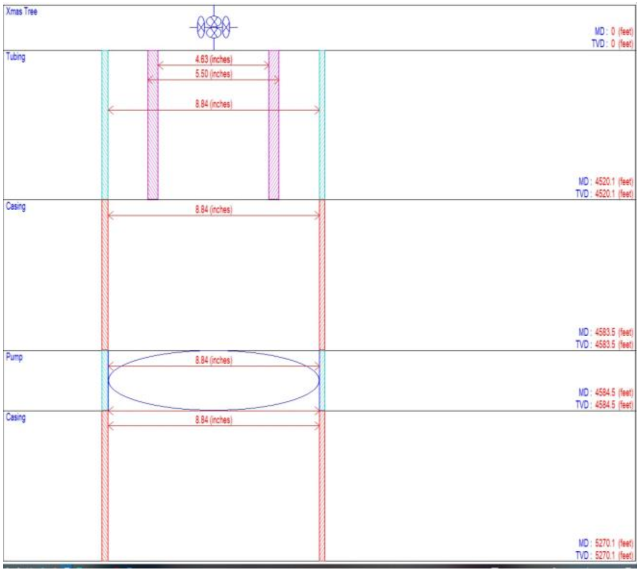
(b)

Fig. 1. (a) IPR Curves for Layers 1, 2 and (b) IPR/VLP Curves for Well k88 in Initial State. The VLP Curve is in Red and the IPR Curve is in Green

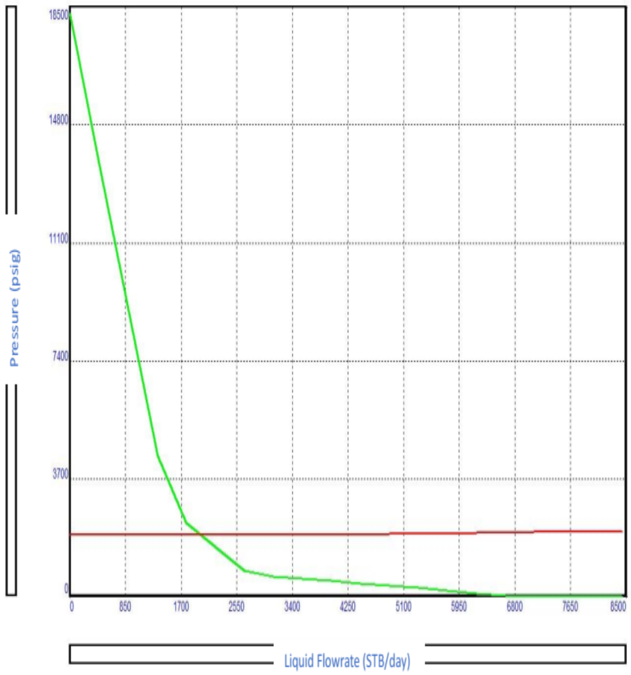
Fig. 2 a shows well K88 at a depth of 5270.1 ft with the PCP installed at 4583.5 ft and a casing of 5.50 inch OD, 4.63-inch ID and 8.84-inch casing. The operating point of the PCP-activated well K88 is determined by the intersection of the VLP and IPR curves. Fig. 2 b shows a maximum liquid production rate of 2001.1 STB/day and a maximum oil production rate of 1600.9 STB/day at a maximum pressure of 1116.28 psig.

Optimization is performed by varying the following parameters: PCP installation depth, pumping speed, and wellhead pressure. Table 2 shows the variations in the produced oil flow rate as a function of PCP installation depth.

A sensitivity analysis of the different scenarios of PCP installation depth shows that PCP installation depth has no real effect on the oil flow rate produced. Fig. 3 shows the influence of different pumping speeds on production.



(a)



(b)

Fig. 2. (a) Profile and (b) Operating Point of the PCP-Activated Well K88. The VLP Curve is in Red and the IPR Curve is in Green

Table 2. Variations in Oil Flow Rate as a Function of PCP Installation Depth

PCP installation depth (ft)	Liquid flow rate (STB/day)
4384.5	2001.3
4484.5	2001
4584.5	2001.1
4684.5	2001.2
4784.5	2001.2

The operating points corresponding to each pumping speed obtained from Fig. 3 are shown in Table 3.

Fig. 3 and Table 3 show that the increase in pumping speed is proportional to the oil flow rate. Table 4 shows the variation in produced oil flow rate as a function of well K88 head pressure.

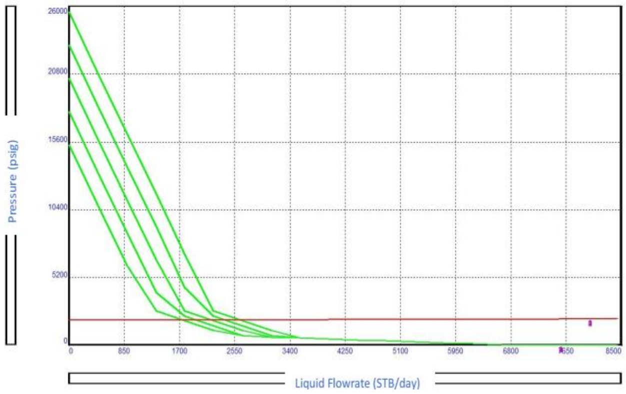


Fig. 3. Sensitivity Analysis on Pumping Speed. The VLP Curve is in Red and the IPR Curve is in Green

Table 3. Variations in Oil Flow Rate as a Function of Pumping Speed

Pumping speed (rpm)	Oil flow rate (STB/day)
500	1750.1
550	1968.9
600	2187.8
650	2406.5
700	2625.1

Table 4. Variations in Liquid Flow Rate as a Function of Wellhead Pressure for Well K88

Overhead pressure (psig)	Liquid flow rate produced (STB/d)	Downhole pressure (psig)	Reservoir pressure (psig)
45	2005	1932.29	1468.5
50	2001.1	1937.31	1468.5
55	1997.4	1942.33	1468.5
60	1993.8	1947.35	1468.5
65	1990.2	1952.36	1468.5

Table 4 shows that increasing the K88 wellhead pressure not only results in a considerable increase in production flow rate, but also increases the volume of oil drawn in for PCP and reduces the pressure drop in the production tubing. Reducing the head pressure is therefore a good idea, as it improves the pump's performance without affecting it. Fig. 4 shows the intersection of two curves (IPR and VLP) giving a liquid flow rate equal to 2550 STB/day and an oil flow rate of 2005 STB/day under the influence of the optimum parameters.

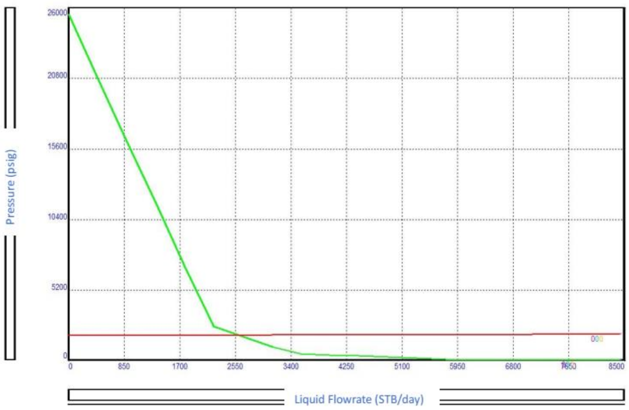


Fig. 4. Nodal Analysis of PCP-Activated Well K88 with Integration of Optimal Values. The VLP Curve is in Red and the IPR Curve is in Green

Optimal parameter values are shown in Table 5.

Table 5. Optimum Parameters

Overhead pressure (psig)	**Pump installation depth (ft)**	**Speed (rpm)**	**Oil flow rate (STB/day)**
45	4384.5	700	2005

2.2. Economic evaluation

Using the exponential form of the decline curve method, the time-dependent production trend of the PCP-activated well K88 is shown in Fig. 5.

According to Fig. 5, production from the PCP-activated K88 well decreases over time, with a duration of 10 years. Table 6 shows Capex, Opex and pay-out time as a function of the price per barrel of oil.

The results in Table 6 show that the decrease in crude oil price directly affects the payout time: the payout period is 5.17 days for the barrel of oil estimated at $70, and is expected to be around 7 days for the barrel of oil estimated at $50. Table 7 summarizes the economic evaluation of the PCP-activated well K88 over 10 years of production.

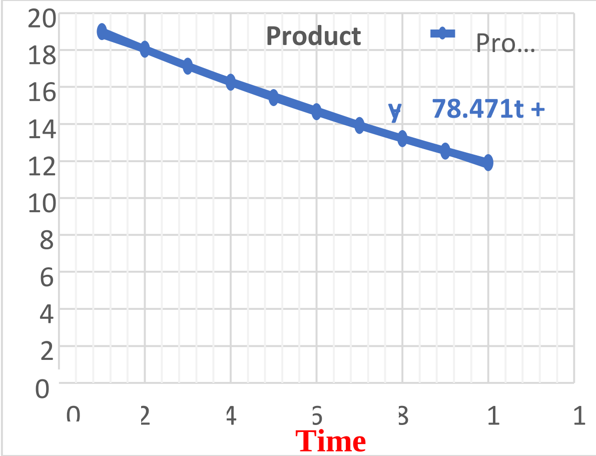


Fig. 5. Evolution of PCP-Activated K88 Well Production as a Function of Time

Table 6. Capex, Opex and Pay-Out Time as a Function of the Price of a Barrel of Oil

Production profit			**Crude oil price**	**Profit**	**Capex**	**Pay out time**
(m^3/h)	(m^3/day)	(bbl/day)	$/bbl	$/day	($)	Days
13.25	318.17	2001.1	100	200110	446118480	3.6
13.25	318.17	2001.1	70	140077	446118480	5.17
13.25	318.17	2001.1	50	100055	446118480	7.19

Table 7. Summary of the Economic Evaluation of the PCP-Activated Well K88 over 10 Years of Production

Year	**Oil Cost ($)**	**Revenue ($)**	**Cash flow**	**Net cash flow**	**Tax %**	**Net present value**	**Opex**	**Return on investment (%)**
0	720000	0	-720000	-720015	15	-720000	-50000	-1
1	1040294.9	62417692.84	70432939	70432924	15	46955293	71678413	39.277567
2	987779.5	52681573.14	59304851	59304836	15	26357712	60489976	23.220105
3	937915.15	40642990.02	45527800	45527785	15	13489718	46655622	12.51572
4	890568.03	41559841.23	46635826	46635811	15	9212014.9	47709238	9.0012749
5	845611.04	31005738.16	34559052	34559037	15	4550986.2	35580801	4.6832934
6	802923.54	32116941.59	35885066	35885051	15	3150403.6	36857760	3.4143536
7	762390.96	43202154.23	48670416	48670401	15	2848565.7	49596531	3.2513596
8	723904.51	36195225.49	40662505	40662490	15	1586587.6	41544393	1.9072133
9	687360.91	22912030.21	25439878	25439863	15	661749.6	26279771	0.8377711
10	652662.07	19579862.09	21650532	21650517	15	375453.34	22450550	0.5005922

The results in Table 7 show a good net present value (NPV) and a good return on investment of 39 days, despite a barrel price of $70/bbl. The choice of PCP activation is a good one, as it enables high-flow hydrocarbon recovery at medium, cost.

3- Conclusion

At the end of this paper, which focused on production start-up using a progressive cavity pump in the K88 dead well, the general objective was to maximize the flow rate of oil produced, and increase the productivity index while playing on the sensitivity of the parameters. The results obtained from the PROSPER and Excel data analyses indicated the correct choice of the PCP pump as the means of activation, with a rotation speed of 700 rpm and an installation depth of 4384.5 ft. The productivity of well K88 activated by a progressive cavity pump improved; from 0 STB/day to 2005 STB/day with a wellhead pressure of 45 psig. According to the economic calculation results, a very significant gain in production and a return on investment equal to no more than 39 days of production were achieved. This period of return on investment is quite small; compared to other projects.

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انتاج نفط من بئر ميت بواسطة المضخة التجويفية التقدمية وتحسين انتاجيته

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الخلاصة

في سياق استخراج النفط والغاز يشير البئر الميت الى البئر الذي توقف عن انتاج الهيدروكربونات. ان من المشاكل الرئيسية التي تفسر ذلك هي: استنفاذ الخزان او انخفضا الضغط لدرجة لاتسمح باستخراج النفط، او وجود مشكلات فنية مثل الانسداد او تعطل المعدات. ان الهدف الرئيسي من هذا البحث هو تحليل اداء بئر ميت يسمى K88 يتم تفعيله بواسطة المضخه الحلزونية التقدمية (PCP) من اجل تحسين وتعظيم معدل تدفق النفط المنتج. تتم معالجة بيانات الانجاز، الخزان، الانتاج والضغط، حجم، درجة الحرارة (PVT) بموجب برنامجي Excel وProsper باستخدام طرق التحليل العقدي والتحليل الحساس والتحليل الاقتصادي ومنحنى الانخفضا للحصول على النتائج. أظهرت النتائج ان البئر K88 الذي تم تفعيله بواسطة PCP لديه معدل تدفق للنفط قدره 1600.9 برميل / يوم. ان عملية التحسين تجعل من الممكن الحصول على معدل تدفق صافي النفط يبلغ ٢٠٠٥ برميل / اليوم مرتبط بضغط راسي يبلغ ٤٥ psig. ووفقا لنتائج الحساب الاقتصادي يلاحظ زيادة في الانتاج خلال ١٠ سنوات من الانتاج و عائد على الاستثمار في ٣٩ يوما على الاقل من الانتاج.

الكلمات الدالة: بئر ميت، المضخة الحلزونية التقدمية، التحليل العقدي، التحسين، برنامج Prosper، العائد على الاستثمار.