Reservoarfluider og Strømning

Reservoir Fluids and Flow Course TPG 4145

Homework Problem 5

<u>Handed Out</u>: May 2, 2017 <u>Due Date</u>: Not turned in | solution given to compare your results

This problem is designed to illustrate the use of a wellhead backpressure equation as presented in the paper "Multipoint Testing of Gas Wells" by Michael J. Fetkovich. A set of reservoir and well data are given in Table 1 for a high-permeability (kh) system where the tubing diameter is to be designed for a limited-well development of the 3.5 Tcf reservoir.

Find the tubing inner diameter that is required to balance pressure drop (given at surface datum) in the reservoir and within the tubing at a specified rate of $10^6 \text{ Sm}^3/\text{d}$ (ca 35 MMscf/D) at the end of plateau when average reservoir pressure has dropped to half of its initial value (from 300 to 150 bara) – i.e., the pressure drop p_c - p_w should equal the pressure drop p_w - p_t . If the tubing inner diameter that satisfies this criterion exceeds the equipment constraint of 6 inches, then one should then use 6-in tubing.

With the average-well wellhead backpressure equation known (with final tubing selection) and well-defined at the end of plateau ($p_R=150$ bara), estimate the number of wells required to produce the DCQ (daily contract quota) of 0.05G/year.

Note: use Gas-PVT e-note Excel file for calculating gas PVT properties (Ex-1.xls).

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	Curtis'	Provided	Provided		Fetkovich
	Nomenclature	Data	Units		Units
Average Reservoir Properties					
Temperature	TR	120	oC	707.67	oR
Initial Pressure (at datum depth)	pRi	300	bara	4351	psia
Gas specific gravity	SG	0.7	air=1	0.7	air=1
Permeability	k	500	md	500	md
Thickness	h	100	m	328	ft
Rate-dependent skin constant	D	2.50E-06	1/(Sm3/d)	7.08E-05	1/(Mscf/D)
Constant skin	S*	3		3	
Initial Gas in Place	G	1.00E+11	Sm3	3.53E+09	Mscf
Initial (irreducible) water saturation	Swi	0.30		0.30	
Porosity	φ	0.21		0.21	
Average Well Properties					
Datum Depth	TVD	3000	m	9840	ft
Average tubing temperature	Tt,avg	80	oC	635.67	oR
Wellbore radius	rw	0.1	m	0.328	ft
Minimum tubing pressure (end plateau)	pt,min	30	bara	435	psia
Maximum number of wells (economic limit)	Nw	7		7	

TABLE 1 – RESERVOIR AND WELL DESCRIPTION

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TABLE 2 – SOLUTION

Fetkovich Parameters					
Gas Initial FVF (Bgi)	Bgi	0.00451	m3/scf	0.00451	ft3/scf
Gas HCPV	Vpg	4.51E+08	m3	1.59E+10	ft3
Total Area	A	30699789.2	m2	330280612	ft2
Average well drainage area (max wells), re	re	3126.02726	m	10253	ft
In(re/rw)	In(re/rw)			10.4	
PVT Properties from Gas-PVT e-note (Ex-1.xls): read manual	ally in this solution				
Zg at average tubing conditions				0.957	
Low-Pressure PVT Properties in Reservoir					
Zg at standard pressure				0.999	
ug at standard pressure				0.0140	ср
ugZg at standard pressure				0.0140	ср
Average reservoir pressure end plateau		150	bara	2176	psia
Zg at 150 bara TR				0.913	
ug at 150 bara TR				0.0179	ср
ugZg at 150 bara TR				0.0163	ср
ugZg used in AR constant				0.0145	ср
Step 1. Calculate AR' BR'					
Constant	1424(uZ)T/(kh)			0.0891	
Darcy term	AR'			1.1226	
Rate-dependent term	BR'			6.31E-06	
p					
Step 2. Gas Gradient Column					
Gravity term	S			0.424	
Convert surface to reservoir pressure-squared	exp(S)			1.529	
Convert surface to reservoir pressure	exp(S/2)			1,236	
	CXP(3/2)			1.250	
Step 3. Reservoir Rate Eq. using surface pressures					
Darcy term	AR''			0.734	
Rate-dependent term	BR"			4.13E-06	
Ston 1 Tubing Data Far constants					
Step 4. Tubing Rule Eq. constants	Th				
				0.0	in
	Fr			0.00100178	
lubing rate constant				88.195	
BI=1/CI^2	BI			1.29E-04	
Step 5. Wellhead Rate Ea. constants					
Darcy term	Awh			0.734	
, Rate-dependent reservoir + turbulent tubing term	Bwh			1.33E-04	
Step 6. Solve WH rate equation with contraints					
Average reservoir pressure at surface datum (pc)	рс			1760	psia
Gas well rate	qg	1.00E+06	Sm3/d	3.53E+04	Mscf/D
Pressure-squared Total (Awh Bwh)	pc2-pt2			1.91E+05	psia^2
Pressure-squared Reservoir (AR" BR")	pc2-pw2			3.11E+04	psia^2
Pressure-squared Tubing (BT)	pw2-pt2			1.60E+05	psia^2
Surface-Datum Pressure Drops					
Pressure drop Total	pc-pt			55	psi
Pressure drop Reservoir	pc-pw			9	psi
Pressure drop Tubing	pw-pt			46	psi
Contribution of pressure drop in Tubing	(pw-pt)/(pc-pt)			84	%
Tubing inner diameter required so (pc-pw)=(pw-pt)	dT.design			8.2	in
Actual tubing diameter used for field development (max 6")	dT,actual			6.0	in
Sten 7 Number of Wells at end plateau to deliver DCO					
WH pressure-squared at at min and plateau	nc7-n+7			2 01E±06	nsia^2
Average well gas rate at nt min and plateau	ag and plat			2.910+00	Mscf/D
Eiold gas rate throughout plateau paried (DCO)	qg,enu-piat			143200	Mccf/D
Number of wells (reunded up) to deliver DCO and all t	yg,rieiu			465099	
wurnber of wells (rounded up) to deliver DCQ end plateau	inw,tield			4	