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Model to Detect Water Production in An Oil Reservoir

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Abstract: ***Paper Model to detect water production in an oil reservoir has been developed and this is given as equation 12. The data for this study was obtained from Well A in Reservoir x and it was assumed that there is a linear relationship between each variable and the produced water. With this understanding, the least square method of regression was approved and the Model developed is given as equation 12. Application of the model is presented in Table 2, the values zero and negative indicate that water was not produced at that particular time***

Keywords: Gas, Model, Oil, Produced Water.

I. INTRODUCTION

Major fluids that come out of a well, are crude oil and water. During the production stages, the well not only produces hydrocarbons it also produces water. Water produced water is water stuck in underground developments that are transported to the surface sideways with oil or gas. It is by far the largest volume byproduct or waste stream associated with oil and gas production and also represents a significant component in the cost of producing oil and gas[1,2].Managing of water produced poses a lot of problems to operators. Water production is a result of oil and gas exploration and production.Water produced is also known as formation water[3,4]

Detecting the source of the increased water production from a well is significant in determining whether to follow water-shutoff options. Water must be produced to recover the oil if the field is water flooded, following relative permeability, only water above this should be a focus for remedial treatments [5,6]. If this is edge water, water shutoff can be difficult, even with polymer-gel technology. Polymer-gel water-shutoff treatments have shown fruitful in cases in which faults intersect the wellbore, initiating a channel for water flow. [7].

The chemical and physical properties of produced water differ significantly dependent on the physical location of the field. [8].

It is very important to find a means of detecting water produced during oil production and this will help in controlling water produced during oil and gas production [9]. Hence this paper will look at developing a model that can detect water production during production.

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II. MATERIALS AND METHOD

The data for this study was obtained from Well A in Reservoir x. This is shown in

Table 1 below

Table 1: Production data for Well A

Wp(bbls)	Gp(MMscf)	Np(STB)	Qw(bbl/d)	Qg(Mmsefd)	Qo(STB/d)	GOR	WOR	FLP(Psi)	Choke (1/64)	Time(days)
Y	ρ_1	ρ_2	ρ_3	ρ_4 ρ_5	ρ_6		ρ_7	ρ_8	ρ_9	ρ_{10}
0	0	0	0	0	588	0	0	220	16	0
0	0	85698	0	0	1242	0	0	320	20	69
0	403.6641	342875	0	1.9131	1625	1177	0	390	24	211
0	612.416	499200	0	1.9138	1560	1227	0	350	24	320
0	701.7965	553790	0	1.7767	1402	1267	0	360	24	395
0	874.0368	713632	0	1.8837	1538	1225	0	370	24	464
590	1383.904	699740	1	2.3436	1186	1978	8.00E-04	330	24	590
0	1808.4371	753043	0	2.7113	1129	2402	0	370	24	667
0	1715.3508	724170	0	2.3924	1010	2369	0	380	24	717
1804	3901.15	820820	2	4.325	910	4753	0.002	410	24	902
986	1220.2736	429896	1	1.2376	436	2839	0.002	420	24	986
14574	3939.9768	1420965	14	3.7848	1365	2773	0.01	370	24	1041
3462	4921.5792	1579826	3	4.2648	1369	3115	0.002	500	24	1154
0	5245.704	1696170	0	4.2648	1379	3093	0	320	24	1230
2768	2740.7352	1269128	2	1.9803	917	2160	0.002	350	24	1384
10864	6618.9696	2129344	7	4.2648	1372	3108	0.005	260	24	1552
22165	6143.797	2254010	13	3.6034	1322	2726	0.01	280	24	1705
22763	5191.0146	1383290	13	2.9646	790	3753	0.016	280	24	1751
58344	7111.78	1888224	33	4.0225	1068	3769	0.031	420	24	1768
62526	1864.746	1370055	34	1.014	745	1361	0.046	280	24	1839
50706	2243.6466	1079850	27	1.1947	575	2078	0.047	250	24	1878
30375	1275.75	1176525	15	0.63	581	1084	0.026	170	24	2025
4282	782.3214	811439	2	0.3654	379	964	0.005	150	24	2141
4458	793.7469	902745	2	0.3561	405	879	0.005	240	24	2229
2341	955.128	1233707	1	0.408	527	774	0.002	500	24	2341
0	1168.313	1251590	0	0.4798	514	933	0	290	24	2435
766287	4280.0796	2179998	303	1.6924	862	1963	0.352	380	24	2529
1124496	4160.9088	2073888	411	1.5208	758	2006	0.542	300	24	2736
1208136	4544.69	2688528	426	1.6025	948	1709	0.449	610	24	2836
796325	4870.504	2527205	265	1.6208	841	1927	0.315	450	24	3005
1328397	5798.2818	2165256	427	1.8638	696	2678	0.614	450	24	3111
1381392	6040.0062	2251278	424	1.8539	691	2683	0.614	430	20	3258
1510413	6876.265	2172697	447	2.035	643	3165	0.695	440	20	3379
1173492	3548.3156	1430744	333	1.0069	406	2480	0.82	290	20	3524
1320956	3995.2836	1629634	364	1.0934	446	2452	0.816	330	20	3654

It was assumed that there is a linear relationship between each variable and the produced water. With this understanding, the least square method of regression was approved10-11 The regression equation is given in equation (1) below.

$$Y = nb_0 + b_1\rho_1 + b_2\rho_2 + b_3\rho_3 + b_4\rho_4 + b_5\rho_5 + b_6\rho_6 + b_7\rho_7 + b_8\rho_8 + b_9\rho_9 + b_{10}\rho_{10} \quad (1)$$

$$\sum y = nb_0 + b_1\sum\rho_1 + b_2\sum\rho_2 + b_3\sum\rho_3 + b_4\sum\rho_4 + b_5\sum\rho_5 + b_6\sum\rho_6 + b_7\sum\rho_7 + b_8\sum\rho_8 + b_9\sum\rho_9 + b_{10}\sum\rho_{10} \quad (2)$$

$$\sum y\rho_1 = b_0\sum\rho_1 + b_1\sum\rho_1^2 + b_2\sum\rho_1\rho_2 + b_3\sum\rho_1\rho_3 + b_4\sum\rho_1\rho_4 + b_5\sum\rho_1\rho_5 + b_6\sum\rho_1\rho_6 + b_7\sum\rho_1\rho_7 + b_8\sum\rho_1\rho_8 + b_9\sum\rho_1\rho_9 + b_{10}\sum\rho_1\rho_{10} \quad (3)$$

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$$\sum y\rho_2 = b_0\sum \rho_2 + b_1\sum \rho_1\rho_2 + b_2\sum {\rho_2}^2 + b_3\sum \rho_2\rho_3 + b_4\sum \rho_2\rho_4 + b_5\sum \rho_2\rho_5 + b_6\sum \rho_2\rho_6 + b_7\sum \rho_2\rho_7 + b_8\sum \rho_2\rho_8 + b_9\sum \rho_2\rho_9 + b_{10}\sum \rho_2\rho_{10}$$
(4)

$$\sum y\rho_3 = b_0\sum \rho_3 + b_1\sum \rho_1\rho_3 + b_2\sum \rho_2\rho_3 + b_3\sum {\rho_3}^2 + b_4\sum \rho_3 x_4 + b_5\sum \rho_3 x_5 + b_6\sum \rho_3\rho_6 + b_7\sum \rho_3\rho_7 + b_8\sum \rho_3 x_8 + b_9\sum \rho_3\rho_9 + b_{10}\sum \rho_3\rho_{10}$$
(4)

$$\sum y\rho_4 = b_0\sum \rho_4 + b_1\sum \rho_1\rho_4 + b_2\sum \rho_4 x_2 + b_3\sum \rho_4\rho_3 + b_4\sum {\rho_4}^2 + b_5\sum \rho_4\rho_5 + b_6\sum \rho_4\rho_6 + b_7\sum \rho_4\rho_7 + b_8\sum \rho_4\rho_8 + b_9\sum \rho_4\rho_9 + b_{10}\sum \rho_4\rho_{10}$$
(5)

$$\sum y\rho_5 = b_0\sum \rho_5 + b_1\sum \rho_1\rho_5 + b_2\sum \rho_5\rho_2 + b_3\sum \rho_5\rho_3 + b_4\sum \rho_5\rho_4 + b_5\sum {\rho_5}^2 + b_6\sum \rho_5\rho_6 + b_7\sum \rho_5\rho_7 + b_8\sum \rho_5\rho_8 + b_9\sum \rho_5\rho_9 + b_{10}\sum \rho_5\rho_{10}$$
(6)

$$\sum y\rho_6 = b_0\sum \rho_6 + b_1\sum \rho_1\rho_6 + b_2\sum \rho_6\rho_2 + b_3\sum \rho_6\rho_3 + b_4\sum \rho_6\rho_4 + b_5\sum \rho_6\rho_5 + b_6\sum {\rho_6}^2 + b_7\sum \rho_6\rho_7 + b_8\sum \rho_6\rho_8 + b_9\sum \rho_6\rho_9 + b_{10}\sum \rho_6\rho_{10}$$
(7)

$$\sum y\rho_7 = b_0\sum \rho_7 + b_1\sum \rho_1\rho_7 + b_2\sum \rho_7\rho_2 + b_3\sum \rho_7\rho_3 + b_4\sum \rho_7\rho_4 + b_5\sum \rho_7\rho_5 + b_6\sum x_7\rho_6 + b_7\sum {\rho_7}^2 + b_8\sum \rho_7\rho_8 + b_9\sum \rho_7\rho_9 + b_{10}\sum \rho_7\rho_{10}$$
(8)

$$\sum y\rho_8 = b_0\sum \rho_8 + b_1\sum \rho_1\rho_8 + b_2\sum \rho_8\rho_2 + b_3\sum \rho_8\rho_3 + b_4\sum \rho_8\rho_4 + b_5\sum \rho_8\rho_5 + b_6\sum \rho_8\rho_6 + b_7\sum \rho_8\rho_7 + b_8\sum {\rho_8}^2 + b_9\sum \rho_8\rho_9 + b_{10}\sum \rho_8\rho_{10}$$
(9)

$$\sum y\rho_9 = b_0\sum \rho_9 + b_1\sum \rho_1\rho_9 + b_2\sum \rho_9 x_2 + b_3\sum \rho_9\rho_3 + b_4\sum \rho_9\rho_4 + b_5\sum \rho_9\rho_5 + b_6\sum \rho_9\rho_6 + b_7\sum \rho_9\rho_7 + b_8\sum \rho_9\rho_8 + b_9\sum {\rho_9}^2 + b_{10}\sum \rho_9\rho_{10}$$
(10)

$$\sum y\rho_{10} = b_0\sum \rho_{10} + b_1\sum \rho_1\rho_{10} + b_2\sum \rho_{10}\rho_2 + b_3\sum \rho_{10}\rho_3 + b_4\sum \rho_{10}\rho_4 + b_5\sum \rho_{10}\rho_5 + b_6\sum \rho_{10}\rho_6 + b_7\sum \rho_{10}\rho_7 + b_8\sum \rho_{10}\rho_8 + b_9\sum \rho_{10}\rho_9 + b_{10}\sum {\rho_{10}}^2$$
(11)

Equation 2 through to 11 can be written in matrix notation, this can be written as AX = B

with A =

11	107732.6	46188960	3570	68.3847	32225	72870	5.4296	12260	812	59826
1E+05	5.00E+08	1.89E+11	17641521	273116.3	1.00E+08	2.86E+08	2.63E+04	4.01E+07	2.50E+06	2.28E+00
5E+07	1.89E+11	7.86E+13	7.50E+09	1.00E+08	4.15E+10	1.08E+11	1.09E+07	1.70E+10	1.08E+09	9.89E+10
3570	17641521	7.50E+90	1321540	5882.847	2527038	8492435	2012.16	1457400	79408	10912002
68.38	273116.3	1.00E+08	5882.847	190.7405	72999.38	180451	8.484424	25122.66	1617.276	107731.4
32225	1.00E+08	4.15E+10	2527038	72999.38	68408487	30.1225	3570	11565470	754984	461890
72870	2.86E+08	1.08E+11	8492435	180451.3	68408487	1.91E+08	13155.7	26550230	1705760	1.33E+08
5.43	2.63E+04	1.09E+07	2012.16	8.484424	3570	13155.7	3.300244	2126.432	118.5299	17103.23
12260	4.01E+07	1.10E+10	1457400	25122.66	25122.66	1.2E+07	265502.3	2126.432	285240	21422960
812	2.50E+06	1.08E+09	79408	1617.276	7.55E+05	1.71E+06	1.19E+02	2.85E+05	1.90E+04	4.41E+04
59826	2.28E+08	9.89E+10	10912002	107731.4	46189010	1.33E+08	17103.29	21422960	1380288	1.41E+08

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$$X = \begin{bmatrix} \\ \\ \\ \\ \\ \\ \\ \\ \\ \end{bmatrix} = \begin{bmatrix} -6971.8 \\ -45.7462 \\ 5.79E-84 \\ 4372.039 \\ -6763.97 \\ 264.623 \\ 128.3786 \\ -35728.1 \\ -3275.47 \\ 28679.56 \end{bmatrix} \quad B = \begin{bmatrix} 143E \\ 1E+07 \\ 5.43E+10 \\ 2.28E+13 \\ 4.13E+09 \\ 1.76E+07 \\ 7.50E+09 \\ 2.63E+10 \\ 6.43E+06 \\ 4.44E+09 \\ 2.40E+08 \end{bmatrix}$$

III. RESULTS AND DISCUSSION

The results of solving equation 2 through to equation 11 are given as X. Therefore, the model to detect and predict water produced is given equation 12. The results of using equation 12 to detect and predict water produced are presented in Table 2.

$$W_P = -76689.8 - 45.7462Gp + 5.79Np + 4372.039Qw - 6763.97Qg + 264.623Qo + 128.3786GOR - 35728.1WOR - 3275.47FLP + 28679.56Choke - 0.9471T + 182821.916 \quad (12)$$

Table 2: Actual and Estimated Water Produced

Time(days)	Actual water produced	Estimated water produced
0	0	-4254582.9
69	0	-3798222.2
211	0	-2202820.5
320	0	-1187119.1
395	0	-943705.5
464	0	-29046.628
590	590	2833.1028
667	0	-193478.48
717	0	-35809.5
902	1804	600548.46
986	986	1927732.7
1041	14574	4126543.3
1154	3462	4569438.8
1230	0	-9874947.9

From Table 2, the values zero and negative indicate that water was not produced at that particular time.

Water production is one of the greatest outstandingly practical, environmental, and economical problems connected with oil and gas production. Productive life of the oil and gas wells and can be limied by water production and can cause several problems including corrosion of tubular, fines migration, and hydrostatic loading. Produced water characterizes the largest waste stream associated with oil and gas production. Water production can be avoided by implementing new drilling practices such as drilling horizontal, deviated, or infill wells [5].

IV. CONCLUSION

A model to detect water production in an oil reservoir has been developed. When looking at excess water production problems, the easiest problems should be confronted first, and analysis of water production problems should begin with information already at hand.

REFERENCES

1. Simon GK., Yulin, T., Chunyu, Li., Emanuel, WJ. Petroleum Industries: Produced Water Effects, Management and Treatment Technologies,International Journal of Scientific and Research Publications, 10(3), (2020).
2. Al-Ghouti MA., Al-Kaabi, MA., Ashfaq, MY., Da'na DA., Produced water characteristics, treatment and reuse: A review. Journal of Water Process Engineering,28, pp.222–239, (2019) DOI: 10.1016/j.jwpe.2019.02.001
3. Al-Kaabi, MA, Al-Ghouti, MA., Ashfaq, MYM., Ahmed, T and Zouari, N. An integrated approach for produced water treatment using microemulsions modified activated carbon.Journal of Water Process Engineering ,31, 100830 ,(2019) DOI: 10.1016/j.jwpe.2019.100830
4. Kusworo, TD., Aryanti, N., Utomo, QDP., using integrated activated carbon-bentonite adsorbent and double stages membrane process, Chem. Eng. J. 347, pp. 462–471, (2018).
5. Bedaiwi, E., Al-Anazi, BD., Al-Anazi, AF., Paiaman,AM, Polymer Injection for Water Production Control through Permeability Alteration in Fractured Reservoir, NAFTA, 60 (4), pp. 221-231,(2009).

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6. Seright, RS., Lane, RH., Sydansk, RD., A Strategy for Attacking Excess Water Production, SPE 70067, pp.1- 16, (2001).
7. Fanchi, JR., Blumer, DJ., Properties of Produced Water, Petroleum Engineering Handbook, Society of Petroleum Engineers, ISBN 978-1-55563-108-6, pp. 465-497,(2007).
8. Clark, CE., Veil, JA., Produced water volumes and management practices in the United States. DOI:10.2172/1007397.
9. Jiménez, Sm, Micó, MM., Arnaldos, M; Medina F, Contreras S, State of the art of produced water treatment, Chemosphere 2018; Vol.192,pp.186-208,(2018).
10. Richard, L., Cooley, and Richard L., Naff, Regression modeling of ground-water flow, U.S. Geological Survey., (1990),https://doi.org/10.3133/twri03B4.
11. Bouquet, C., Morrison, A., Birkinshaw, J, International attention, and multinational enterprise performance. J Int Bus Stud 40, pp. 108–131, (2009). https://doi.org/10.1057/jibs.2008.64

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