Gas coning in oil wells

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Abstract

Gas coning is one of the most serious problems in oil wells. Gas will reach the perforations and be produced with oil. Anyhow there is a certain production rate called critical production rate. The daily production rate should not exceed the critical production rate. In this research ten oil wells have been tested for problem of gas coning for a period of time of eighteen months. The production rates of these Ten oil wells are tabulated in a table exist in this research.

These production rates are considered as critical production rate because no gas coning has been observed in these wells. The critical production rates of these wells don't concide with those obtained from (Meyer, Gardiner, Pirson) method and also they don't concide with the values calculated by Albert Lewis (a.l).

An empirical equation was found which represents the actual production rates exactly.

Errors percentage in the calculations by using (Meyer, Gadiner and Pirson) method and also by using Albert Lewis (a.l) method are shown in table exist in this research.

Keywords: Critical Production Rate , Oil Saturation , Water Saturation

تقمع الغاز في آبار النفط

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الخلاصة

مشكلة تقمع الغاز واحدة من المشاكل الخطيرة في آبار النفط . نسبة الإنتاج اليومي يجب أن لا تزيد على نسبة الإنتاج الحرجة. في هذا البحث تم فحص عشرة آبار نفط لمدة ثمانية عشر شهراً . نسبة الإنتاج هذه اعتبرت هي نسبة الإنتاج الحرجة لأنه لم ينتج الغاز مع النفط . هذه النتائج لم تنطبق مع تلك المحسوبة بطريقة (ماير ، كاردنر ، بيرسون) وكذلك المحسوبة بطريقة ألبرت لويس (A.L). تم أيجاد معادلة تجريبية تمثل النتائج بصورة دقيقة موجودة في جدول في هذا البحث .

Introduction:

Gas coning is one of the most serious problems in the oil wells because the gas will reach the perforations and be produced with oil.

Gas coning in an oil well occur when the flowing pressure gradient in the vicinity of the oil well cause vertical flow across the bidding planes [1].

In the case of hetrogenious reservoir, the problem will be more complicated and it need to use numerical simulation and the necessary calculations should be used by an advanced computer

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program, However the reasons of coning are (constant production rate , constant pressure gradient in the drainage area , flowing pressure gradient is greater than gravity force) , [2].the combined effect of the mentioned reasons give stable gas coning as shown in figure -1

There may be (gas coning, water coning, gas and water coning simultanously) .in this work we dealed with gas coning because of its importance and existence in oil fields.

Any change in one or more of the mentioned reasons will give unstable gas coning. [3] the critical production rate which is the maximum production rate of oil without gas coning should not be exceeded at all conditions.grouping of wells according to similar reservoir properties is necessary . The ten wells that we have studied are of similar reservoir properties. The available methods which treat the coning problem are: (A) craft and Hawkins method. (B) Meyer, gradiner, pirson method.

(C) Albert Lewis (al) method. [3]

Theory of the problem:

The gas coning behavior was correlated to one critical parameter (the average oil column height above the perforated interval of the well).we have determined the average oil column height above the perforations by first calculating an average oil column height within the drainage area of the well. This oil column height was determined by averaging oil saturation around the well and calculating an average oil column height as if the gas / oil contact was level. The calculation procedure is shown in figure-2. This calculations based on basic assumption that the oil is diplaced by the gas in a piston like displacement, it is assumed that the well receives little or no aquifer support [4] .

Three regions are considered around the wells these are (the gas cap, the gas invaded region and the oil column).

In gas cap the oil saturation is zero and the water saturation is at its connate level [5] . from initial gas / oil contact to the present gas / oil contact , the oil saturation is equal to residual oil saturation to gas flood .

Below the present gas / oil contact the saturation is the critical gas saturation (sgc) and the water saturation is connate water saturation (swc) .

Average oil saturation (so) , saturation of the original oil is (s.o.o) . the material balance of the three regions of the well is [6] .

Soht = (ht - hoi) s.o.o + (hoi – h) sor + h (1 – sw - sgc) …..(1)

$$h = \frac{soht - hoisor}{1 - sw - sgc - sor}. \qquad \ldots\ldots\ldots (2)$$

hap = h – hp – hbp ………. (3)

Where:

So = average oil saturation .

ht = total height , hoi = initial oil height .

s.o.o = original oil saturation .

h = effective oil height .

sor = residual oil saturation.

sw = water saturation .

sgc = critical gas saturation .

hap = oil column height above perforations .

hbp = oil column height below perforation .

hp = perforation thickness .

the average oil column height above perforations is major parameter up on which gas coning is correlated. All correlations are a functions of (production rate, horizontal permeability (Kh), vertical permeability (Kv), perforation thickness (hp), well spacing, viscosity (μ), water saturation (sw), oil saturation (so) , gas saturation (sg)).[7]

Initially the (G.L.R) is due only to solution gas until the the gas cone reaches the perforations, as the well produce further the (G.L.R) increase as the oil column height decreases [8].

The rapid increase in(G.L.R)indicate the formation of the gas cone and this indicate a pluge flow displacement [9].

Data and Results:

The following reservoir properties are used in our calculations ,these are : ρo = 0.81 gm/cc , ρg = 0.28 gm / cc ,
re = 600 ft
rw = 6 inch
Ko = 1325 m . d
μo = 1.3 c.p
Bo = 1.2 bbl / S.T.B
Those data are taken from wells reports .
(Meyer , Gardner , Pirson) method is represented by the following equation :

$$Qo\ max. = 0.001535 \frac{\rho o - \rho g}{\ln (re/rw)} * \frac{Ko}{\mu o Bo} * (h^2 - D^2)$$

where:
ρo = oil density gm / cc
ρg = gas density gm / cc
re = drainage radius ft
rw = well radius ft
Ko = oil permeability m.d
μo = oil viscosity c.p
Bo = oil formation volume factor bbl / S.T.B
h = formation thickness
D = distance that the well penetrates the formation
Qo max. = maximum oil production without coning S.T.B / D
Albert lewis (al) method is represented by the following equation :

$$Qo\ max. = 0.001535 \frac{\rho o - \rho g}{\ln(re/rw)} * \frac{Ko}{\mu o Bo} * (h^{1.99} - D^{1.97})$$

all variables are obtained previously …… [10]
the values obtained by these two methods are not concide with measured actual values, the values are tabulated in table-1 .
An empirical equation was found which represent the actual measured values with high accurancy inwhich the capillary pressure is taken into consideration, it is on follows:

$$Qo\ max. = 0.001535 * \frac{\rho o - \rho g}{\ln (re/rw)} * \frac{Ko}{\mu o Bo} * (h^{1.98} - D^{1.96})$$

all variables are defined previously .

Error percentage and standard deviations of these three methods are calculated and tabulated in table-2.
Table-1 shows that our method is best and give values which concide with the actual measured values.
Table-2 shows that the average error percentage of (Meyer, Gardner and pirson) method is %7.6 which that of Albert lewis is %6.9 and our method is %0.208 and the standard deviation of (Meyer, Gardner and Pirson) method is 5.5 and that of Albert Lewis is 5.2 and our method is 0.34

Table 1

Well no.	h (ft)	D (ft)	Qo max. meyer (S.T.B/D)	Qo max. Albert Lewis (S.T.B/D)	Qo max. Talib (S.T.B/D)	Qo max. recorded (S.T.B/D)
2	96	82	246.82	288.48	274.69	275
3	97	84	232.96	278.24	264.96	266
5	99	78	367.8	398.2	379.11	379
6	100	90	187.9	244.8	233.08	233
8	101	95	116.4	264.16	176.17	175.95
11	104	91	250.95	306.13	291.33	291.2
13	98	86	218.6	267.47	254.78	255

14	105	79	473.6	499.39	475.68	475.4
16	103	85	355.02	376.69	313.28	313.4
17	102	89	245.82	298.06	257.85	258.1

Table 2

Well no.	**Error percent**			**Standard deviation**		
	Meyer method	**Albert Lewis method**	**Talib method**	**Meyer method**	**Albert Lewis method**	**Talib method**
2	10.3	4.9	1.2	5.5	5.2	0.34
3	12.4	4.5	0.39			
5	2.9	5.06	0.029			
6	0.19	5.06	0.034			
8	3.4	5.0	0.12			
11	13.7	5.2	0.04			
13	14.5	4.7	0.08			
14	0.04	5.0	0.059			
16	13.4	20.1	0.038			
17	5.04	15.5	0.097			
	Average = %7.6	Average = %6.9	Average = %0.208			

Standard deviation is calculated by using the statistical equation :

$$S.D = \sqrt{\frac{1}{n} * \sum (X - X)^2}$$

Conclusions:

1 All the existing methods are defined on certain fields and not applicable on other fields.
2 These methods assume homogenous reservoirs and in fact they are not so.
3 These methods neglect the effect of capillary pressure for simplicity which a weak assumption.
4 It is necessary to take into consideration the effect of heterogeneity of reservoir.

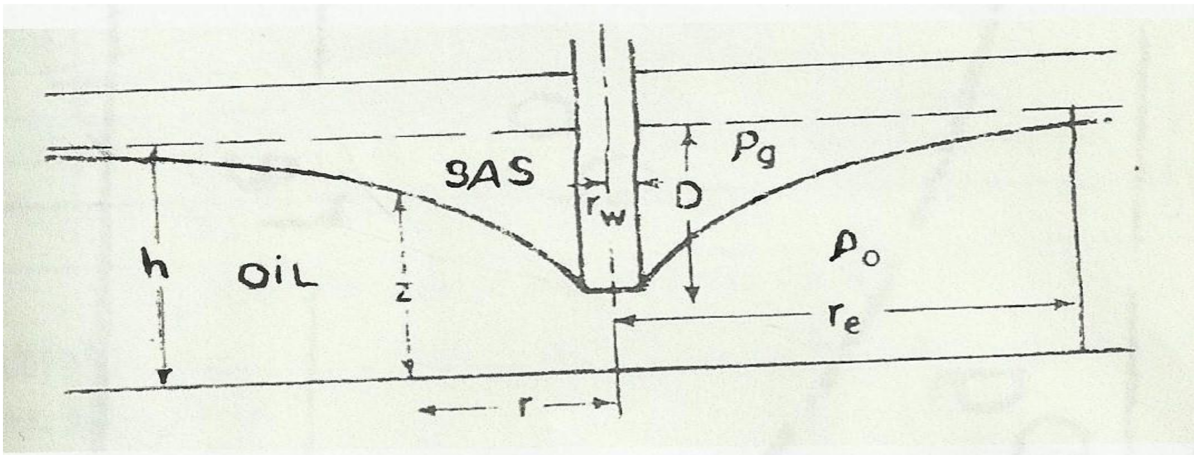

Figure 1- Gas coning

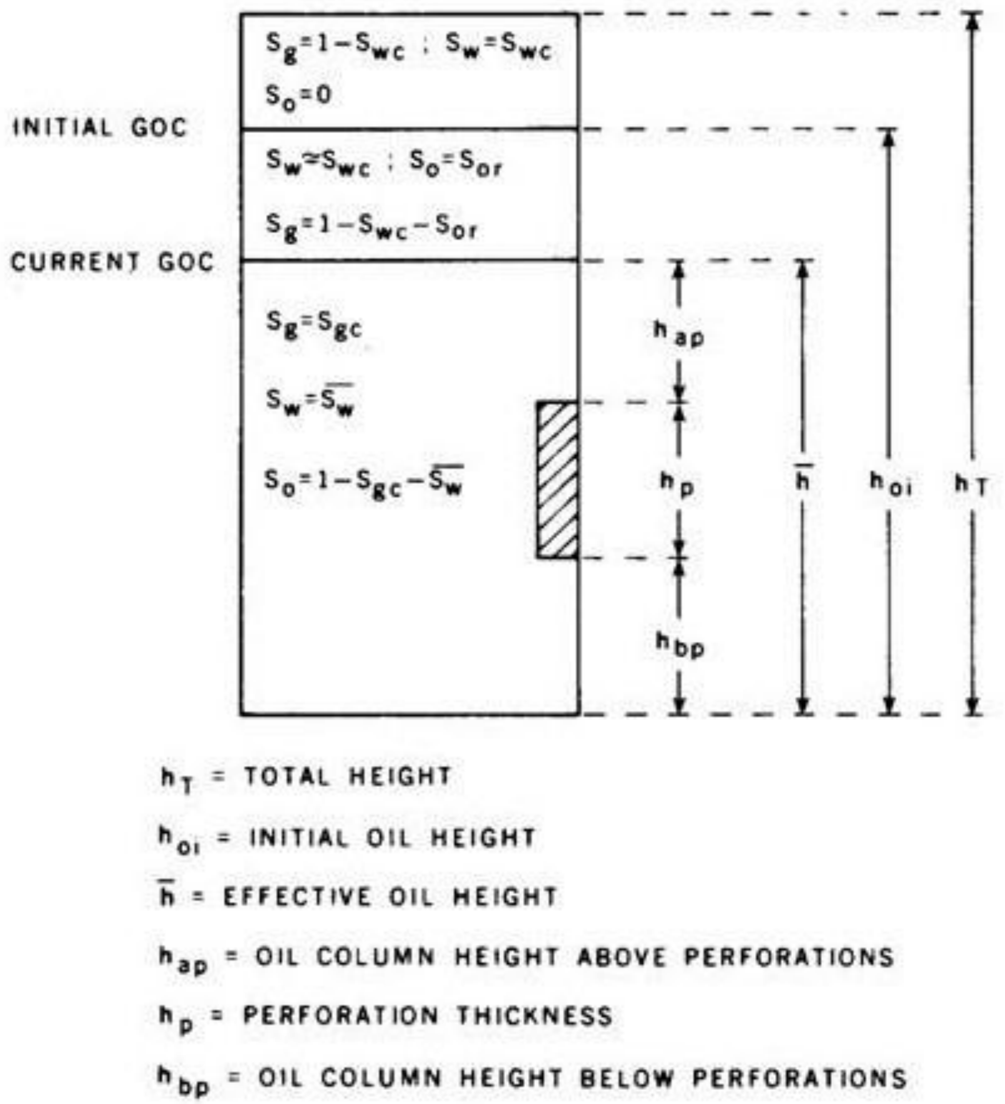

Figure 2- Schematic of coning correlation calculation.

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